Verification of Poultry Carcass Composting Research through Application during Actual Avian Influenza Outbreaks

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Abstract

An avian influenza outbreak in 2002 affected 197 poultry farms in Virginia and cost an estimated $130 million in losses and cleanup. In 2004-2005, researchers initiated a project to investigate the feasibility and practicality of in-house composting of turkey mortalities (heavy hens and toms) as a method of disposal and disease containment. Occurrences of low pathogenic avian influenza (LPAI) in West Virginia and Virginia in 2007 provided an opportunity for first responders to verify composting as an effective carcass disposal method. Many lessons learned from these experiences have led to improvements in the application of this technology. Market-weight turkeys, once thought too large for effective composting, were composted sufficiently for land application within 4 to 6 weeks. Additionally, fire-fighting foam, a new method of mass depopulation, proved to be compatible with composting. Knowledge gained from these incidents will be valuable not only for future responses to LPAI but also for outbreaks of highly pathogenic avian influenza such as the H5N1 virus, which currently causes disease in both animals and humans in many parts of the world. Since three-quarters of all recent emerging infectious diseases (EIDs) have arisen from animals, control of disease in animals is the principal way to reduce human exposure and prevent EIDs. Many of the general approaches and specific techniques used to eradicate the avian influenza virus can also be used to control other EIDs such as H1N1, Nipah virus, Rift Valley Fever, and plague.

Key Words: avian influenza (AI); bird flu; carcass disposal; emergency response; H5N1; in-house composting; outbreak containment; poultry; windrow

Introduction

Early developments (1900-1950) in commercial hatchery technology, artificial incubation and brooding, marketing, diagnostic testing, and key infrastructure improvements contributed to the growth and strength of the poultry industry in Virginia and in many other parts of the world. In Virginia's Shenandoah Valley the resulting expansion and density of poultry production as well as the diversity of poultry (broilers, turkeys, layers, and breeders) have posed challenges to the industry and to regulatory officials in efforts to control contagious diseases such as avian influenza (AI[1]).

Poultry diseases were noticed, tested, and reported as early as 1928. More recently, AI outbreaks in 1984 and 2002 were particularly challenging and problematic due to the magnitude and urgency of the epidemics and problems with carcass disposal. The 1984 outbreak cost Virginia poultry farmers and industry $40 million and required the disposal of 5,700 tons of poultry carcass material, most of it (88%) in on-site burial trenches and the remainder (655 tons) in a local sanitary landfill at a cost of $25 per ton, or $142,000 (McClaskey 2004). Neighbor concerns about contaminated groundwater from these sites and the discovery, during the excavation of a school building site in the late 1990s, of relatively intact carcasses affected future decisions about disposal methods.

The 2002 AI outbreak in the central Shenandoah Valley was even larger. At the time, more than 56 million commercial turkeys and chickens were being raised on over 1,000 poultry farms. On March 12, low pathogenic avian influenza[2] (LPAI[1]) was confirmed in a turkey breeder flock near Penn Laird, Virginia, and 1 month later more than 60 flocks tested positive. A total of 197 farms in the Shenandoah Valley were infected with the virus and by July 2 4.7 million birds had been destroyed to eradicate it. Turkeys accounted for 78% of the positive farms and bird losses (DEQ 2002); the cost to the industry exceeded $130 million and resulted in the disposal of 16,920 tons of poultry carcass material.

On-site burial, used for the first flock, was assumed to be an acceptable method of disposal until nearby landowners complained about possible well contamination. In response to this concern, state authorities developed stricter criteria for on-site burial such as public disclosure of sites on deed records, a compacted clay layer, the burial of fewer birds and use of more cover, and the installation of monitoring wells. As the disease progressed, many alternative disposal methods were researched, and five were implemented: on-site burial, burial in sanitary landfills, controlled slaughter, incineration

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[1]Abbreviations used in this article: AI, avian influenza; LPAI, low pathogenic avian influenza

[2]Definitions for this and other terms are in the Glossary on page 157.

with air curtain destructors, and in-house and Ag-Bag[2] composting (Table 1). Of these, in-house composting provided the highest level of disease containment by confining the virus to the poultry house. It also provided higher levels of environmental protection than other disposal methods.

