CHAPTER 4

Management, Handling, Transfer, Storage and Treatment of Manure and Litter from Poultry Production Facilities

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The type of manure management techniques is dependent upon the type of bird or poultry product produced. Almost all poultry production systems in operation in South Carolina produce a dry manure by-product. The are a few remaining systems that produce a wet manure by-product and require a lagoon treatment system.

Manure/Litter Types

1. Dry Solids
2. Broiler
3. Roaster
4. Pullets
5. Breeders
6. Turkeys

Broilers, Roasters, Pullets, Breeders, Turkeys

Typically these poultry types are grown in litter based systems. The material is a dry solid. The manure or "litter" by-product usually has a sawdust or woodshavings base. The final product is a mixture of this base material, feed, and manure. Litter may be cleaned out of the houses after every flock or after several flocks. Some producers may go one or more years without a complete cleanout. The cleanout period is usually determined by the integrator for whom the birds are being grown. If a complete cleanout does not occur the producer will often take a "cruster" through the house and remove large, usually wet, litter cakes, and it fluffs the remaining litter before the next flock of birds enters the house. Often, a new layer of base material will be spread throughout the house between flocks. Usually the litter is cleaned out of the houses using a front-end loader or a skid-steer loader and put into a manure spreader or truck to be land applied. Figure 4-1 shows a house cross-section that may be used in production of broilers, roasters, pullets, and turkeys. Breeders have a unique type of house that is a combination of a layer high-rise and a broiler house. The outer portions near the walls are raised for the hens to roost. Manure drops through through a hardware cloth type floor and collects underneath. The center portion of the house has typical litter much like broiler production. Figure 4-2 shows the cross-section of a house that may be used in a breeder operation.

Historically, this was the completion of manure handling and transfer. However, many producers do not have an adequate land base to properly utilize the nutrients in the litter/manure at the time the houses are cleaned. Therefore, litter storage is recommended so that the material can be applied according to proper crop management criteria.

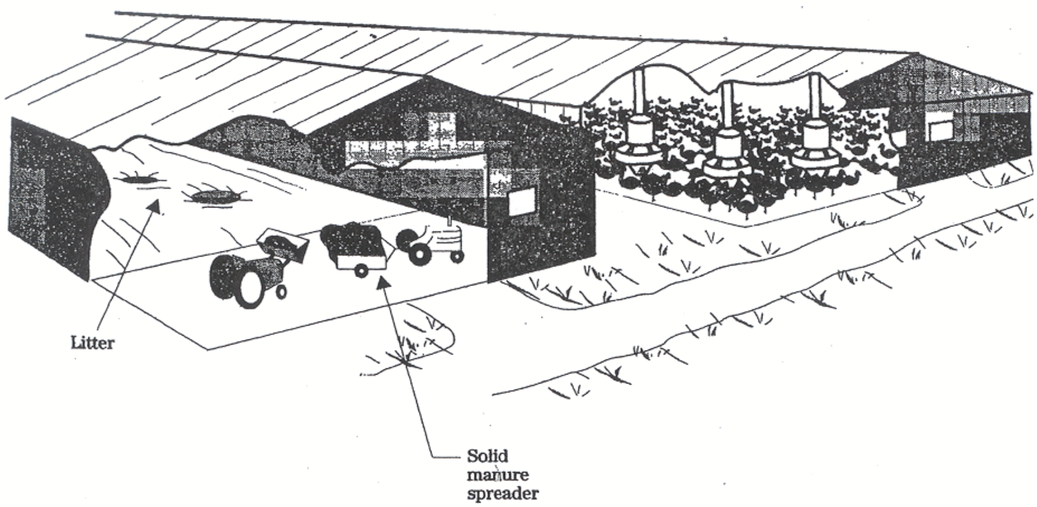

Figure 4.1. Building with litter floor system for broilers and turkeys.
Source: Agricultural Waste Management Field Handbook USDA-NRCS

