Bulletin 981 June 1992

A Practical Guide for Poultry Litter Composting

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A Practical Guide for Composting Poultry Litter

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Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine, Mississippi State University. Edited by Keith H. Remy, Publications Coordinator. Cover designed by Beth Carter, Artist.

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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 recycling 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 (Weaver and Souder, 1990). 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 furnaces.

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 adapted for the treatment of solid waste (Goldstein, 1980). When manure is composted, volume decreases and nutrient density and acceptability for land application increase (Holden, 1990). Elution of raw litter cake and composted manure through soil columns demonstrated that compost nitrogen has a slower release than raw manure or cake (Murphy and Carr, 1989). This is due to the utilization of inorganic nitrogen by bacteria in the composting process and the conversion of this nitrogen into bacterial proteins and other organic compounds (Willson, 1989). A pound of nitrogen in the organically bound form has a significantly slower mineralization rate than does a pound of soluble nitrogen (Beegle, 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, good compost applied at the correct rate will generally out-perform a similar level of nutrients supplied by synthetic fertilizer (Holden, 1990).

Handling properties of composted litter make it more suitable for many uses. The small and uniform particle size of composted litter makes it easier to apply more evenly at suitable agronomic rates (Holden, 1990). Furthermore, Gouin (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 yearly; however, it is significantly higher than for raw litter. The higher application rate of compost attests to the stability and the safety of the 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 carbon: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, 1989). Nitrogen is calculated by the Kjeldahl method and carbon is determined as described by Haug (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 inhibitive temperature levels are reached, mesophile activity is limited. The elevated temperature induces thermophilic bacterial growth. The pattern is then repeated in a second hotter stage. The process is self-limiting because of excessive accumulation of heat. Temperatures will eventually fall (Finstein and Morris, 1975).

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 temperatures at different levels within a Stage I compost pile. Turning and mixing of the material was advantageous because the temperature level striation was not evident in Stage II. Furthermore, earth acted as a major heat sink. On an uninsulated earth foundation, as in a broiler house, heat was conducted away from the pile producing a sharp 50 °F temperature gradient within the bottom 5 inches of the pile. Mixing assured that all portions of the pile were exposed to composting temperatures.

Recycling of litter has become attractive to broiler growers for many reasons. The cost of replacing litter in a growout house has become very expensive (Malone, 1982). Cost and scarcity of litter materials have resulted in routine reuse of broiler litter without deleterious effects on broiler growout (Kennard and Chamberland, 1951; Jones and Hagler, 1983). New litter has been reported to favor the survival of salmonella more than old litter in which the organisms tend to die out more rapidly because of competition from other bacteria present in the built-up litter (Botts et al., 1952; Snoeyenbos et al., 1967; Duff et al., 1973). Furthermore, previously used and built-up litter aids birds in developing competitive organisms in the gut, thus inhibiting salmonellae colonization (Fanelli et al., 1970). Bacon and Burdick (1977) and Jones and Hagler (1983) reported that fungal numbers were lower in old litter than in new litter.

Biocidal temperatures are achieved quickly when composting is done properly. Composting conditions were demonstrated to be lethal to gram negative enterics and pathogenic poultry viruses (Anthony and Nix, 1962; Murphy, 1990a). Reduction of pathogens will make recycling of litter for further use for growing chickens very attractive. The increased populations of the thermophilic bacteria will help compete against reinfestation of the gram negative enterics. If this proves to be true, subsequent broiler flocks should be healthier, and less disease could be one benefit of composting.

Problems may arise from extensive composting. Grub et al. (1965) reported that as litter aged, dust increased because of fragmentation.

Another management concern is the moisture level of freshly composted litter. Litter must be allowed to dry after composting is completed and before reuse because leg problems and litter caking have been associated with wet litter (Harms and Simpson, 1977; Martland, 1984).

In conclusion, composting is a biological process; therefore, it requires a certain degree of management to assure proper conditions. The basic objective in composting is to maximize microbial activity at the expense of the waste material. To achieve this, maximum metabolic heat output by thermophilic bacteria must be attained.

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.

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. Weighing 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 determinations 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 muffle furnace. The residue, ash, is the mineral content of the litter.

$$C = \frac{100 - (\text{Ash }\%)}{1.8}$$

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

$$C = \frac{100 - 29.8}{1.8} = 39\%$$

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%.

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-loaders for "caking" between flocks.
3. Litter moisture content.

The N content of the litter within broiler houses in the composting studies was in the range of 3.2 to 3.9%, with a mean of approximately 3.6%.