Ag-Bag composting was used as a disposal technology in two instances—for a commercial layer flock and as secondary treatment for turkey carcasses from a farm where in-house composting was initiated. Improper windrow[2] construction and management at the turkey farm resulted in an inability to both adequately mix the carcasses and carbon material in a biosecure manner and maintain optimum moisture content in the compost. After this experience, in-house composting was not viewed as a viable option by the industry because of the potential loss of production space and the (erroneous) perception that composting would not work on larger birds.

But during a 2004 AI outbreak on the Delmarva Peninsula successful in-house composting of 5-pound chicken broilers proved the effectiveness of this method of disposal and containment as the AI was confined to three farms despite the area's high density of poultry farms (Malone 2004; Malone et al. 2004). The method appeared to be the most acceptable option because it limited the risk of groundwater and air pollution as well as the potential for farm-to-farm disease transmission. It also reduced transportation costs and eliminated landfill tipping fees (Tablante and Malone 2009).

The successful use of composting during this incident provided the incentive to conduct research in Virginia on the composting of larger birds such as market-weight[2] turkeys. Additional refinements to this method were made following the detection and containment of LPAI in turkeys in West Virginia and Virginia in April and July 2007, respectively. Experience from the first incident was invaluable for improving the process for the second.

Virginia Research, 2004

Project Summary

In the fall of 2004, a working group of Virginia state agency and poultry industry personnel initiated a research and demonstration project to build on the Delmarva experience and evaluate the effectiveness of in-house composting of turkeys, various carcass treatment methods, and carbon materials. Previous composting efforts had not been successful with larger birds, so a primary goal of the project was to evaluate the effectiveness of composting market-weight turkeys; several carcass treatments were evaluated to determine which methods enhanced the decomposition process.

Table 1 Disposal methods and quantities for avian influenza–infected poultry in 2002

Method of disposal	Number of birds	Percent of total
Composting (Ag-Bag and in-house)	43,000	0.9
Incineration	641,000	13.4
Landfill	3,103,000	65.5
Controlled slaughter	943,000	19.9
On-site burial	15,000	0.3
Total	4,745,000	100.0

The project involved the construction of compost piles in a typical turkey production house. Researchers used market-weight turkeys collected as dead on arrivals at a local poultry processing plant and arranged for the construction of eight windrows (12' wide × 6' high × 40' long). Each windrow represented a different treatment and contained 2,500 to 3,000 pounds of turkey carcasses.

Composting for disease control requires an adequate supply of carbon material for the windrows, and this research project examined the effectiveness of several commonly available carbon sources. Sufficient carbon may be available in the form of poultry litter either in the poultry houses or stored on the farm. However, diseases such as AI often affect older (and thus larger) birds, which have had more potential exposure to disease, and on-farm carbon sources may not be adequate because larger birds require more carbon for composting. In addition, carbon material type and availability vary regionally. If carbon sources are scarce, maintaining a stockpile of carbon material sufficient to compost two or three diseased flocks may be a reasonable solution. In some areas, however, this approach may be difficult; in Virginia, for example, wood residuals such as sawdust and wood chips are used by many industries and so are not readily available. An alternative to maintaining a stockpile is to identify, prior to an incident, regional sources of carbon such as wood chips, sawdust, and mulch. First responders should evaluate the local carbon materials available in sufficient quantities for use in response to animal diseases; factors such as carbon-to-nitrogen (C:N) ratio, moisture content, and particle size all affect the material's value as a compost amendment.

A cautionary note is in order about off-site carbon sources, which may present a potential biosecurity risk. Epidemiological studies have shown that a primary mechanism for the spread of the AI virus is vehicle traffic, so it is very important to limit the number of vehicles entering and exiting the farm, including those for delivery of carbon material. (If necessary, however, it is possible to manage transportation biosecurity by cleaning and disinfecting all equipment that leaves the farm, including trucks delivering supplemental carbon material.) In light of these biosecurity concerns and the potential scarcity of carbon materials, experiments were conducted to determine the minimum amount of carbon necessary to compost heavy toms.

