Reduction in Manure Weight and Volume Using an In-House Layer Manure Composting System Under Field Conditions

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Primary Audience: Commercial Egg Producers, Extension Specialists

Summary

Many of the problems that have currently beset the commercial egg layer industry have arisen because of methods of handling the manure output from large flocks. Alternative techniques for handling of animal manure within animal production facilities will need to be developed to satisfy current and future zoning and environmental criteria placed on these types of operations. This paper discusses tests conducted in a commercial, naturally ventilated, high-rise layer house that involved an in- house deep litter manure management system. Layers at commercial densities deposited their manure onto stacked litter materials located directly beneath the cages. Regular turning of the litter facilitated composting within the layer house, resulting in a reduction of manure volume and weight. In the full-scale house, the deep litter system produced a 39% reduction in manure weight and a 37% reduction in manure volume over that of deep stacked raw manure. The compost at the end of these tests had a dry basis nutrient density of approximately 2% N, 8.5% P_2O_5, and 5.5% K_2O. The compost had a decreased moisture content, improved handling properties, and less odor than raw manure.

Key words: Commercial layers, in-house composting, manure

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Description of Problem

Animal agriculture is facing more problems today than just those associated with the proper care and feeding of animals to optimize production. Producers are having to deal with state and federal regulations involving the manner and rate at which they dispose of their waste materials, potential litigation involving "good neighbor" practices associated with insect control and odor problems, zoning problems as subdivisions and cities encroach on farm lands, and even the question in some states of the farmer's "right to farm."

Odor and insect control are becoming critical parameters in the design of animal production facilities. Much of the portion of the 1993 North Carolina state legislative session that was devoted to environmental issues was taken up with matters of odor abatement [1]. Effective January

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1, 1997, all waste management plans in North Carolina for animal facilities must include provisions for odor and insect control [2]. Animal agriculture is going to have to adopt more of a "good neighbor" policy in the future by controlling on-site odor and insect problems [3].

Alternative waste management systems are being investigated to alleviate problems associated with manure production. Kauffmann [4] reported on a deep litter fermentation system for fattening pigs in which sawdust was used as a litter base in place of straw or wood chips. A depth of sawdust of 45 to 50 cm (18 to 20 in.) was found to be better than conventional bedding such as straw or wood chips. The bedding material was turned every 2 wk with no detrimental effects on biological activity. The bedding product had a final dry-basis N content less than that normally observed with manure slurries. The reduction in N content was believed to be caused by the release of ammonia from the deep bed material in the house.

Many of the problems that have beset the commercial layer industry have arisen because of methods of handling the manure output from large flocks. This paper will discuss an in-house layer manure management system that has been tested under field conditions in a commercial layer house. In particular, this paper will focus on the reduction of manure volume and manure weight achieved using such a system.

Materials and Methods

Tests were conducted in a 100,00-hen capacity, curtain-sided, high-rise commercial layer house located in southern Georgia to determine whether an in-house layer manure composting system would work under commercial conditions. The test house was chosen because of its concrete floor within the manure area, which aided in the use of a prototype mobile compost turner. The layer house was equipped with adjustable curtains, which could be opened and closed, and depended on natural ventilation within the pit area. During the winter months (approximately November to April), the curtains were almost completely closed, allowing only minimal ventilation within the manure area. Tests were started on October 28, 1997 and concluded on July 1, 1998.

The commercial layer house was approximately 500 ft long × 40 ft wide and had five rows of battery cages. The test area was located in one end of the layer house. All manure was removed from the test area at the start of the study. Windrows of fresh, undried pine shavings 130 ft long × 5 ft wide with depths of 5, 10, or 15 in. (one windrow each) were placed beneath adjacent cage rows on the cleared concrete floor. Hens deposited their manure directly onto the shavings. Hereafter, the treatments will be indicated as 5, 10, or 15 in. shavings in reference to their initial shavings depths. An additional 130-ft section of manure line was cleared at the start of this study and was used as a control treatment to compare against the litter treatments. The experiment consisted of four adjacent manure lines. White leghorns were housed in four-tier, semi-stair stack, A-frame design cage batteries. Each cage was 16 in. wide × 20 in. deep and held 6 hens. Thus, there were 36 hens per linear foot of manure line under the cage rows.

