# Observations of Static Pile Composting of Large Animal Carcasses Using Different Media


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## **Introduction**:

*Disposal of routine and catastrophic mortalities remains a continual challenge for the animal-rearing industry. Until recently, traditional disposal methods, including rendering, burial and incineration, have proven to be dependable and cost-effective approaches. However, tightening of rendering regulations in response to livestock disease outbreaks of Bovine Spongiform Encephalopathy (BSE) in Europe and Canada, coupled with a general decline in the demand for rendered products, has resulted in a disappearance of rendering facilities (Looper, 2001). Threats to groundwater from burial practices, especially in areas with shallow water tables, along with allegations of declining air quality and public health risks from incinerator emissions, have forced the animal-rearing industry to seek suitable alternatives elsewhere (Langston et al., 1997). The ultimate goal of any disposal scenario must include a plan that is cost effective, environmentally sound and, ultimately, protective of public health. Composting offers such a solution. During composting, organic ingredients, including soluble nutrients, are consumed through microbial activity and transformed into complex organic compounds that are resistant to breakdown, contain very low levels of biological activity and are resistant to leaching (Rynk, 1992). A proper compost mix requires an appropriate balance of carbon, nitrogen, water and unrestricted airflow to help initiate and sustain the compost process. The compost blend should have a carbon-to-nitrogen ratio of approximately 20:1 to 40:1 to ensure that the required nutrients to support composting are present in adequate amounts (Rynk, 1992). Large animal carcasses are ideally suited for composting, as the carcass provides the "bulk" of the nitrogen component necessary for the compost mix (Carr, 2004). This paper focuses on observations noted during the course of compost trials (conducted from May through December, 2004), including: pathogen reduction performance, odor generation, animal (vector) activity, and leachate generation.*

## **Study Methodology**

During the summer of 2004, the Maine Compost Team, a collaborative interagency team including members from the Maine Department of Environmental Protection, Maine Department of Agriculture, and University of Maine Cooperative Extension Service, began a study to determine if large animal carcasses (bovine and equine) could be properly composted using a host of residuals that are commonly found on-farm and at various solid waste processing facilities. We chose to conduct our trials at Highmoor Farm, a University of Maine owned agricultural research center located in Monmouth, Maine. Highmoor Farm operates as a "working" farm, focusing on fruit and vegetable production. The entire site consists of 250 acres of hay fields, interspersed with various garden trials and apple orchard plots. Our study site, consisted of an eight (8) acre parcel of hay field underlain by moderately well-drained soils with 0-8% slopes. The entire study area was surrounded by a dense mixture of hardwood and coniferous trees (Figure 1). This combination, soils with the ability to properly treat leachate losses and excellent visual-screening afforded by the tree buffer, gave us an opportunity to conduct our trials in a real-life situation.


FIGURE 1. Aerial view of Highmoor Farm agricultural research center. Photograph on right shows research trials (center), feedstock storage area (bottom center), vegetable dump site (located to the right of compost trials) and, "biosecurity" demonstration area (orange snow fenced-in area upper left of center).

**<u>Study Design</u>:**

Previous studies have documented successful static-pile composting of large animal carcasses using a host of ingredients found on-farm, including: sawdust (Glanville (1995), Glanville and Trampel (1997), Keener et al. (2000) and Carr (2004)), animal manure and sawdust combinations (Looper (2001), and Mukhtar (2003), and wood chips (Bonhtal, 2004). To date, however, no studies have compared the relative effectiveness of various combinations of compost ingredients in side-by-side trials. In the present study, a total of eight (8) separate trials, with up to four (4) variants each (two (2) horse carcasses and two (2) cow carcasses) were set up and allowed to run for a two to three month "active compost" period, without turning or disturbance. Initial compost piles were formed using a farm tractor and combinations of the following residuals (exact trial recipes are listed in Table 1, below): horse manure, poultry manure, leaves, sawdust shavings, wood chips, animal bedding, N-Viro© Soil, and, hot, immature municipal sludge compost. For each trial, an initial base layer of compost mixture, measuring 24 inches thick (60 cm), was placed on the ground surface prior to off-loading the carcass. Previous studies have documented using an initial base depth of 12 inches (30 cm) thick (Looper (2001) and Mukhtar et al. (2003)). For our study, we chose to double the recommended base depth due to the high incidence of shallow water tables statewide and the potential for leachate losses to groundwater. Carcasses were then covered with an additional 24 inches (60 cm) of the compost mixture to help decrease odor potential and to help insulate the pile to retain heat (Keener et al., 2000). Approximately 8-14 $yd^3$ (6-12 $m^3$) of compost mixture was required to completely cover the study animals. One notable exception was a large Belgian draft horse (first study animal received) which required just under 27 $yd^3$ (24 $m^3$) to completely cover it. Prior to final covering, each carcass abdomen was vented, in numerous areas, using a six-foot-long piece of re-bar. A four-foot thermometer (dial type, Reotemp Instrument Corp., San Diego, CA) was inserted into the abdomen to allow continual carcass temperature monitoring throughout the compost period (eight (8) to 12 weeks).

