A Practical Guide for Poultry Litter Composting

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Donald W. Zacharias, President  Mississippi State University  J. Rodney Fall, Vice President
A Practical Guide for Composting Poultry Litter

Julian D. Brake
Assistant Professor
Department of Poultry Science

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Introduction

The increasing size and concentration of poultry production in certain areas of the United States, especially in the Southeast, is a long-established and continuing trend. This poultry concentration can present problems for procurement, management, and disposal of litter. One possible solution is recycling litter through the age-old process of composting. Composting of waste is viewed as a viable means of reducing litter needs by recycling and reusing litter. If composting proves to produce a suitable reusable litter, the headaches and expenses associated with procurement of new litter material for each poultry house on a yearly basis will be reduced. Composting also results in a product that is much more environmentally acceptable than raw litter for land application.

The 1987 Amendments to the Clean Water Act require each state to assess nonpoint water pollution problems and to develop a management plan to address these problems. Wastes generated by animal agriculture operations have been implicated as potential contributors to nonpoint source pollution. If not properly managed, the waste can pollute water resources, lose fertilizer value, and create a negative social and regulatory environment. Therefore, the poultry industry should develop management plans for use and disposal of waste. It is in the best interest of all concerned for the poultry industry to regulate itself rather than have the process placed in the hands of those who may not understand the industry.

The development of practical methods of recycling poultry litter and rendering it more suitable for land application has been described by the Mississippi Poultry Association, Inc. (MPA) as a top research priority in Mississippi. In fact, the MPA Research Committee has requested the Poultry Science Department of Mississippi State University to lead an industry-wide effort to develop a comprehensive plan. The plan is intended to provide a means for poultry companies in Mississippi to develop guidelines for litter management and disposal.

In response to the industry request, an extensive review of published results of composting research was conducted. In addition, studies were initiated in a number of commercial poultry houses to determine the most efficient and effective methods of composting and replacing litter. The "how-to-do-it" section beginning on page 3 is based on knowledge gained from earlier research combined with extensive studies in Mississippi poultry houses.

Earlier Research

The management and disposal of poultry waste may become a limiting factor in the expansion of the poultry industry in established areas of high poultry concentration. A broiler complex, including breeders and pullets, that processes one million birds per week produces approximately 65,000 tons of manure annually (Weser and Studios, 1980). A poultry complex is usually concentrated within a radius of approximately 25 miles of the hatchery, feed mill, and processing plant. This concentrates manure output into a relatively small area.

Several opportunities for poultry litter use have been investigated. Zimet et al. (1988) used computer simulation to determine the value of broiler litter as cattle feed. They found the mean economic value of broiler litter to be $684 per metric ton. This would be a very economical method of litter disposal; however, cattle numbers are limited. Another method of litter disposal is as a fuel source for a gasification furnace (Muir, 1987). However, continued use of litter results in a buildup of slag, which reduces heat output efficiency of the furnace.

Raw poultry manure and litter has historically been used as a source of plant nutrients and soil amendment. Depending upon the waste management program, land application can be either an economical and sound agricultural decision (that makes us good neighbors) or an environmental hazard.

As the industry continues to expand and increase in concentration, the need to address environmental issues becomes more critical to the poultry industry (Truitt, 1990). Limitations placed upon the use of raw litter may become a limiting factor in expansion. One method of litter treatment that will enhance raw litter quality and reduce the environmental impact of land application is composting.

Composting is being widely advocated for the treatment of solid waste (Goldstein, 1980). When manure is composted, volume decreases and nutrient density
How to do it...  
A Step-by-step Guide for Composting

The following in-house litter composting procedure is based upon research experience in Mississippi poultry houses. It is intended to assist the poultry industry with startup of litter recycling. There are several common pitfalls to be avoided in in-house composting. Once again, experience has proven to be the ultimate teacher. The mistakes made during the composting research have been addressed throughout this section. Experience with the procedures described in the following guidelines will give companies some general ideas of how much of each variable to expect within their housing and management schemes.