To aerate the compost and incorporate newly deposited manure into the mixture, the composting material (pine shavings and manure mixture) was turned at 2-wk intervals using a prototype mobile compost turner built by Farmer Automatic Inc. (Register, GA). It was thought that growers would be less likely to use such a manure management system if the compost had to be turned more often than once every 2 wk. The mobile compost turner was approximately 6.5 ft wide, 6.5 ft tall, and 7 ft long and used a 10-HP gasoline-powered engine. Turning was accomplished by a set of forward-rotating tynes mounted on a horizontal axle. The depth at which the tines on the turner operated was adjustable. During the turning process, the pit level side-wall curtains were lowered to provide ventilation within the manure area.

DATA COLLECTION

Pile volumes and manure accumulation. The volumes of the compost piles were monitored by measuring the cross profile of the compost after every second turning. Cross profiles were taken after the turning of the compost at two different locations within each row. Manure accumulation by weight was monitored every fourth turning by cross-sectioning and weighing

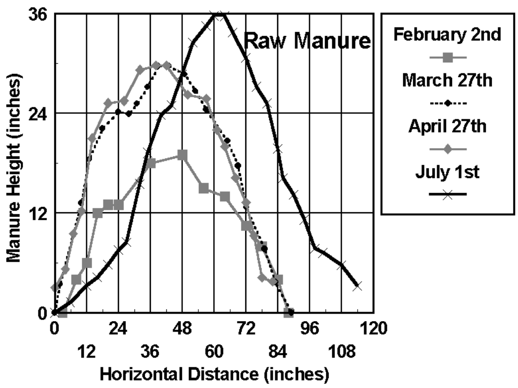

FIGURE 1. Cross-sectional profile of the raw manure piles within the layer house at different times up to 246 d of the study.

the total accumulated manure within a 16-in. length cut of each compost pile. Cuts were made at two different locations within the compost row. The material volumes and weights were compared with the build up of undisturbed manure within the control line.

Nutrients. Analytical sampling of the litter was performed every fourth turning to determine the concentration of N, P, K, and trace minerals. Grab samples were taken from different points within the piles and pooled to determine the nutrient concentration of the material.

Compost temperature and moisture. Temperature measurements were taken at three different sites in all compost treatments and in the raw manure control every 2 wk prior to the turning of the litter. Temperature measurements were taken using thermocouple probes stuck into the center core of the pile and at mid-depth halfway between the mid-line and outer edge of the pile. During cold weather conditions (March 2 through 9, 1998), continuous temperature measurements (1-hr sampling rate) were taken using an OM-5000 Omega data logger [8] to determine the temperatures of the piles for an 8-d period after turning.

Results and Discussion

REDUCTION IN MANURE VOLUME USING IN-HOUSE COMPOSTING

Figure 1 shows the cross-sectional profile of the raw manure pile at different times up to Day 246 of the study (October 28 to July 1). Dropping boards were part of the cage battery system, and some manure piled on these boards before falling to the area below. The raw manure pile ultimately grew wider than the width of the cage battery system. In this house, the raw manure formed a thin fragile crust on the top and remained fairly wet underneath, allowing the pile to push out laterally as the manure mass in the center increased.

Figure 2 shows a comparison of the cross-sectional profile of the 15-in. compost pile and the raw manure pile after 246 d of testing. The cross-sectional profile of the 15-in. treatment is defined by the inner boundary of the shaded region. The cross-sectional profile of the raw manure is defined by the outer boundary of the shaded region. The shaded portion of the curve is the difference in volume between that of the raw manure and the 15-in. treatment after 246 d. The 15-in. treatment originally started with a pile of shavings 15-in. tall × 5 ft wide, which is depicted by the dotted lines on the figure. The shapes of the compost piles were formed by the mechanical turner as the compost material exited the machine. The compost piles were slightly wider than the exit dimensions of the turner because material sluffed off the slopes of the pile after it left the machine. Between turnings, the piles retained their approximate shape throughout the 2-wk cycle, with only a slight increase in width. After 246 d of testing, the 15-in. treatment had increased in volume by only 41%. This figure illustrates the volumetric reduction that can be achieved using the in-house manure composting system. For this treatment,