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:

$$39 \div 3.6 = 10.83.$$

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 (sawdust, shavings) 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:

$$C = \frac{100 - 3.5}{1.8} = 53.6\%$$

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 .036 = 2.88 tons or 5,760 lb of N
80 tons x .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 53.6% 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 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 disappointing (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.

   Total litter weight: 114 tons
   Moisture: 30% or 34 tons
   Dry matter: 70% or 80 tons

2. Topdress with four loads of sawdust

   Total topdress weight: 48 tons
   Moisture: 50% or 24 tons
   Dry matter: 50% or 24 tons

3. Combined totals in house after topdressing

Dry matter:	104 tons
Moisture:	58 tons
Total:	162 tons

4. To achieve the desired 45% moisture content, the following calculations will be necessary.
   Total dry weight of litter at 45% moisture or 55% dry matter:

   104 tons D.M. ÷ 0.55 = 189 tons

5. Total necessary water addition:

   189 tons – 162 tons = 27 tons of water

6. How many gallons are needed?

   27 tons x 2,000 lb/ton = 54,000 lb of water
   54,000 lb ÷ 8.333 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 appling 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 to evaporation prior to windrowing is reduced.

Windrowing 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 repose 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 150°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 3 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-loader over the finished product may be necessary to remove large 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.

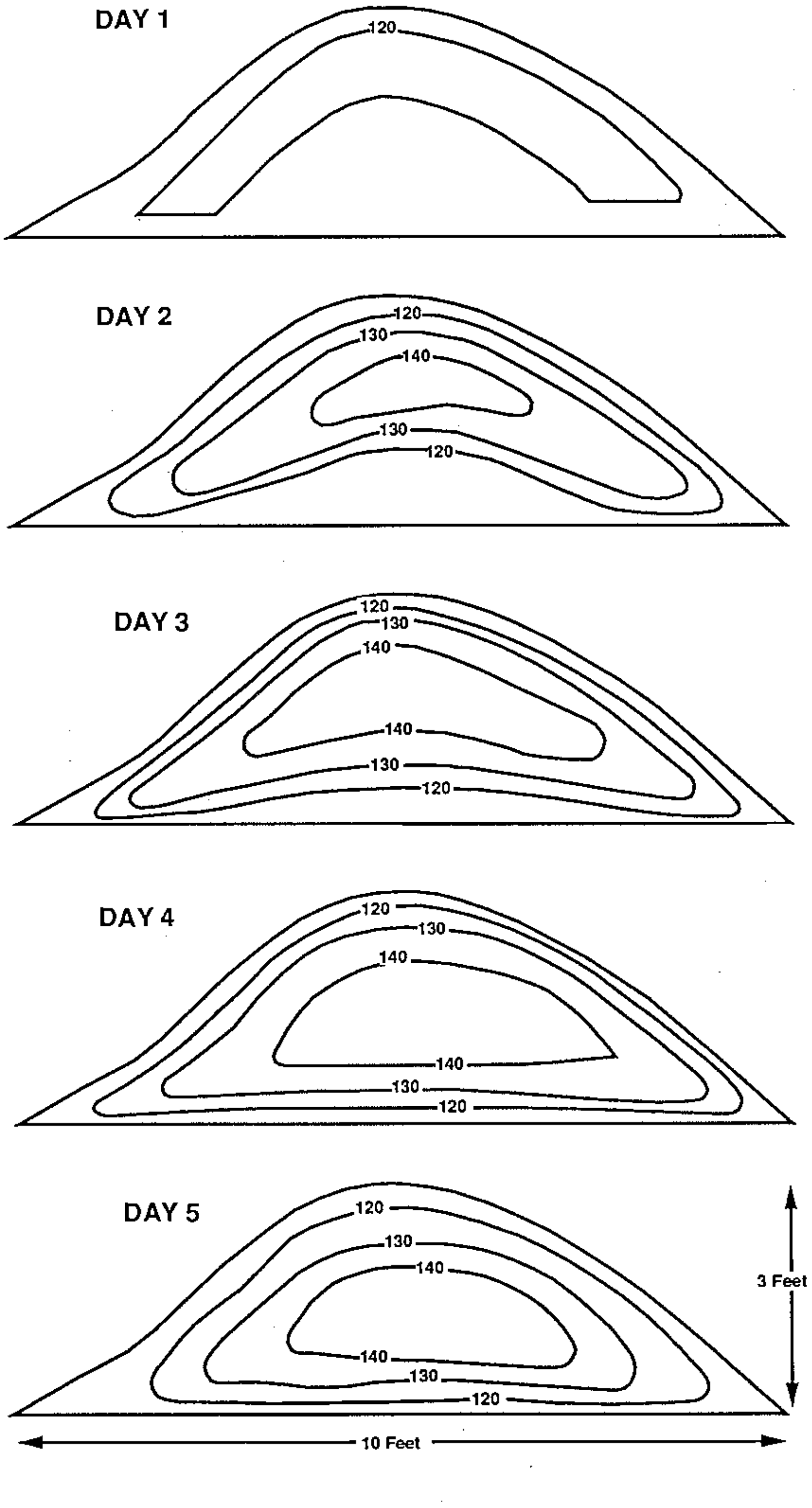

Figure 1. Cross-section of a windrow of poultry litter showing a composite of temperatures of properly composting litter during Stage I. The windrow is 10 feet wide and 3 feet deep.