Nitrogen determination

The N content of the litter (not crude protein) must also be determined. The N content can be determined easily by Kjeldahl analysis. The study demonstrated that several factors may influence the N content of litter:
1. Number of flocks since last clean-out
2. Utilization of self-feeders for "taking" between flocks
3. Litter moisture content

The N content of the litter within broiler houses in the composting studies was in the range of 9.2 to 8.5%, with a mean of approximately 8.6%.

C:N ratio determination

The C:N ratio is extremely important for proper composting. If the means are taken as presented, one calculates a ratio of 10.83:

\[ \frac{39}{3.6} = 10.83 \]

A C:N ratio this low will not compost properly. A C:N ratio between 15 and 25 is necessary for proper composting. If composting is attempted without raising the C:N ratio, several undesirable events will occur:
1. Litter will emit great quantities of ammonia during composting
2. High composting temperatures (150°F) will not be achieved
3. The mass may become sticky and revert to anaerobic digestion, which is much less efficient
4. The end product may cake very readily during the next flock
5. Ammonia levels will be high during the next flock

The C:N ratio must be increased to at least 15:1. To do this, the C, N, and moisture of the bulking material (sand) must be determined. It can be assumed that the N content of the bulking material is negligible. The ash content of fresh litter ranges from 1.5 to 4%, with a mean of approximately 3.5%. Therefore, the C value for the bulking material would be:

\[ C = 100 - 35 \times \frac{18}{18} = 53% \]

Carbon determination

Because of the high ash value of most litter under these conditions, fresh litter will need to be added to increase the C content of the litter prior to composting. To estimate the C content of litter, one must first determine the ash content. Ash content is determined by burning the litter to completion in a muffle furnace. The residue, ash, is the mineral content of the litter.

By completing this calculation, one can estimate an ash content of the litter. For example: Ash = 29.8%

\[ C = 100 - 29.8 \times \frac{18}{18} = 39% \]

Experience during this research demonstrated that the C content of litter within most broiler houses is in the range of 35 to 41%, with a mean of approximately 39%.

for composting to be complete, Stage I compost must be turned, mixed, and aerated for the total process to be repeated in Stage II. Murphy (1990b) defined thermal sections to demonstrate the variability of tempera-

atures at different levels within a Stage I compost pile. Turning and mixing of the material was advantageous because it has a significantly lower mineralization rate than does a pail of soluble nitrogen (Beeke, 1990; Simpson, 1991). Application of composted litter in which most of the nitrogen and phosphorus is organically bound is similar to split applications of commercial fertilizer (Bugbee and Frink, 1989). Further compost applied at the correct rate will generally out-perform a similar level of nutrients applied by synthetic fertilizer (Holden, 1990).

Handling properties of composted litter make it more suitable for many uses. The small and uniform particle size of compost makes it easier to apply more evenly at suitable agronomic rates (Holden, 1990). Furthermore, Gosin (1989) reported that compost could be applied at rates up to 50 tons per acre without environmental problems. It is not clear if this rate is currently; however, it is significantly higher than for raw litter. The higher application rate of compost upward the stability and the inorganic nutrients contained within this product. Furthermore, compost does not possess the odor and fly problems generally associated with raw litter (Murphy, 1991).

Composting is a biological process in which organic wastes are stabilized and converted into a product to be used as a soil conditioner and organic fertilizer. This process depends upon the activity of microorganisms. These microorganisms require a critical balance of carbon to nitrogen (C:N) ratio between 15 and 25, a moisture content of 40 to 60%, a pH between 5 and 12, and greater than 30% free air space (Willson, 1986). Nitrogen is calculated by the Kjeldahl method and carbon is determined as described by Hauy (1980). Soon after organic material is assembled into a self-insulating mass, the temperature begins to increase as metabolic heat accumulates. At first, mesophilic bacterial growth is stimulated by the higher temperatures, but as inhibitory temperature levels are reached, mesophilic activity is limited. These inhibited temperature levels induce thermophilic bacterial growth. The pattern is repeated in a second hotter stage. This process is self-limiting because of excessive accumulation of heat. Temperatures will eventually fall (Feinstein and Morris, 1976).

