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Windrow Mortality Composting of Spent Hens

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ABSTRACT

Traditionally, poultry producers have relied on rendering services to dispose of their spent hens. Today, due to concerns about disease transmission and higher costs regarding rendering services producers are looking toward composting. Five thousand and eight hundred spent hens were composted in a windrow from July through September 2003. The primary and secondary phase of the composting cycle were monitored for temperature, odour, and visual observations.

During the primary and secondary phases of composting the material reached temperatures capable of destroying pathogens, weed seeds, and fly larvae. The final product was analyzed and was found to have no salmonella and less than 3 MPN/g of E-coli. On a wet basis the final product contained a carbon content of 20.02%, nitrogen content of 3.2%, phosphorous content of 2.12%; and the moisture was 31.25%.

After the primary phase there was a slightly offensive odour, very few recognizable remains, and no evidence of layering. After the completion of the secondary phase there was still an objectionable odour, some evidence of mortality, yet the product was homogeneous. The composting process worked very well for composting spent hens in the summer in Alberta.

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INTRODUCTION

Under Alberta's *Destruction and Disposal of Dead Animals Regulation* of the *Livestock Diseases Act* (Appendix A), the owner of a dead animal shall dispose of the animal within 48 hours of its death. Traditionally, poultry producers have relied on rendering services to dispose of their spent hens. Today, due to concerns about disease transmission and higher costs regarding rendering services producers are looking for other options. Composting of livestock mortalities is one option that is available. There are two general approaches to livestock mortality composting: enclosed or bin systems, and open pile or windrow systems. Alberta regulations allow either option for livestock composting, unfortunately most information for composting poultry losses is based on daily losses and bin composting systems. Disposing of a spent flock means constructing a windrow in a matter of hours and on a much larger scale than a daily bin system.

BACKGROUND

Basics of Composting

Composting is a natural biological process of decomposition of organic materials in a predominantly aerobic (presence of air) environment. During this process bacteria, fungi, and other micro-organisms break down organic materials into a stable mixture called compost, while consuming oxygen and releasing heat, water, and carbon dioxide (CO_2). The finished compost resembles humus and can be used as a soil amendment. Composting reduces the volume of the parent materials, and pathogens are destroyed if the process is controlled properly.

Micro-organisms involved in composting can be classified according to temperatures most favourable to their metabolism and growth. The mesophilic 10 - 43°C (50 - 110°F) and thermophilic micro-organisms 43 - 71°C (110 - 160°F) are the principal groups.

Under controlled conditions, composting is accomplished in two main stages: an active composting stage and a curing stage. The active composting stage involves three sub-stages:

- An initial stage (lasting one to three days) when mesophilic micro-organisms degrade constituents such as sugars, starch, proteins and compost temperatures rise rapidly.
- A high rate thermophilic stage (lasting 10 to 100 days) in which temperatures rise above 43°C (110°F) and fats, hemicellulose, cellulose and some lignins are degraded and pathogens are destroyed.
- A stabilization stage (lasting 10 to 100 days) during which time the temperature declines and further degradation of cellulose, hemicellulose, and lignins occurs.

The high rate stage is accomplished through a high rate of oxygen uptake and carbon dioxide (CO_2) output. Large amounts of ammonia (NH_3) and other gases may be released if the process is not controlled well. During curing or maturation, mesophilic organisms recolonize the compost. The length of curing time depends on market opportunities but typically represents a minimum of one month and generally lasts three to six months.

Factors Affecting Composting

While composting is a natural process, it requires proper conditions to occur rapidly, minimize odour generation, and prevent nuisance problems. Over twenty controllable factors affect composting. Table 1 lists eight of these factors and acceptable ranges to target when composting. Four major factors to be controlled in the composting process are the material mix (nutrient balance), water content, porosity, and temperature.

Table 1: Guidelines for composting: major factors

Major Factors	Reasonable Range	Preferred Range
Nutrient Balance (C:N ratio)	20:1 – 40:1	30:1 – 35:1
Water Content	45 – 65% w.b.	50 – 60% w.b.
Particle Size	0.3 – 1.2 cm ($^1/_8$ – ½")	Depends on Material
Porosity	30 – 50%	35 – 45%
Bulk Density	< 640 kg/m^3 (1100 lb/yd^3)	n\a
pH	5.8 – 9.0	6.5 – 8.0
Oxygen Concentration	> 5%	> 10%
Temperature	45 – 68°C (113 – 155°F)	54 – 66°C (130 – 150°F)

Material Mix (C:N)

The proper compost mix requires both carbon and nitrogen at the proper C:N ratio. This will result in a composting process that generates little odour yet offers an environment where micro-organisms can flourish. Generally, an initial C:N ratio ranging from 20:1 to 40:1 is satisfactory. Most compostable materials have a C:N ratio that is too low to compost properly on its own. In order to compost these materials, amendments that contain a high C:N ratio must be added. Plant materials such as wood chips, sawdust, chopped corn stover, shredded paper, or straw have a high C:N ratio for on-farm composting.