Project Variables

Carcass Size

The turkeys used in this study ranged in weight from 17 to 40 pounds.

Carbon Sources

The following materials were compared for their effectiveness in composting turkey carcasses:

- Kiln-dried hardwood sawdust from a lumber mill (39% moisture);
- Aged, weathered wood chips from a tree trimming contractor (38-42% moisture);
- Built-up[2] (from three flocks) turkey litter (32-46% moisture);
- Blended starter litter and built-up litter (25-30% moisture); and
- Starter litter (pine wood shavings; 20% moisture).

Carcass Treatments

The following turkey carcass treatments were studied:

- Whole carcasses mixed and piled;
- Shredded and tilled carcasses mixed and piled; and
- Crushed carcasses mixed and piled.

Project Results

All the carbon materials were effective in composting the turkey carcasses. Temperatures in all the windrows reached 140°F and remained elevated (>120°F) for the duration of the project. The windrows with wood chips reached and maintained the highest temperatures (around 140°F for 2 to 3 weeks) because of good porosity, varying particle size, and ideal moisture content.

No seepage occurred with the carbon materials tested with a 5-inch base layer and 5-inch cap (10 inches total) at a density of 12.5 pounds per square foot. Starter litter was the only carbon material that required the addition of water to bring the moisture content of the windrow to the ideal range of 50-65%.

The rate of decomposition was similar regardless of carcass size, but two carcass treatments (tilling and shredding; crushing) enhanced the composting process by releasing and distributing the body fluids throughout the compost mix. They also raised windrow temperatures by increasing the surface area-to-volume ratio and exposing the bones and marrow to further decomposition. While both methods were equally effective, crushing also reduced the equipment necessary for in-house composting and eliminated the difficult process of cleaning and disinfecting the tiller.

The project demonstrated that market-weight turkeys could be effectively composted as a disease mitigation method.

Sugar Grove, West Virginia, April 2007

Outbreak Summary

Routine preslaughter testing on a Pendleton County, West Virginia, farm identified the presence of LPAI in a flock of turkeys that did not exhibit clinical symptoms or increased mortality. Additional testing in the state as well as in Virginia and at the US Department of Agriculture (USDA) National Veterinary Services Laboratory in Ames, Iowa, confirmed the presence of AI antibodies and identified the virus as H5N2.

The Pendleton County farm (Figure 1) raised 25,560 turkeys in four poultry houses for a Virginia-based poultry company. When the virus was identified on March 30, 2007, the birds weighed approximately 40 pounds each. Depopulation of the turkeys through the use of fire-fighting foam (described below) began on April 1 and resulted in 1,022,400 pounds of carcasses requiring disposal. The farm's 20 tons of feed and 350 tons of litter also required disposal.

On-site burial and composting were the two carcass disposal methods considered (off-site disposal was not an option because the state veterinarian determined that the transportation of infected carcasses off the farm represented too great a biosecurity risk in this area of concentrated poultry production). Review of geologic and soil maps and test pit excavations were used to evaluate potential burial pit locations both on-site and nearby. With thin soils and porous bedrock underlying the site, burial pits would need to be shallow and extremely large to accommodate a million pounds of carcasses. The two sites considered also posed some additional challenges: the off-farm site would have involved transporting the carcasses on a state road, posing a significant biosecurity risk; and the on-farm site presented the logistical challenge of transporting the carcasses up a steep hill where excavating a pit of sufficient size would be difficult.