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Litter quantity determination

Determine the quantity of litter in the house. Normally, a house that has had five to seven flocks and seven loads of sawdust delivered will contain approximately 70 to 80 tons of litter expressed on a dry matter basis. Weighting a measured portion of the litter will help give a good estimate of litter volume within the house. All calculations and analyses must be conducted on a dry matter basis. Therefore, moisture determination must be made. A quick and reliable moisture reading can be made using a moisture balance.

Carbon determination

Because of the high ash value of most litter under these conditions, fresh litter will need to be added to increase the C content of the litter prior to composting. To estimate the C content of litter, one must first determine the ash content. Ash content is determined by burning the litter to completion in a muffine furnace. The residue, ash, is the mineral content of the litter.

\[
C = \frac{100 - \text{(Ash %)}}{18}
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By completing this calculation, one can achieve an estimation of the C content of the litter. For example: Ash = 29.8%.

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C = \frac{100 - 29.8}{18} = 39%
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Experience during this research demonstrated that the C content of litter within most broiler houses is in the range of 35 to 41%, with a mean of approximately 39%.

Nitrogen determination

The N content of the litter (not crude protein) must also be determined. The N can be determined easily by kjeldahl analysis. The studies demonstrated that several factors may influence the N content of litter:

1. Number of flocks since last clean-out.
2. Utilization of self-feeders for “taking” between flocks.
3. Litter moisture content.

The N content of the litter within broiler houses in the composting studies was in the range of 3.5 to 8.5%, with a mean of approximately 3.6%.

C:N ratio determination

The C:N ratio is extremely important for proper composting. If the values are taken as presented, one calculates a ratio of 10.83:

\[
39 + 36 = 108.3
\]

A C:N ratio this low will not compost properly. A C:N ratio between 15 and 25 is necessary for proper composting. If composting is attempted without raising the C:N ratio, several undesirable events will occur:

1. Litter will emit great quantities of ammonia during composting.
2. High composting temperatures (150°F) will not be achieved.
3. The mass may become sticky and reverts to anaerobic digestion, which is much less efficient.
4. The end product may cake very readily during the next flock.
5. Ammonia levels will be high during the next flock.

The C:N ratio must be increased to at least 15:1. To do this, the C, N, and moisture of the bulking material (steam heated) must be determined. It can be assumed that the N content of the bulking material is negligible. The ash content of fresh litter ranges from 1.5 to 4%, with a mean of approximately 3.5%.

Therefore, the C value for the bulking material would be:

\[
C = \frac{100 - 35}{18} = 536\%
\]
How much dry matter with this C content would be needed to increase the C:N ratio to at least 15 in the house? This is calculated as follows:

Used litter: 80 tons of dry matter
C-content: 39%
N-content: 3.6%
80 tons x 0.39 = 2.88 tons or 5,760 lb of N
80 tons x 0.039 = 31.2 tons or 62,400 lb of C

At least 15 times the N-content is needed, therefore:
15 x 5,760 lb = 86,400 lb of C necessary

Since 62,400 lb of C are already available in the house,
86,400 lb of C needed
- 62,400 lb of C available
24,000 lb of C must be added

The C source is 53.8% C. Therefore,
24,000 lb of C needed ÷ 0.536 = 44,776 lb or 22.4 tons of litter must be added (dry matter basis).

Note: It must be remembered that all of these calculations are expressed on a dry matter basis. A 12-ton delivery of sawdust at 50% moisture is only 6 tons of dry matter. If sawdust of this moisture content is used, then four truckloads will be necessary to increase the content of the mass sufficiently for proper composting. A truckload of fresh shavings does not weigh as much as sawdust. However, the moisture content is much lower and dry matter delivery is essentially the same.