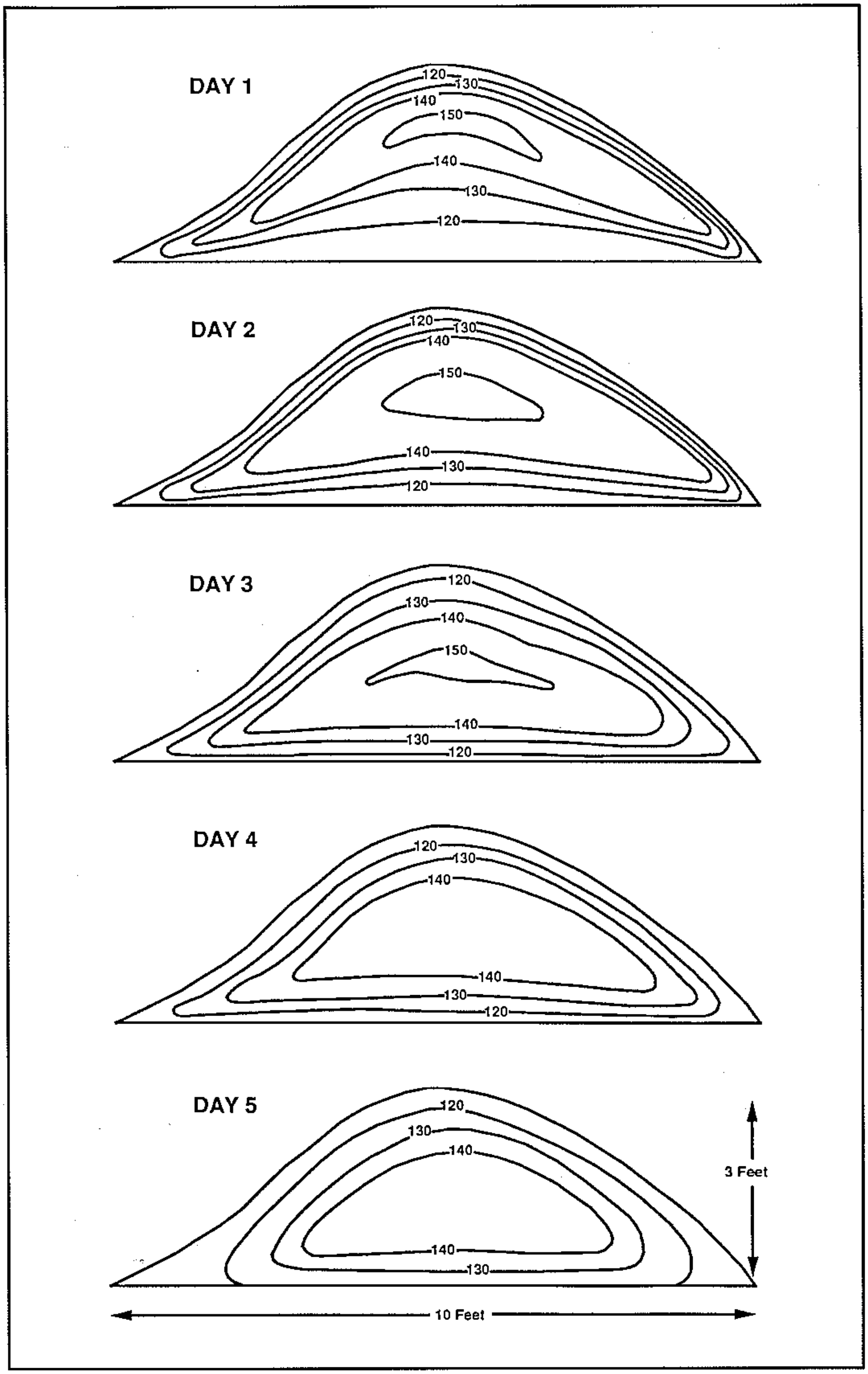

Figure 2. Cross-section of a windrow of poultry litter showing composite of temperatures of properly composting litter during Stage II. The windrow is 10 feet wide and 3 feet deep.

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