Because of the challenges with on-site burial, composting was the carcass disposal method selected for this incident. Construction of the compost piles was completed on April 4. Evaluation of the windrows 2 weeks later indicated carcass decomposition at about 90% (based on visual observation). After 3 weeks of in-house composting, with overall carcass decomposition estimated at 95%, the material in the poultry houses was removed to outside windrows; at that point only large bones, quills, feathers, and a few fleshy pieces of

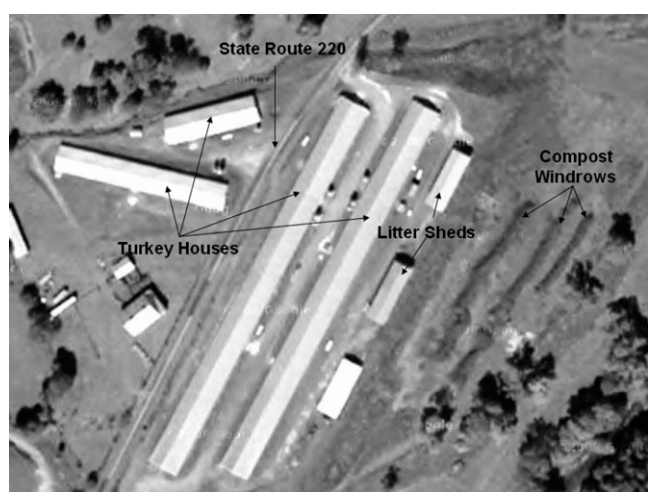

Figure 1 Aerial photograph of West Virginia site showing compost windrows

carcasses were visible. The compost material had an organic odor without a significant ammonia or rancid smell.

There was no seepage from the outside windrows, and only minimal seepage at the ends of the litter storage sheds (Figure 2). A section of a windrow in the first poultry house showed a few areas of seepage at the base due to the excessive amount of water used by the initial foaming equipment. This seepage was absorbed by adding litter to the base of the windrow during the first week of composting.

Throughout the composting process, temperatures were measured along the length of the windrows every 50 feet at a depth of 24 inches. Research indicates that AI virus can be inactivated in a laboratory within 10 minutes at 140°F (60°C) or 90 minutes at 133°F (56°C), and that maintaining a temperature of 98°F for 10 days is sufficient to deactivate the virus (Lu et al. 2003). The temperature probe was inserted at a 45° angle halfway between the peak and the edge of the windrow and showed internal temperatures in the first 3 weeks ranging from 110°F to 135°F; at 5 weeks temperatures in the windrows reformed outside the poultry houses averaged 135°F.

Virus isolation testing produced negative results at 5 weeks for all samples collected from the compost material. The farm's quarantine was lifted 51 days after it was imposed.

At 10 weeks the compost was evaluated for percent of carcass decomposition and for odor; the material's suitability for land application depended on the absence of flesh and of objectionable odor. Approximately 75% of the compost met these criteria and was released for land application as a soil amendment. Some of the remaining material was located in a slight depression that collected and held rainwater shed from the covered windrows. This moisture wicked into the bottom of the windrows and decreased pore space and limited aerobic bacterial activity. To ensure suitability for eventual land application, all of the material was turned for a final heat.

Figure 2 Compost piles in litter storage shed

Lessons Learned

Effect of Fire-Fighting Foam on Composting

Traditionally, diseased flocks were depopulated with the CO_2 gas method, but in 2006 the USDA approved a new method of mass depopulation, fire-fighting foam (Figure 3), for use in certain situations. Both methods have advantages and disadvantages. Fire-fighting foam is fast and requires limited handling of diseased birds and fewer personnel—advantages that make it the method of choice for many disease situations. It is water soluble and applied by a foam-generating nozzle in the poultry house to a height sufficient to cover the standing birds, inducing death by mechanical occlusion of the trachea.

At the time of the Pendleton County outbreak the effect of the fire-fighting foam on the composting process had not been fully evaluated except for a small experiment in 2006 in West Virginia on broiler breeders. During the 2007 incidents in West Virginia (above) and Virginia (described below), two different foaming methods were used. The first involved the use of a hand-held foam-generating nozzle attached by a hose to a water and foam supply; the second method was a larger, modified high-expansion trailer-mounted foam generator. Both demonstrated that the foam did not adversely affect the composting process. In fact, when properly executed, the use of foam increased the compost pile moisture content to near optimum levels. Without the use of foam, additional water may be needed for effective composting.

Poor water quality, however, can reduce the quality of the foam by creating excessive water, which hampers composting.