Water determination

The last thing added to the mass prior to windrow- ing is water. If the water content of the composting mass is not proper, undesirable factors may arise.

Too little water:
1. The heat required for proper composting (140°-150°F) will not be attained in the first stage (see Figure 1).
2. The second stage composting temperatures will be very disparate (see Figure 2).
3. Length of temperature rise and maintenance will be shortened.
4. There will be high ammonia levels in the subsequent flock.

Too much water:
1. The mass will pack and aerobic conditions may cease.
2. If the process converts over to anaerobic conditions, the process will continue and composting temperatures will be attained; however the process will take much longer.
3. The condition of the house after composting will be wet and difficult to manage. Several days will be required to effectively dry the litter prior to chick placement.
4. There will be high ammonia levels in the subsequent flock.

A 45% moisture level is recommended for proper composting. Most of the problems associated with too much or too little moisture can be avoided if one adheres closely to this moisture content.

How is water addition calculated?

1. First, calculate the amount of dry matter in the house.
2. Topdress with four loads of sawdust
3. Combined totals in house after topdressing
4. To achieve the desired 45% moisture content, the following calculations will be necessary.

Water application

The water should be sprayed into the litter instead of simply applying to the surface. This facilitates the following:
1. Formation of a slippery mess is prevented.
2. Water soaks into the litter more readily.
3. Loss of water by evaporation prior to windrowing is reduced.

Winrowing suggestions

Several simple rules should be followed in the process of windrow formation.
1. Incorporate all litter into the mass. It is not necessary to remove cake prior to windrowing.
2. All litter must be disrupted prior to incorporation into the mass.
3. Litter must be incorporated into the mass in a fluffy condition, i.e. never pack the windrow.
4. Old and topdress litter must be thoroughly mixed.
5. Windrows under 2 feet in height do not work well because they lack "critical mass"
6. Windrows over 4 feet in height tend to pack and cause anaerobic conditions.
7. Windrows of 2.5 to 4 feet in depth seem to be optimal.
8. Normal respose of a windrow results in a pile approximately three times as wide as it is high.

Composting suggestions

The composting process encompasses two stages and requires proper management to be successful.
1. It is not necessary to close the house completely to conserve heat. A compost mass is self insulating.
2. Composting materials produce ammonia, carbon dioxide, carbon monoxide, and methane Therefore, it may be dangerous for an individual to enter a house that is not ventilated or open.

3. Record temperatures from the center of the mass at several locations daily (Figures 1 and 2).
4. The first stage compost should be turned when the center of the pile drops below 135°F. This should require 5 to 6 days.
5. When Stage I compost is split out prior to Stage II, the entire mass should be disrupted.
6. Mixing and reincorporation into Stage II compost is necessary for proper composting and more thorough heating
7. Follow the directions for windrowing to start Stage II.
8. Stage II should heat very quickly and attain a center temperature of approximately 140°F within 24 hours. If this does not occur, either the C or moisture level is too low. This is almost impossible to correct at this stage. Monitor the process for the next three days. If temperatures do not peak above 140°F, you should consider spreading the litter and preparing for the next flock.
9. Properly reacting Stage II compost should be left undisturbed for 6 days. At this time, scatter the pile and allow the litter to dry. The litter will have the odor of humus.
10. Some stirring may be required to facilitate drying.
11. Running a self-feeder over the finished product may be necessary to remove larger particles of cake.
12. It must be considered that volume has been added into the house and some may need to be removed to maintain a relatively constant litter depth within the house over time.
13. The use of composted litter as a fertilizer is a much more environmentally sound practice than the use of raw litter for fertilizer.