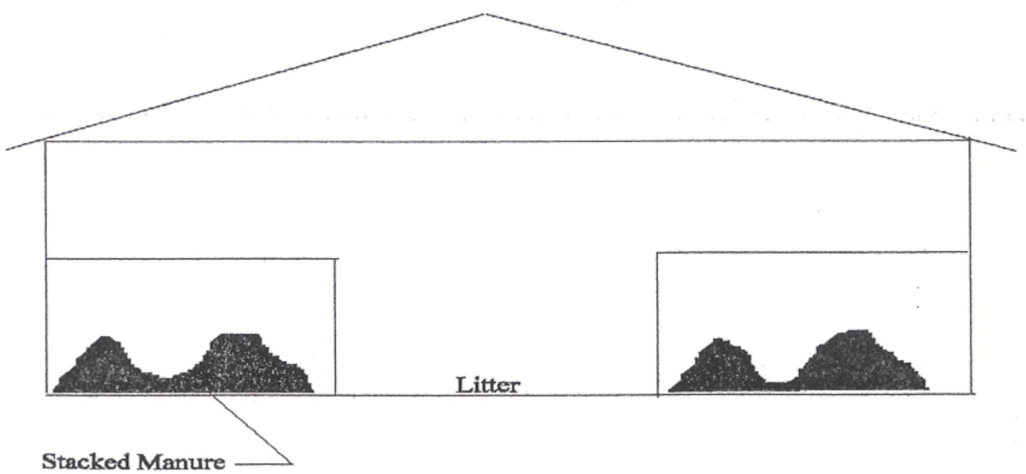

Figure 4.2. Cross section of a breeder house showing stacked manure under the roosting sections and litter in the center of the house.

Layers

A high-rise layer house is commonly used in egg production (Figure 4.3). The house is normally about 40-60 feet wide. Walls may be made of drop curtains, drop curtains with auxiliary fans, windowless walls with mechanical ventilation and light control. The watering systems are typically cups or nipples. Manure is collected and stored beneath the bird cages in a pit under the house. It may be removed anytime during the laying or growing cycle but it is normally removed when the birds are moved out. Manure drops directly to the floor beneath the cages in a high-rise layer house. If the storage area (pit) is properly ventilated rows of dry mounds of manure will accumulate. Control of excess water is required. Drinker leakage and blowing rains can turn a stacks of dry manure into an unmanageable slurry mix. The manure should be stored with a moisture content of less than 45% to assist in fly control.

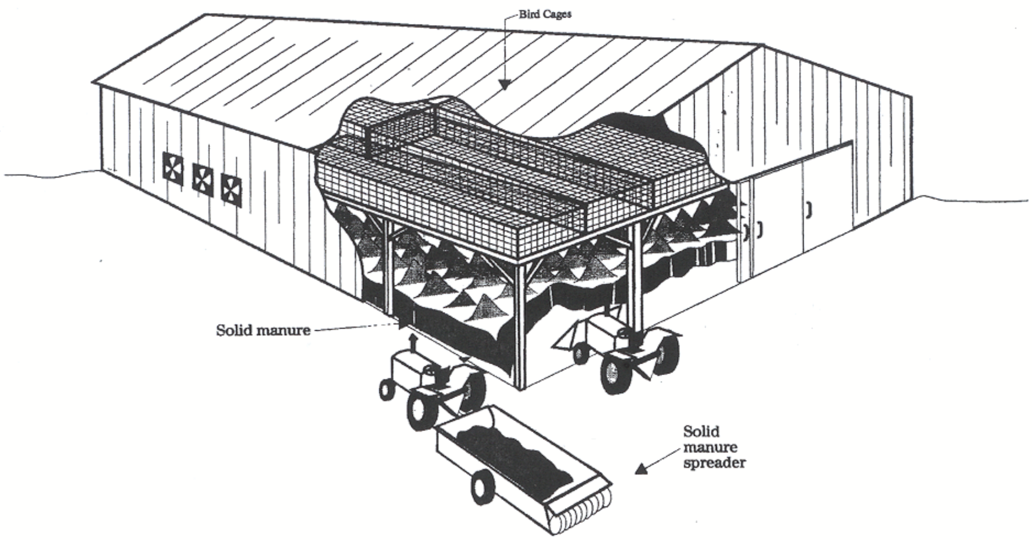

Figure 4.3. High-rise layer house.
Source: Agricultural Waste Management Field Handbook USDA-NRCS

"The system works best with lower level exhaust fan ventilation, which pulls fresh air in through controlled inlets on the top floor; over the birds on the top floor; and down past the manure, taking moisture, stale air, and odors out of the building. Interior circulation fans may also be used in the pit to improve circulation and promote manure drying." (NRAES-132)

Controlling the moisture content in the manure through continual monitoring and maintaining watering systems in the house will help keep manure dry and will make clean-out easier.