Figure 3 Use of fire-fighting foam for the depopulation of turkeys (Virginia, 2007)

It is therefore important to identify sources of water of sufficient quality and quantity before an outbreak. The water should be of minimal hardness, free of sediment, and approximately neutral in pH. A typical 400-foot turkey house will require approximately 8,000 gallons of water to depopulate market-weight birds.

Foam equipment should be tested regularly to ensure that it is in sound operating order and response personnel must be trained in its use. Access to backup foaming equipment is essential to ensure humane depopulation, timely disposal of carcasses, and the rapid containment of disease.

Carbon Sources

This incident represented a worst-case scenario because the birds were large (average weight, 40 pounds) and relatively little poultry litter was available due to a recent cleanout of the poultry houses. Hardwood bark mulch served as the supplemental carbon source. The only other carbon material readily available was poultry litter from other farms, but transporting this litter to the diseased farm presented an unacceptable risk of disease transmission through vehicle traffic.

The first loads of mulch that arrived on the farm were single-ground bark mulch and were too coarse (particle size > 2") to be effective when mixed with the carcasses. This material was used instead for the base of the windrows constructed outside the houses, where it was effective because its porosity both promoted air flow through the windrow and absorbed body fluids.

Subsequent loads of mulch were double ground. The finer particle size (< 2") provided more contact with the carcasses while retaining the heat generated by the biological activity. The double-ground mulch also produced an end product more suitable for land application as a soil amendment.

Traditional carcass composting blends call for a ratio of carbon material to carcass ranging from 2:1 to 3:1; this blend generally results in a C:N ratio between 20:1 and 40:1, which is considered the ideal range for composting. However, because of biosecurity concerns and economic considerations, a carbon material-to-carcass ratio of 1.5:1 was chosen to minimize the amount of supplemental carbon material transported to the farm. Although vehicle cleaning and disinfection protocols were implemented, there was still a potential for disease transmission due to the difficulty of thoroughly disinfecting large equipment in the field. Using this ratio and the calculated volume of litter in the poultry houses, an additional 800,000 pounds (23 trailer loads) of bark mulch were needed to compost the 1 million pounds of carcasses. Transporting material onto a disease control site requires additional biosecurity measures but represents less overall risk than transporting diseased material off the farm.

Siting Considerations

Because of a variety of site conditions, both in-house and outside composting were used to dispose of the turkey carcasses. The following site conditions favored outside composting for a portion of the carcasses:

- Indoor construction constraints (support poles in the older houses);
- Excessive moisture in a portion of one poultry house because of problems with the foam generation equipment used for depopulation; and
- The location of several poultry houses on the opposite side of the state highway from other compost activities. By transporting all of the infected material to one side of the highway, disease containment efforts were minimized by eliminating the presence of exposed vehicles and equipment on the highway after it was opened to the public.

The location of the outside composting site minimized the potential impact to ground and surface water resources. Windrows were constructed on a relatively level plateau above the floodplain with over 250 feet of permanent sod between the nearest windrow and the stream; drainage from the plateau flowed away from the stream toward a floodplain where it would be filtered through more than 1,000 feet of permanent sod. In addition, two covered litter storage buildings (Figure 2) were available for composting birds from the portion of the house that had excessive moisture. These covered buildings offered protection from precipitation, an important feature as the moisture content of the compost was already above optimum levels.

Windrow Construction

The outside windrows were 12 to 15 feet wide with a 12-inch base of single-ground mulch (this base was increased from the 5-inch minimum in the Virginia project to accommodate the additional moisture from foam depopulation).

The in-house windrows were constructed by placing a 9- to 12-inch single-ground mulch base followed by a layer of carcasses (placed with a large front-end loader), topped with 12 inches of double-ground mulch or litter (existing litter was tilled to break up caked material and create a more absorbent base). The construction of two windrows in the large houses left room to operate equipment along the edges of the houses and between the windrows.

Whether indoors or outside, windrows need to be constructed so that equipment does not travel over the base and cause compaction and insufficient air flow. A compacted base cannot readily absorb body fluids and can result in leachate.