It is critical that additional research be done to define alternative uses for this potentially profitable byproduct of the poultry industry.
How much dry matter with this C content would be needed to increase the C:N ratio to at least 15 in the house? This is calculated as follows:

- Used litter: 80 tons of dry matter
  - C-content: 39%
  - N-content: 5.6%
- 80 tons * .388 = 2.888 tons or 5,760 lb of N
- 80 tons * .039 = 3.12 tons or 62,400 lb of C

At least 15 times the N-content is needed, therefore:
- 15 * 5,760 lb = 86,400 lb of C needed

Since 62,400 lb of C are already available in the house,
- 86,400 lb of C needed - 62,400 lb of C available = 24,000 lb of C must be added

The C source is 53.8% C. Therefore,
- 24,000 lb of C needed * 0.538 = 44,776 lb or 22.4 tons of litter must be added (dry matter basis).

Note: It must be remembered that all of these calculations are expressed on a dry matter basis. A 12-ton delivery of sawdust at 50% moisture is only 6 tons of dry matter. If sawdust of this moisture content is used, then four truckloads will be necessary to increase the C content of the mass sufficiently for proper composting. A truckload of fresh shavings does not weigh as much as sawdust. However, the moisture content is much lower and dry matter delivery is essentially the same.

**Water determination**

The last thing added to the mass prior to windrowing is water. If the water content of the composting mass is not proper, undesirable factors may arise.

**Too little water:**
1. The heat required for proper composting (140°-150°F) will not be attained in the first stage (see Figure 1).
2. The second stage composting temperatures will be very distant (see Figure 2).
3. Length of temperature rise and maintenance will be shortened.
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3. The condition of the house after composting will be wet and difficult to manage. Several days will be required to effectively dry the litter prior to chick placement.
4. There will be high ammonia levels in the subsequent flock.

A 45% moisture level is recommended for proper composting. Most of the problems associated with too much or too little moisture can be avoided if one adheres closely to this moisture content.

**How is water addition calculated?**

1. First, calculate the amount of dry matter in the house.
2. Total litter weight: 114 tons
3. Moisture: 30% or 34 tons
4. Dry matter: 70% or 80 tons
5. Topdress with four loads of sawdust
6. Total topdress weight: 48 tons
7. Moisture: 50% or 24 tons
8. Dry matter: 50% or 24 tons
9. Combined totals in house after topdressing
   - Dry matter: 104 tons
   - Moisture: 58 tons
   - Total: 162 tons
10. To achieve the desired 45% moisture content, the following calculations will be necessary.
11. Total dry weight of litter at 45% moisture or 55% dry matter:
   - 104 tons D.M. + 0.55 = 189 tons
12. Total necessary water addition:
   - 189 tons - 162 tons = 27 tons of water
13. How many gallons are needed?
   - 27 tons * 2,000 lb/ton = 54,000 lb of water
   - 54,000 lb / 8.33 lb/gal = 6,480 gallons of water needed

The quantity of water required in this example is a little higher than normally required. However, water requirements exceeding 5,000 gallons should be expected.

**Water application**

The water should be sprayed into the litter instead of simply applying to the surface. This facilitates the following:
1. Formation of a slippery moss is prevented.
2. Water soaks into the litter more readily.
3. Loss of water to evaporation prior to windrowning is reduced.

**Windrowing suggestions**

Several simple rules should be followed in the process of windrow formation.

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It is critical that additional research be done to define alternative uses for this potentially profitable byproduct of the poultry industry.
Figure 1. Cross-section of a windrow of poultry litter showing a composite of temperatures of properly composting litter during Stage I. The windrow is 10 feet wide and 3 feet deep.

Figure 2. Cross-section of a windrow of poultry litter showing composite of temperatures of properly composting litter during Stage II. The windrow is 10 feet wide and 3 feet deep.
Figure 1. Cross-section of a windrow of poultry litter showing a composite of temperatures of properly composting litter during Stage I. The windrow is 10 feet wide and 3 feet deep.

Figure 2. Cross-section of a windrow of poultry litter showing composite of temperatures of properly composting litter during Stage II. The windrow is 10 feet wide and 3 feet deep.
Literature Cited


Murphy, D. W. 1991. Personal communication.


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