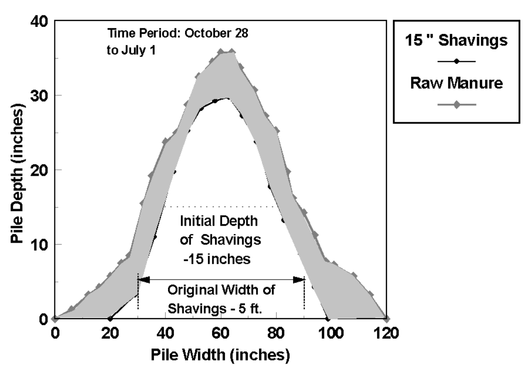

FIGURE 2. Comparison of the cross-sectional profile of the 15-in. pile with that of the dry stacked raw manure after 246 d of the study.

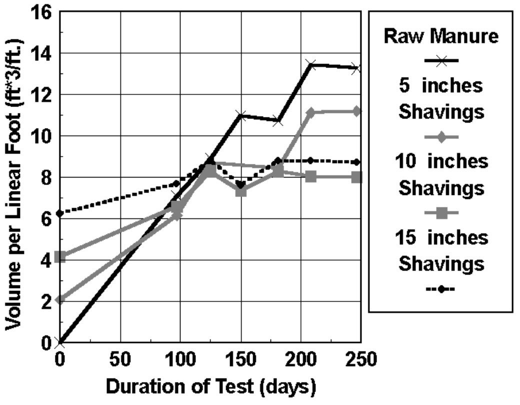

FIGURE 3. Volume (cubic feet) per linear foot of the compost piles and dry stacked raw manure over the 246 d of testing.

a 34.5% reduction in volume was observed over that of the raw manure. If the whole house was littered and a similar volumetric reduction was obtained, this would represent over 11,700 ft^3 less material that would need to be removed by the grower over this period.

Figure 3 shows the volume per linear foot for each treatment over the 246 d of testing. Many of the properties (volume, moisture content, pile temperature, and nutrient density) of the 10- and 15-in. compost piles were similar over the test period. It appears that both the 10- and 15-in. depths were sufficient to allow composting to occur at this bird density and manure deposition rate over the duration of this experiment.

Over parts of the 5-in. compost pile, leaking drinkers caused sections to become overly wet, which made this treatment difficult to turn with the mechanical turner. It appears that at this bird density and manure deposition rate, this amount of shavings was too small to allow the composting process to occur over a long period of time. After Day 181, the volume of the 5-in compost pile and the raw manure pile increased approximately the same amount, indicating that the unturned 5-in. compost pile performed in much the same way as the raw manure.

Between Day 125 and 181, volume measurements decreased or stayed approximately the same for all treatments. During this time, the weather warmed, and the curtains were opened, providing much more ventilation in the manure holding area of the house, allowing additional manure drying to occur. The birds were also molted during this time period, causing a decrease in manure output for a few weeks.

REDUCTION IN MANURE WEIGHT USING IN-HOUSE COMPOSTING

Figure 4 shows the estimated weight of the raw manure and the compost piles after 246 d of testing in each pile. The total pounds of manure in each pile was estimated using the bird density within the house and standard fresh manure production characteristics as shown in ASAE Standard D384.1 [5]. This standard estimates that 1,000 lbs of layers produces 64 lb/d of wet weight manure. If the layers are assumed to weigh 4 lb per bird, then each bird deposits 0.256 lb wet manure/d on the compost piles. For each foot of line, there were 36 birds. Therefore, over each foot of line, 9.22 lb wet manure/d were deposited. For the compost piles, the total pounds of manure also include the estimated weight of shavings used initially in each pile. These results indicate that by even dry stacking of the raw manure a significant loss in weight occurs during storage. However, by the addition of a carbon source and by turning, an additional reduction in manure weight can be achieved through the in-house composting process.