Use of Compost Covers

Compost fleece covers (Figure 4) simultaneously prevent precipitation from entering the compost pile, allow the flow of air through the fleece, and limit scavenger activity. The fleece used in this project, a breathable polypropylene geotextile with a thickness of 1.7 mm, covered all but about 100 feet of the 1,200 feet of windrows. From a comparison of the material in the uncovered and covered windrows, it appeared

Figure 4 Use of composting fleece on windrows during 2007 incident of low pathogenic avian influenza (LPAI) in West Virginia

Figure 5 Mixing windrow with the horizontal tractor-mounted aerator

that the fleece inhibited air flow and retained excessive moisture. However, this effect may be partially due to the volume of mulch used to secure the fleece at the base of the windrow. Based on this combination of factors, the authors determined that the use of compost fleece for covering windrows may not be necessary except in climates with frequent precipitation.

Carcass Treatments

As in the Virginia research and demonstration project in 2004, different carcass treatments were used on a limited basis to assess their effectiveness in reducing decomposition time in an actual disease scenario. The team attempted to crush the carcasses using skid loaders or to shred them using a tractor with a disc before placing them in the windrows, but the moisture and surfactants in the fire-fighting foam made the carcasses slick and difficult to crush with either rubber-tired or tracked equipment. To the extent that these carcass treatments were effective, they did not, unlike the 2004 research, significantly accelerate decomposition nor seem to be necessary for successful composting. Furthermore, they required additional time for cleaning and disinfecting the equipment.

Experimental Use of Composting/Aeration Equipment

This project involved testing of both the skid steer-mounted and larger tractor-mounted Brown Bear horizontal aerators. In general, windrows aerated with a compost turner achieved internal temperatures 5°F to 10°F higher than the untreated reformed windrows, but the skid steer-mounted unit was not practical because of its limitations in managing in-house windrows of the height and width necessary to compost poultry mortalities. The large tractor-mounted turner (Figure 5) completely mixed and aerated one of the outside windrows such that 3 weeks later the only visible evidence of carcasses was leg bones, quills, and a few feathers; no other bones, flesh, or bird parts were visible. Flesh that remained at the time of turning (about 5%) was well decomposed and fell apart easily.

Mt. Jackson, Virginia, July 2007

Outbreak Summary

A turkey flock at a farm in Shenandoah County (Figure 6) was found to have antibodies for H5N1 avian influenza in a routine preslaughter test on July 6, 2007; the results of the test were confirmed by the USDA's National Veterinary Services Laboratory in Ames, Iowa. The flock did not exhibit clinical signs of disease or increased mortality. The farm raised a total of 54,000 birds in 9 poultry houses; 27,000 were market-weight birds weighing 40 pounds each, and the rest were 3-week-old poults.

Virus isolation was not available at that time but, based on the absence of clinical signs in the flock and normal mortality, it was assumed to be a low pathogenic strain of H5N1, not the lethal strain in humans that had been circulating in parts of Asia, Europe, and Africa. However, without virus isolation testing to confirm this assumption, all on-farm response activities were conducted as if the virus were the lethal Asian strain.

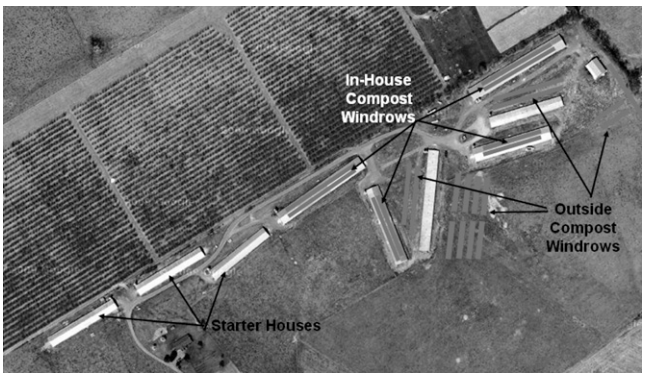

Figure 6 Aerial photograph of Virginia site

Depopulation using the foam method began on July 11 and was completed on the 14th. Disposal efforts also began on the 11th with the construction of outside compost windrows for the poults. The turkeys in two smaller, older houses were also composted in outside windrows, but most of the birds were composted inside the poultry houses (Figure 7). Disposal efforts included the composting of 1.1 million pounds of poultry carcasses, 30 tons of feed, and 400 tons of poultry litter.