Water Content and Porosity

Like all living things, micro-organisms need water. To encourage their growth and rapid composting, water content of the mixture should be 50 - 60% (wet basis). It is important to avoid excess water due to the potential for odour and leachate conditions. If the mixture feels moist, yet no water drips from it when a handful is squeezed, the mixture probably has adequate water content.

Micro-organisms that are encouraged to grow in a compost pile are aerobic, or require oxygen. Open spaces (porosity) must be maintained to allow air to penetrate and move through the pile providing oxygen. Ideally, 35 - 45% of the pile volume should be small, open spaces. Optimum porosity is achieved by balancing the material's particle sizes, water content of the mix and pile size.

Temperature

The composting process will generate and regulate its own temperature. However, to maintain high temperatures the pile must be large or have some insulation. A layer of inactive material, sawdust, or finished compost placed over the entire pile will insulate the pile. As the pile heats up, warm air within the mixture will rise and move out of the pile, while fresh air will be drawn in to replace it. This process exhausts the CO_2 created in the pile and maintains an aerobic environment for the micro-organisms.

The highest rates of decomposition occur at temperatures in the range of 43 - 66°C (110 - 150°F). Also, high temperatures above 55°C (131°F) over three days will kill parasites, and fecal and plant pathogens within the pile. At temperatures above 66°C (150°F), microbial activity declines rapidly with activity approaching low values as compost termperatures exceeds 71°C (160°F). Mechanical windrow turners can be used to turn the material to help release excess heat when the temperatures reach dangerously high levels.

Livestock Mortality Composting

Composting livestock mortality almost always moves toward satisfying the principles previously mentioned. Unfortunately, strict application of these standards should only be done when dealing with a consistent, thoroughly mixed pile. The reality is that a pile in which livestock mortality is composted is an inconsistent mixture. Therefore, composting livestock mortality must be approached slightly differently.

A mortality compost pile (either windrow or in a bin) is an inconsistent mixture. It is composed of a large mass of material (the animal) with a low C:N ratio, a high moisture content, and nearly zero porosity surrounded by material (the carbon amendment) with a high C:N ratio, moderate moisture levels, and good porosity. The animal and amendments are layered into the pile, and no mixing is done until after the high-rate stage of composting has occurred and the animal has fully decomposed. Composting livestock mortalities (primary stage) can best be described as an "above ground burial in a bio-mass filter with pathogen kill by high temperatures."

The decomposition process is anaerobic (lacking oxygen) in and around the animal mortality, but as gases are produced and diffused away from the mortality, they enter an aerobic zone. Here the gases are trapped in the surrounding material, ingested by the micro-organisms, and degraded to CO_2 and H_2O. The surrounding material supports bacteria to form a biological filter, or a biofilter.

With this scenario, avoid turning the pile until the mortality has been decomposed. For moderately sized animals (poultry, pigs, sheep, etc.) this is generally less than three months after the last mortality has been placed into the pile. After this time, the pile is moved to a secondary area where it is allowed to compost for an additional 10 days to several months. This procedure introduces air back into the pile and mixes the contents, leading to more uniformity in the finished compost. The secondary pile is then turned and placed in a pile for storage for 30 days or more. When composting large mature animals, bones sometimes remain intact after completion of the secondary/storage process. They are generally quite brittle and pose no health risks or danger to equipment when land applied. In some instances however, it may be desirable to recycle the larger bones back into the compost to allow for more decomposition.

PLANNING CONSIDERATIONS

Location / Access

Location of a compost windrow should follow the criteria in Section 2, subsection (4)(d)(ii) of the *Destruction and Disposal of Dead Animals* (A.R. 229/2000) of the *Livestock Diseases Act.* It states that the windrow be:

- at least 100 metres from wells or other domestic water intakes, streams, creeks, ponds, springs, and high water marks of lakes and at least 25 metres from the edge of a coulee, major cut or embankment,
- at least 100 metres from any residences,
- at least 100 metres from any livestock facilities, including pastures, situated on land owned or leased by another person.