Table 1. Compost trial pile feedstock mixtures used in 2004 study. Note: A "C" prefix in the trial column indicates a cow carcass trial and an "H" indicates a horse trial.

| Trial | Pile Composition | Density (lbs./yd$^3$) | C:N |
|---|---|---|---|
| C1A | Horse Bedding | 450 | 62 |
| C1B | Horse Bedding | 450 | 62 |
| C2B | Cow Manure (wet) + Horse Bedding | 750 | 21 |
| C3A | Wood Shavings | 250 | 578 |
| C3B | Wood Shavings | 250 | 578 |
| C4A | Wood Chips | 250 | 677 |
| C4B | Wood Chips + Horse Bedding (core) | ---- | ---- |
| C5A | Sludge Compost (3 weeks old) | 550 | 28 |
| C5B | Sludge Compost (3 months old) | ---- | ---- |
| C6A | Hen Manure +Leaves | 550 | 16 |
| C6B | Hen Manure/Leaves | 300 | 52 |
| C7A | 2/3 Silage + 1/3 Horse Bedding | 700 | 18 |
| C7B | 1/3 Silage + 2/3 Horse Bedding | 550 | 17 |
| C8A | Sludge Compost + N-Viro© Soil | 800 | 30 |
| H1A | Horse Bedding | 450 | 62 |
| H1B | Horse Bedding | 450 | 62 |
| H3A | Wood Shavings | 250 | 578 |
| H5A | Sludge Compost (3 weeks old) | 550 | 28 |
| H5B | Sludge Compost (3 months old) | ---- | ---- |

Each completed pile was sampled and tested for: bulk density (lbs./yd$^3$), Carbon to Nitrogen Ratio (C:N), and pile nutrients (N, P, K and Total C). Additionally, overall mixture quality was observed, focusing on pile texture and relative porosity. During the "active" compost period, temperatures were taken, on a daily basis, from the three points within each pile: one foot deep, three feet deep and within the core of the carcass itself. Finally, pile observations were made regarding odor generation, animal (vector) scavenging activity/disturbance, and leachate generation. A field monitoring system (Taylor Instruments Digital Thermometer, Model 1425) and a disposable rain gauge was set up to provide daily data on ambient temperatures and collected precipitation volumes.

**Study Results:**

*Pathogen Reduction Performance*

All but four (4) of the compost trials (N = 20) met or exceeded the EPA time and temperature standards for pathogen reduction (three consecutive days at 130$^{o}$ F). The trials using horse bedding (C1A, C1B, and H1B), municipal sludge compost (C5A, C5B, H5A, and H5B), one mixture combining 1/3 silage and 2/3 horse bedding (C7B), and one mixture using hen manure mixed with municipal leaves (C6A), performed exceptionally well, sustaining temperatures in excess of 130$^{o}$ F for greater than 17 consecutive days (range 17-53 days). Trial H1A (equine carcass in horse bedding) was the first study pile constructed, and consisted of a large draft horse. Although this pile never reached the pathogen reduction goal, it is important to note that it did manage to sustain 128$^{o}$ F for most of the active compost period. The trials using wood shavings (C3A, C3B, and H3A) had moderate success (averaging greater than eight consecutive days above 130$^{o}$ F). The remainder of the piles failed to reach target temperatures for a variety of reasons explained below.