For the raw manure, a 67.2% reduction in manure weight was estimated during this test period. Patterson [6] reported, after long-term manure storage in fan-ventilated high-rise commercial layer houses, losses in manure mass were consistent with a presumed loss of 50% or more in volume. It should be expected, because only natural ventilation was used in this house, that a somewhat different amount of manure mass reduction would be observed. For the 10- and 15-in. treatments, reductions of 80.0 and 82.2% in total manure mass accumulation were estimated, respectively. This reduction in weight of the composted material is believed to be caused by drying of the material as well as by decomposition of organic substances within the manure and shavings mixture as would normally be observed in a composting process.

Figure 5 shows the estimated accumulation of manure weight in each pile and the percentage reduction in manure weight over the duration of these tests. Sections of each pile were weighed

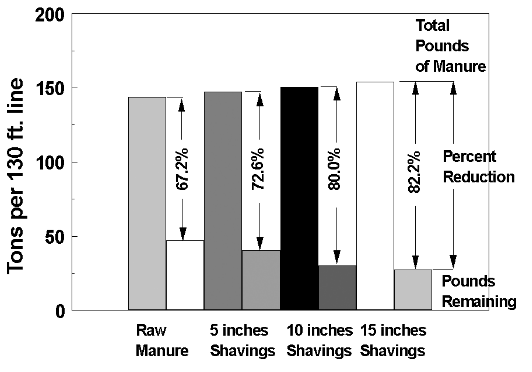

FIGURE 4. Weight of manure and compost remaining in the house after 246 d of testing.

on Days 55, 125, 181, 208, and 246. The weight of the 10- and 15-in. shavings treatments were very similar throughout the experiment and were approximately the same on Day 246. The weight of the raw manure was higher than either of these two treatments after Day 125. On Day 246, a 39% reduction in weight on average was observed for these two treatments over that of the raw manure. If the whole house was littered and a similar reduction in weight was observed throughout the house, this reduction in manure weight would represent 400 tons less material, which would need to be removed by the grower over an 8-mo period.

Although significant reduction in both manure weight and volume were observed under these house conditions, the ventilation conditions within the manure pit are not necessarily those typical of most high-rise layer houses. It is believed that the differences observed between the raw manure and those of the compost piles would be less in a tunnel-ventilated layer house. Tests involving in-house composting of layer manure are being conducted in a tunnel-ventilated house and will be reported on at a later date.

TEMPERATURES OF THE COMPOST MATERIAL

Figure 6 shows the temperatures measured within the layer house over a 2-wk cycle between March 2 and March 9, 1998. Hour 0 represents the time immediately after the turning of the compost piles by the mechanical turner. Ambient (approximately 6 ft above floor level) and floor temperatures were measured in the manure

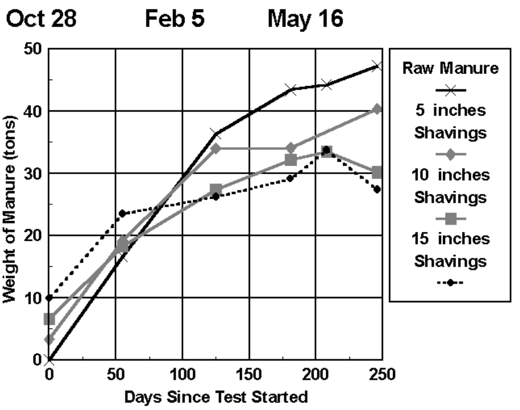

FIGURE 5. Estimated weight of manure of the compost pile and dry stacked manure over the 246 d of testing for the 130-ft long windrows.

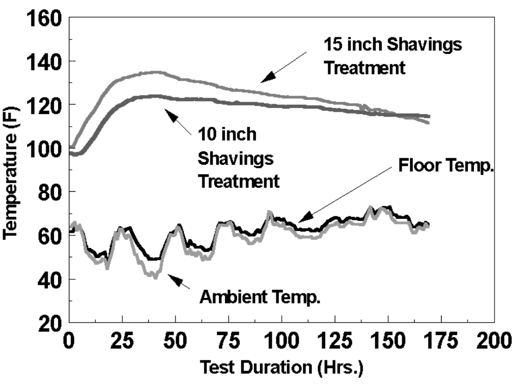

FIGURE 6. Temperatures within the commercial layer house and treatment piles between March 2 and 9, 1998. (Hour 0 is immediately after the turning of the compost.)