The location should also take into account any impact it may have on the farm residence and any nearby neighbouring residences. While offensive odours are not usually generated in the composting process, the handling of dead animals, manure, and litter may not be aesthetically pleasing. When locating a compost windrow consideration should be given to traffic patterns required for moving dead animals, the required ingredients, and removing the finished compost from the composter. The compost site should be well-drained, have good run-off collection, and provide access roads and work areas.

The location should also take into account any impact it may have on the farm residence and any nearby neighbouring residences. While offensive odours are not usually generated in the composting process, the handling of dead animals, manure, and litter on a daily basis may not be aesthetically pleasing. When locating a composter, consideration should be given to traffic patterns required for moving dead animals, the required ingredients, and removing the finished compost from the composter. The composter site should be well-drained and provide all-weather access roads and work areas.

PROJECT SCOPE AND OBJECTIVES

The scope of this project was to assess the biological efficiency and feasibility of composting spent hens. The specific objective of this project was to investigate the composting of large spent hens in a windrow constructed in less than one day. The windrow was constructed on July 8, 2003 and monitored for a total of 12 weeks.

MATERIALS AND METHODS

Site Preparation

The co-operator scraped the topsoil off an area of cultivated land, approximately 12 m x 30 m (39 ft x 98 ft). The sub soil was heavy clay and the site had good run-on and run-off control. On July 8, 2003 a straw base approcimately 5.5 m (18 ft) wide by 18 m (60 ft) long by 15 cm (6 in) deep was established down one side of the prepared site to act as an absorbent base in case of leaching and to provide for some aeration under the windrow. A thin layer (5 cm (2 in)) of poultry manure was spread on top of this straw layer. A separate pile of 3 parts poultry manure to 1 part wood shavings/sawdust was mixed near by.

Windrow Construction

A layer of dead birds was placed, by hand, on top of the bottom straw/manure layer, Figure 1. This layer of mortality was then covered with 10 cm (4 in) of the manure/shavings mixture. The process of layering birds and covering with 10 cm (4 in) of manure/shavings was repeated until there were 6 layers of birds, total of 5800 birds. The windrow was completely covered with 20 cm (8 in) of manure/shavings mixture, Figure 2.

Figure 1: Construction of the windrow and placement of hens

Figure 2: Windrow after completion, 5800 hens

Compost Sampling and Temperature

Temperatures were recorded 3 times per week in 8 locations, 4 on each side of the windrow, using a 90 cm (3 ft) stemmed dial thermometer. Samples of the poultry manure, manure/shavings mixture, and straw were taken and submitted for carbon and nitrogen content analysis at the beginning of the process. Samples of the final product were taken and submitted for analysis of salmonella, E-coli, carbon, nitrogen, and phosphorous.

Compost Process

The windrow was constructed on July 8, 2003 and left undisturbed for 6 weeks. It was turned on August 21, 2003 with a front-end loader. Due to the dry conditions of the windrow, some water was added and an additional 15 cm (6 in) layer of manure/shavings mixture was added to cover any exposed carcasses. The windrow was left undisturbed for an additional 5 weeks. The pile was investigated on Sept 24, 2003 before land application occurred.

RESULTS AND DISCUSSION

Construction and Materials

The total volume of manure/shavings (3:1 ratio) used was approximately 61 m^3 (80 yd^3) and 15 m^3 (20 yd^3) of straw was used in the base. It required approximately 3 ½ hours with 6 workers and 2 loader tractors to construct the windrow.

Compost Sampling and Temperature

The material analyzed at the beginning of the process were composite samples and contained a C:N of 5.8:1 for the manure and a C:N of only 4.9:1 for the manure / shaving mix. The reason for such a low C:N for the manure / shavings mixture is unknown since the C:N of the shavings component was 80.1:1. This indicates that the samples taken from the mixture were not representative and the mixture was not homogeneous.

During the primary phase the average temperature from the eight windrow locations rose from 41ºC (105ºF) when the construction of the windrow was complete to 55ºC (131ºF) by day 6. With a few slight fluctuations, the average temperature was over 54ºC (129ºF) for 21 days and then slowly dropped to 50ºC (122ºF) by the end of the 6th week, Figure 3. Temperatures above 55ºC (131ºF) for 15 days have been proven to destroy pathogens and weed seeds in compost, not mortality composting specifically.