Pile C2B (adult Holstein in 50% cow manure + 50% horse bedding) reached a maximum temperature of 116$^{o}$ F. This mixture had a very high bulk density (750 lbs./yd$^{3}$) which made it difficult to achieve a homogenous blend using the farm tractor bucket. As a result, this pile performed poorly due to inadequate porosity and texture, although it had a near optimal C:N ratio of 21.

Pile C6B (adult Holstein in 50% poultry manure + 50% municipal leaves) reached a high of 114$^{o}$ F. This pile, like C2B, was difficult to mix thoroughly (bulk density 300 lbs./yd$^{3}$), even though a manure spreader was used to enhance the mixing process. Additionally, C6B suffered due to the relative lack of "energy" afforded by the leaves and manure mixture. The municipal leaves had been stored on-site for several years, and were fairly decomposed when added to the manure, which was also about two months old. The combined mixture had a fairly high C:N of 52.

Pile H3B (adult horse in 100% wood shavings) reached a high of 111$^{o}$ F. This pile was formed in early August and never seemed to take-off. The final mixture had a bulk density of 250 lbs./yd$^{3}$ and a C:N ratio of 578. Although the texture and porosity allowed for ample aeration, the carcass did not provide enough nitrogen to "fuel" the compost process and overcome the high C:N ratio. Additionally, this pile was susceptible to cooling from heavy winds and drenching rain.

Pile C8A ( 50% N-Viro© Soil + 50% municipal sludge (three months old) achieved a peak temperature of 103$^{o}$ F. This mixture had a "high" bulk density (800 lbs./yd$^{3}$), a very fine texture, and poor porosity. This combination greatly inhibited self-aeration of the pile during active composting. Additionally, the relative high pH of the N-Viro© Soil (pH = 10-11) also served to inhibit microbial activity, resulting in a poor temperature response.

*Odor Generation and Vector Attraction*

Six of the compost trials (N = 20) experienced numerous odor releases (# >2) and animal disturbances (# > 2) during our study. This was especially true for the trials using recipes comprised entirely of wood chips or wood shavings. Additionally, the site was frequented by scavenging animals (vectors) due to a local farm dump, consisting of waste fruits and vegetables, located adjacent to our study area. The odorous piles proved to be very attractive to vectors, resulting in the need for diligent site management (Figure 2).

FIGURE 2. Example of animal disturbance noted during carcass study. Pile H3A, turkey foraging activity for maggots.

Pile C4A and C4B (adult Holsteins in wood chips) had the highest incidences of odor releases and animal disturbances (14 odor incidents and four (4) animal disturbances for C4A, and four (4) odor incidents and 5 animal disturbances for C4B). Both of these trials had a very low bulk densities (250 lbs./$yd^3$) and very coarse texture that self-aerated easily. These mixtures also had the highest C:N ratios recorded during the study (677) and very little fine textured material available to capture soluble nutrients or to provide energy for microbial activity. As a result, as the carcasses decomposed, anaerobic (odorous) gases escaped the pile unabated and proved to be irresistible to vectors. Additionally, flies and maggots were observed on numerous occasions on the surface of these piles. Our belief is that the lack of aerobically driven microbial activity in the pile, coupled with the lack of fine carbon particles (to help absorb leachate) and resultant low temperatures in the media surrounding the carcass provided an optimal environment for the maggots, allowing them to travel back and forth between the carcass and the pile surface without consequence.

Pile H1A (adult horse in horse bedding) and H3A (adult horse in wood shavings) also had numerous odor releases and animal disturbances ( three (3) odor releases and five (5) animal disturbances for H1A, and six (6) odor releases and four (4) animal disturbances for H3A). Like the wood chip trials, both of these piles had relatively low bulk densities (H1A = 450 lbs./$yd^3$; H3A = 250 lbs./$yd^3$) and excellent porosity. Trial H1A, as previously noted, was the first pile constructed as part of this study. Because of the large size of the horse (lengthwise), the pile was constructed in a long rectangular shape. Initially, we believe that we had applied sufficient cover, but later found that as the animal decomposed and shifted, there was not enough cover material to maintain pile structure. Another confounding factor was venting of the animal. This carcass was punctured once in the abdomen to release trapped gasses. This proved to be insufficient, as the carcass continued to expand and contract as it released trapped gasses; resulting in further compromise of pile structure. As a result of the odor releases and lack of proper cover material, this pile was continually disturbed during the first couple weeks necessitating numerous rakings and additions of horse bedding. We finally decided to add a thicker coating of horse bedding, place snow fencing over the pile surface, and erect a snow fence around the entire pile as a "biosecurity" measure. Additionally, a scarecrow (with visual and auditory distracters) was added to help discourage on-site animal activity (Figure 3). These collective acts resulted in elimination of the vector problem.