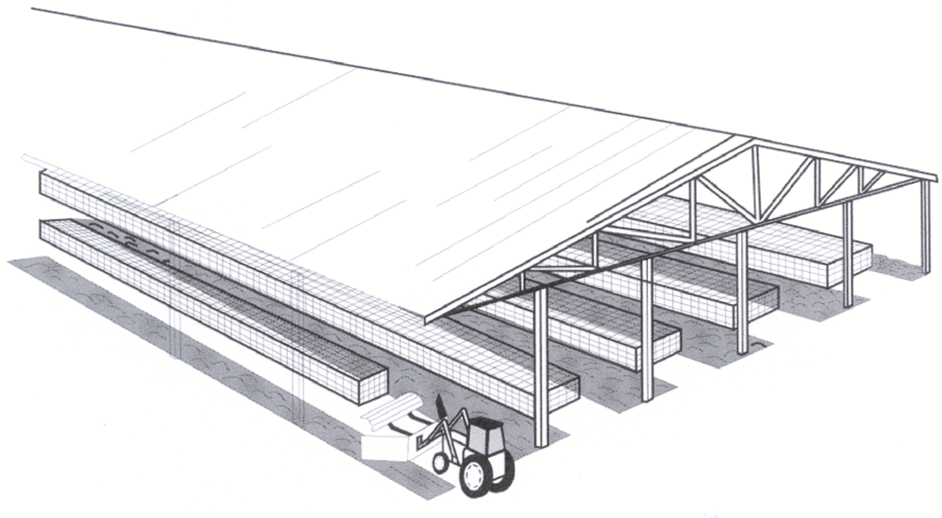

Figure 4.4. Wide-span caged layer house with collection alleys or gutters for flushing or scraping. Source: Agricultural Waste Management Field Handbook USDA-NRCS

Another type of house used in layer production is a single story stair-step house. This type of house is 30 to 60 feet wide. Ventilation may occur through sidewall drop curtains, drop curtains in conjunction with auxiliary fans, or solid walls with mechanical ventilation. The watering system may be cups or nipples. Manure is removed with a scraper or by flushing to a waste treatment lagoon or waste storage pond or the manure may be taken directly to the land application area. Figure 4.4 shows a wide-span caged-layer house with collection alleys (gutters) for flushing and scraping. Figure 4.6 shows a mechanical scraper systems for removing manure from under the cages.

Manure removal from caged-layer houses may be fully automated where a collection belt runs underneath each tier of cages. The belts carry the manure to a common collection point. Proper management of the system can greatly reduce the moisture in the manure. In many cases special ventilation ducts are installed to assist in drying the manure. Collection alleys are not necessary with a belt cleaning system.

New poultry production systems are being installed are typically using dry treatment and handling methods. However a few liquid treatment/storage for manure remain operating in South Carolina. These systems are managed the same as any other manure treatment lagoon or waste storage pond. For a waste treatment lagoon, the design criteria is based upon the volatile solids loading rate, just as when designing a lagoon for other livestock. For a thorough discussion on the management and operation of liquid waste treatment and storage see the Swine version of the CAMM Handbook. For proper design information for liquid treatment and storage systems check with your local NRCS or Extension offices.

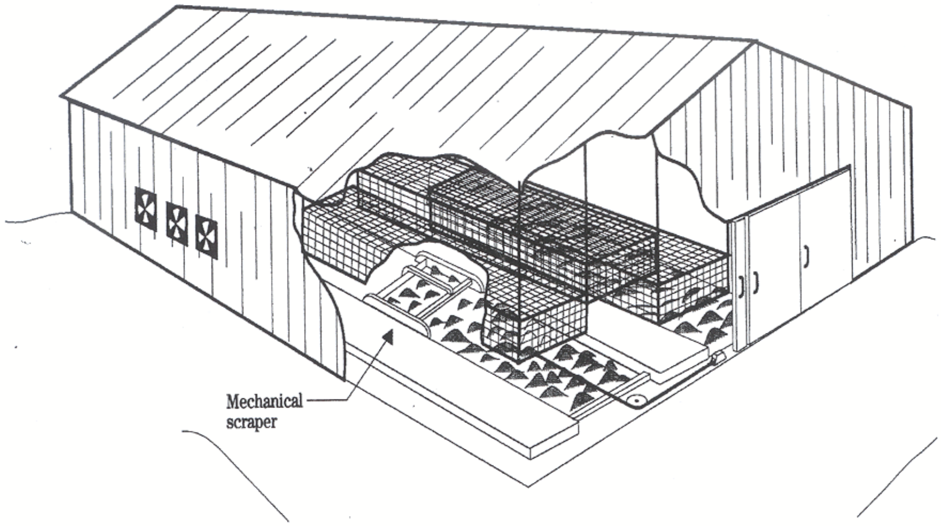

Figure 4.5. Mechanical scraper system for removing manure from under the cages.
Source: Agricultural Waste Management Field Handbook USDA-NRCS

Manure Storage

This handbook will focus only on storage of dry manure / litter production systems. Liquid systems are similar to those in the CAMM Swine handbook.