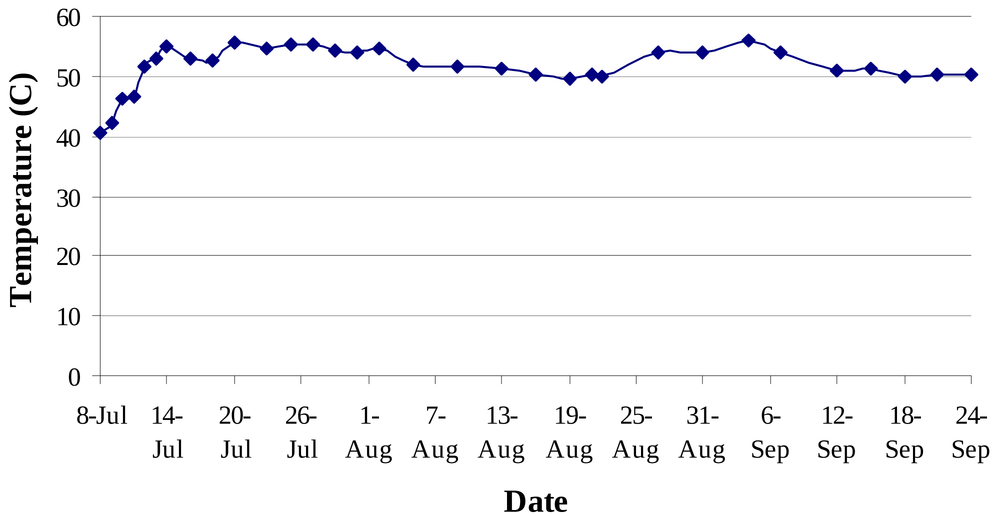

Figure 3: Average temperature throughout the two phases of composting

During the secondary phase the average temperature again rose to 54ºC (129ºF) within 6 days and reached a maximum of 56ºC (133ºF). An average temperature of 54ºC (129ºF) or higher was maintained for 12 days and then slowly dropped off to 50ºC (122ºF) by the end of the fifth week, Figure 3.

Analysis of the compost material after the secondary phase showed no trace of Salmonella, and less than 3 MPN/g (Most Probable Number) of E-coli, which is considered negligible by the Canadian Council of Ministers of the Environment (CCME) guidelines (CCME, 1996) . On a wet basis the carbon content of the compost was 20.02%; nitrogen content was 3.2%; phosphorous content was 2.12%; and moisture was 31.25%.

Odour and Visual Observations

Scavenging by a neighbour's dog was a problem for the first 2 to 3 weeks. Additional cover was added in an attempt to discourage this once the perpetrator was identified. There was no problem with coyotes or other scavenging animals.

When the windrow was turned the first time after the primary phase there was a slightly offensive odour, yet there were very few recognizable poultry remains, Figure 4. The few birds that were discernible were either completely dehydrated or mainly decomposed with some soft tissues remaining. There was no evidence of layering and very little evidence of leachate on the ground under the windrow. This indicated that the process was working very well but could benefit from some additional carbon (straw or shavings) to reduce the odour.

Figure 4: Windrow contents after the primary phase of composting

When the windrow was investigated after the secondary phase there was still a slight objectionable odour and there was some evidence of mortality, some wing feathers and bones, indicating the process needed more carbon. The bones were either very brittle or very soft and posed no risk to field equipment. The compost pile was subsequently land spread at this time.

CONCLUSIONS

- Windrow composting is an efficient and practical method for disposing of spent hens in the summer in Alberta.
- The slight odour and evidence of bones after the secondary phase may have been the result of the low C:N ratio of the initial manure/shavings mix. It is recommended that future composting projects use a manure:shavings mix of 1.5:1, by volume.
- Sufficient depth of cover is necessary to discourage scavenging.
- Temperatures reached high levels for sufficient time periods to destroy the pathogens, indicated by lab results for Salmonella and E.coli.

Appendix A

Livestock Diseases Act: Destruction and Disposal of Dead Animals Regulation

Method of Disposal

2 (4)

(d) composting

(i) in a Class 1 compost facility as defined in the Waste Control Regulation (AR 192/96) that is designed, constructed and operated in accordance with sections 6 and 7 of the Code of Practice for Compost Facilities, published by the Department of Environment, or

(ii) subject to subsection (5), in a farm open compost pile that is

(A) located at least 100 metres from wells or other domestic water intakes, streams, creeks, ponds, springs and high water marks of lakes and at least 25 metres from the edge of a coulee, major cut or embankment,

(B) located at least 100 metres from any residences,

(C) designed in a manner that will exclude scavengers, and

(D) at least 100 metres from any livestock facilities, including pastures, situated on land owned or leased by another person,

References

AAFRD Mortality Composting Handbooks

B.C. Agricultural Composting Handbook
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