TABLE 1. Nutrient density of the manure and compost on a percentage dry matter basis after 246 d (October 28 to July 1) of testing. In parentheses are shown the pounds per ton on an "as-is" basis for each treatment

	N	P_2O_5	K_2O	Ca	Mg	H_2O	ANNUAL PRODUCTION PER 100,000 HENS (ton)
Raw layer manure	2.1 (15)	8.6 (63)	5.4 (39)	15.7 (114)	0.8 (6)	64	1,498
5-in. Treatment	1.9 (17)	7.2 (63)	2.2 (20)	16.9 (148)	0.7 (6)	56	1,279
10-in. Treatment	2.0 (23)	8.5 (102)	6.9 (82)	18.5 (222)	0.8 (10)	40	957
15-in. Treatment	1.9 (21)	8.9 (99)	4.8 (54)	16.9 (188)	0.9 (10)	44	868

storage area and are shown in the figure as the two lowest curves within the figure. Ambient temperatures ranged between approximately 40 and 60°F over this period. Temperatures above 110°F, which would be sufficient for thermophilic composting [7], were observed to occur in both the 10- and 15-in. compost piles over much of this period. Temperatures in the 5-in. shavings treatment (not shown) remained at approximately 80°F throughout this period, which were not that much different than those of the raw manure. The low temperatures observed in this compost pile were believed to be caused by inhibition of composting action caused by the high moisture content of the material, which was greater than those normally associated with good composting conditions. This manure management system is very moisture-sensitive, as are other composting systems, and, if a grower cannot control leaking drinkers or water entry into the house, then this system should not be considered.

NUTRIENT COMPOSITION OF THE COMPOST

Table 1 shows the nutrient density of the raw manure and the three different compost treatments after 246 d of testing. By in-house composting, the product had a dry-basis nutrient density of approximately 2% N, 8.5% P_2O_5, and 5.5% K_2O. The value of the product leaving the house is affected by its moisture content. The compost had an advantage over the non-composted manure in that it had very little odor and improved handling properties over that of the raw manure. Patterson [6] reported the nutrient density of commercial layer manure for samples taken from eight different flocks of birds, housed in fan-ventilated commercial layer houses, after long-term manure storage, ranged from 1.98 to 9.42% N, 2.71 to 11.73% P_2O_5, and 2.16 to 5.72% K_2O. The values reported in this experiment are between those reported by Patterson for high and low nutrient density, with the percentage of N closer to that reported for the low sample; the percentage of P_2O_5 and K_2O were more toward the middle of Patterson's reported range. Patterson reported that some of the variation in nutrient density of layer manure could be traced to the age of the birds, bird diet, and the management of the manure. In the present study, composting had little effect on the dry-basis nutrient density of the manure. However, the moisture content of the raw manure was much higher than that of any of the three treatments in the present study. Obviously, this decrease in moisture content within the three shavings treatments is related to the decrease in manure weight and manure volume, which were previously reported in this study. In-house composting was able to put the same amount of nutrients into a smaller amount of more easily handled and less objectionable material.

CONCLUSIONS AND APPLICATIONS

1. The in-house composting system under commercial conditions produced a reduction in both weight and manure volume over conventional methods in which the manure is only stacked under the house. Regular turning of the 10- and 15-in. piles facilitated composting within the layer house, resulting in a 39% reduction in manure weight and a 37% reduction in manure volume over that of deep stacked raw manure.

2. The 5-in. pile did not appear to provide enough carbon source to keep the compost process working over a long period of time under these conditions.
3. The shavings and layer manure mixture has many of the same properties as a leaf manure compost. The layer manure compost had a dry-basis nutrient density of approximately 2% N, 8.5% P_2O_5, and 5.5% K_2O. From a material standpoint, the composted material was an improvement over that of raw layer manure from a curtain-sided house in that it had reduced volume, decreased moisture content, improved handling properties, and less odor.
4. The success of this system, similar to any other compost system, is dependent on the control of water input; therefore, control of water entry into a house and monitoring of the drinking system by the grower for leaking drinkers would be necessary.

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