Pile H3A experienced a somewhat different vector issue. This pile was formed in late August and almost immediately maggots were noted at the top of the pile surface. In fact, the maggots became so populous that the top of the pile literally appeared to be moving. Not long after the maggots appeared, the study site became populated with 10 to 20 wild turkeys. The turkeys, initially attracted by the adjacent dump site and an on-site hen manure stockpile, began feeding on the maggot-infested pile. Turkeys are notorious for tearing apart the ground as they forage. Pile H3A was no exception. Large portions of the pile face were torn away as the turkeys foraged for maggots (see Figure 2, above). Turkeys continued to disrupt the piles even after numerous re-coverings of the compost pile with horse bedding, and application of hot sludge compost to kill back the maggots. Therefore, we finally decided to obtain a "Animal Nuisance Control" permit from the Maine Department of Inland Fisheries and Wildlife to help discourage turkey scavenging at the study site.

FIGURE 3. Photo depicting "Biosecurity" area around pile H1A, digital thermometer and rain gauge combo and Scarecrow.

The remainder of the piles had infrequent odor releases and incidental animal disturbances (animal tracks on pile surface or slight exploratory digging events). For most of these piles, surface raking and additional amendment placed over the chimney area (upper top of pile) was sufficient to suppress additional odor events and to discourage animal disturbances.

*Leachate Occurrences*

The final area of observation involved incidents of leachate generation following precipitation events. As with other factors, leachate incidents were most prevalent for the piles constructed entirely of wood chips (C4A, six (6) occurrences and C4B, eight (8) occurrences). Both of these piles exhibited pools of leachate at the base following rain events in excess of one inch. The leachate was usually pink to dark red during the first part of the active compost phase and brown to dark brown near the very end of the compost phase. The low bulk density and coarse pile structure (very few fines) of these piles, allowed precipitation to percolate down through; flushing nutrients as it exited. This continual loss of nutrients is of concern as it affects the overall quality of the finished product, as well as raising the potential for dissolved nutrients to leach to groundwater and/or enter nearby surface waters. Based on these observations, along with the odor and vector issues noted previously, we decided not to conduct additional wood chip trials using horse carcasses. The remainder of the piles experienced fewer than two (2) leachate episodes during the course of the study, and only following precipitation events in excess of two (2) inches.

**Recommendations:**

The observations from this study indicate that on-site management is crucial throughout the composting event, especially during the first two weeks. Good site and carcass preparation facilitate carcass decomposition without causing nuisance odors, vector attraction issues, or generation of nutrient-rich leachate. Piles should be constructed using compost mixes with moderate bulk densities (300-550 lbs./yd.$^3$), optimal C:N ratios (25 to 40), good texture (appropriate mix of fine and coarse particles) and optimal porosity and pile structure. Horse bedding and municipal sludge compost performed very well during our trials and are ideal for most carcass disposal situations. Carcasses must be vented in numerous locations to release trapped gasses and allow abdominal contents an opportunity to mix with compost ingredients. In many cases, carcass legs may be tied together, depending on state of "rigor mortis", to help prevent extension out of pile as the carcass expands. Carcasses should be covered with 24 to 36 inches of cover material. This should be monitored during the first two weeks of composting, as carcasses slump, causing pile structure to collapse. Additional amendment may be needed, especially following pile collapse. Any occurrences of odors or maggots must be addressed before scavenging animals arrive. Covering with an appropriate amount of amendment will aid in reducing odor. Covering piles with hot, active compost will deter maggots. Likewise, leachate pools may also be amended and then re-incorporated into the compost piles.

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