On July 17, virus isolation tests confirmed that the turkeys had been exposed to a low pathogenic North American strain of the H5N1 avian flu virus.

After 2 weeks of composting and monitoring windrow temperatures, the compost was moved outside the poultry houses for further decomposition and all windrows were mixed with a compost turner. Achieving and maintaining adequate temperatures in the compost windrows is critical to ensure that any disturbance (e.g., high winds, heavy rain, scavenging animals) does not result in the airborne transmission of the virus or endanger the health of responders. After an additional 2 weeks of composting and negative virus isolation test results, the compost material was removed from the farm for land application.

Remaining cleaning and disinfection activities were completed on August 3 and the farm quarantine was lifted on August 28.

Lessons Learned

Coordinating Depopulation and Composting

In addition to decreasing responders' exposure to disease agents by reducing the number of workers needed in the poultry house, the use of fire-fighting foam cut the time required to depopulate poultry flocks to 1 or 2 hours per poultry house, down from the 4 to 8 hours per house using the CO_2 method. This efficiency has benefits in terms of responder safety (the use of CO_2 poses a suffocation hazard for workers) and operational costs.

Figure 7 Completed in-house windrows

However, depopulation and disposal should be coordinated so that they support each other and do not create operational problems. In particular, depopulation efforts must be timed so that carcasses are not left for more than 24 hours before being formed into windrows. At the Mt. Jackson site, the depopulation team began its work before the composting team was able to get resources on the farm and construct the windrows, with the result that there was a delay in the disposition of the accumulating carcasses. With midday temperatures in the 90s, carcasses left for more than 24 hours posed worker health and safety concerns by increasing the amount of manual handling, which in turn increased exposure to the AI virus and other pathogens associated with decomposing carcasses.

Carbon Sources

As with the West Virginia outbreak, the Virginia farm had just completed a total cleanout of litter and had insufficient litter for composting, so approximately 1.2 million pounds of additional carbon material had to be transported to the site (more carbon was used in Virginia than West Virginia because wood chips were readily available and less costly than alternatives such as hardwood mulch). The carbon came from two local landfills that had a stockpile of wood chips ground from yard waste; however, the chips had to be ground a second time, which caused a delay in constructing the windrows and slowed the disposal efforts.

End Use of Compost

Composting as a carcass disposal method has at least two benefits: (1) it produces a useful end product and (2) any virus present in the feed or litter can be deactivated by mixing this material into the compost windrows. But it is important to bear in mind that fertilizer prices, compost quality, and disease stigma can all affect the viability of compost as a soil amendment.

In 2007 high commercial fertilizer prices made it easy to find end users of the compost. Lower fertilizer prices would most likely result in the need for additional compost processing to generate a higher-quality material.

The quality of the resulting compost should also be considered. The end product should be free of:

- AI virus (with supporting documentation),
- decomposing flesh,
- large pieces of wood or stones, and
- objectionable odors.

The commercial grade mulch used in West Virginia as a supplemental carbon source resulted in a homogeneous end product, whereas the wood chips used in Virginia contained many larger pieces that needed to be broken up or removed before land application. A tractor-mounted compost turner was used to thoroughly mix the compost, break up bones and smaller woody pieces, and separate large woody debris, which was removed by hand from the base of the windrow.

Some larger leg bones remained in the compost, but this was not a problem for farmers who received the compost for use on row crops. Further screening would have been needed if this compost had been applied to hay fields or pasture land.

Regarding stigma, in 2002 there was resistance in the agricultural community to using compost or litter from LPAI-infected farms even though the material tested negative for the virus. LPAI had placed a tremendous financial burden on infected farms, an impact that discouraged the use of this material on other farms.

Use of Contractors

Diseases in the poultry industry used to be controlled by poultry company personnel, but with recent changes in the federal response strategy for disease eradication, efforts now rely heavily on emergency response contractors to handle depopulation, disposal, and decontamination. Although these contractors have extensive experience working in hazardous environments, at the time of the 2007 incident in Virginia none had experience with the unique challenges of eradicating poultry diseases—in particular, operating equipment in the confines of a poultry house and working with live animals. Since 2007, designated response contractors have received training on certain aspects of animal disease response activities. Additional training is necessary on specific aspects of poultry disease eradication, such as working with large birds, mastering composting techniques, and operating equipment in a poultry house.

Use of Compost Covers

In light of the experience in West Virginia, compost fleece was not used on the windrows in the Virginia outbreak. Monitoring of the windrows confirmed that vectors were not a problem, temperatures were maintained at sufficient levels (120-150°F) to inactivate the virus, and decomposition was effective. Carcass composting in colder climates or during wet seasons may benefit from the use of compost covers.

Carcass Treatment

Carcasses of market-weight turkeys removed from one of the poultry houses were crushed with a pad (or sheep's) foot roller to determine whether this would decrease the decomposition time. This method had not been evaluated during previous studies or outbreaks. Although effective in crushing the carcasses, the treatment did not significantly reduce the decomposition time and both the crushing process and subsequent equipment disinfection added unnecessary time to the construction of the windrows.

Use of Aeration Equipment

Windrows created inside the poultry houses were moved outdoors after 10 to 14 days of composting, reformed, and completely mixed and aerated by a tractor-mounted horizontal aerator. Although this additional treatment may not be necessary in all situations, the yard waste–derived wood chips used as a supplemental carbon source contained a significant amount of large woody debris that needed to be removed before land application. When aeration is necessary, windrows should not be wider than 12 feet to facilitate the use of this equipment.

Applicability for Highly Pathogenic H5N1 Outbreaks

In-house composting offers important advantages for eradicating a highly pathogenic H5N1 outbreak: containment of the carcasses inside the poultry houses minimizes the spread of the virus by minimizing transmission pathways such as aerosolization and vehicle tracking; and composting minimizes human exposure by reducing the number of personnel needed by at least 50 percent (as few as two equipment operators and a laborer can complete construction of in-house windrows whereas loading carcasses for landfilling requires seven to eight such workers for the same size poultry operation).

Future Research Needs

Further virus survival research on compost would be beneficial for updating time and temperature requirements and the effect of ammonia and moisture on deactivation of the AI virus. The current pathogen reduction standard for composting (USEPA 1995) is based on research conducted on aerated windrows for municipal sewage sludge, but some research indicates different standards for effective inactivation of the AI virus (e.g., Lu et al. 2003). Furthermore, environmental conditions (e.g., high levels of ammonia) in poultry mortality compost windrows may contribute to inactivation of the virus.

Summary

The use of composting during two LPAI outbreaks in 2007 confirms that it is an effective carcass disposal method for all types of commercial poultry operations and with modern depopulation methods such as fire-fighting foam and CO_2 gas. Because composting quickly inactivates the AI virus it can be a valuable tool for responding to outbreaks of more dangerous strains of avian influenza such as the highly pathogenic H5N1.

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Glossary

Ag-Bag: brand name of equipment (manufactured by Miller St. Nazianz, Inc.) designed to load organic material into a horizontal plastic bag for composting

built-up litter: litter compiled from several flocks; wet litter is removed between flocks and the remaining litter is used for the following flock

low pathogenic avian influenza (LPAI): form of avian influenza virus that causes mild disease and little or no mortality in poultry (distinct from high pathogenic avian influenza, HPAI, a strain with pronounced respiratory symptoms and up to 100% mortality in poultry)

market weight: for turkeys, 14 to 20 weeks and weighing about 25 to 40 pounds

windrow: long row of mounded organic material constructed for composting; for poultry carcasses, consists of a base of a coarse carbon source, a layer of carcasses and feed, and another layer (a "cap") of a carbon material (e.g., poultry litter, wood chips)

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