Solid manure storage begins in the house with the animal production system. High-rise houses for caged birds allow for accumulation beneath the cages while floor litter systems allow for manure to mix with the litter base and buildup for a period of time. The cleaning frequency of both types of systems may be based on several factors: the quality of the manure or manure litter in the pit or in the house; the storage space remaining; or the integrator specified clean-out cycle. Typically, deep-pit or high-rise houses should be cleaned once or twice per year. However, floor systems might be cleaned after every flock or they may clean cakes out after every flock and have a total cleanout only once a year or more.

Watering systems within the houses have a significant impact on manure quality within the houses. Water leaks should be repaired immediately. In floor systems wet cakes will form and ammonia production from the house will increase. Also, there is a greater possibility for fly and other vector problems and cleanout will be required more often. Leakage or spillage in a high rise house can turn solid manure into a slurry capable of breaching the containment doors and flowing outside to cause potential environmental damage and costly cleanup.

Storage Requirements

An animal manure management plan must include a crop production plan which accounts for proper utilization of the nutrients in the manure. With poultry houses being cleaned year-round, a crop may not be available for the application of the litter at the time of clean-out. Therefore, storage of litter may be required. Two types of storage will be discussed: (1) short-term and (2) long term.

Short-term Storage

Short-term storage is typically used when a house is being cleaned out or when the material will be land applied soon after cleanout. Litter may be stored up to 3 days open to the environment. Any manure stored longer than three days must be covered to eliminate contaminated run-off from the pile. The most common method of covering a litter stack is to use black plastic. The plastic should be tied down with old tires or similarly weight item.

Long-term storage

Long-term manure/litter storage is typically consists of a manure stacking shed or similar-type roofed structure. Figures 4.6 and 4.7 show two types of buildings that may be used. Another type of long-term storage is a roofless stacking facility. These structures consist of bunker walls and a concrete pad. Each facility must have a heavy-use area and a grass filter strip around the site. The bunker walls shall have ties so that the manure/litter can be covered with a tarpaulin or similar type material, as required by South Carolina Regulation 61-43. Figure 4.7 shows on example of a roofless stacking facility.

Storage Capacity

Short-term storage capacity is based upon the immediate need for storage. If a producer is cleaning a house he may need an area where a one or more houses of litter can be placed until it is land applied. Long-term capacity is typically based upon a producers animal production and crop production management systems. A producer may be able to apply one-half of the litter to the land when houses are cleaned. Thus, one-half of the litter must be stored. Or the producer may sell all the litter that is above what he can use on his crops on an annual basis. Essentially, storage capacity is based upon the manure production and the producers farm management scenario.

Storage Safety

Any time manure or litter is stacked for storage there is the potential for spontaneous combustion. "These fires are caused by self-heating of the manure due to microbial activity. During heating, combustible gases are released into the air spaces between manure particles. If the concentrated gases come in contact with oxygen at the proper ignition temperature, combustion occurs. Within the pile of manure, incomplete combustion results in a charring of the manure, which is evidenced by a black color with the manure is removed for spreading. When charred sections of the stack are exposed to enough oxygen, an open flame sometimes results." (NRAES-132)

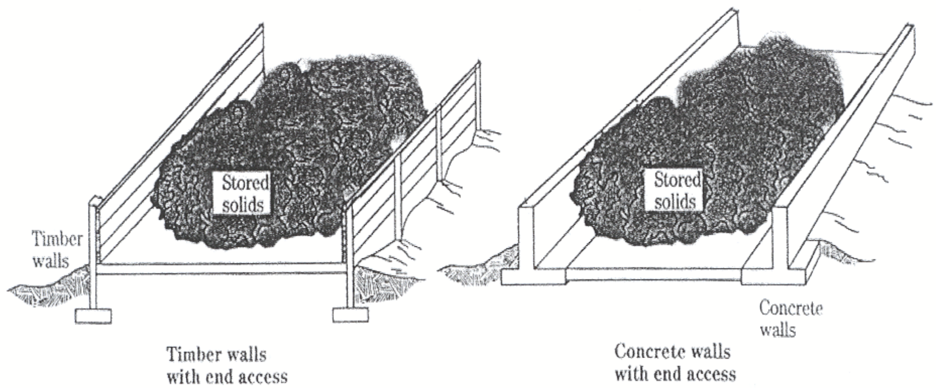

Figure 4.7. Examples of roofless stacking facilities. These structures must be covered with a tarpaulin or other cover when manure/litter is stacked for more than three days.

Several management techniques can be used to reduce the potential for spontaneous combustion.

1. Do not stack litter of various ages in the same pile. Typically, combustion occurs at
   - The interface between wet and dry litter from different flocks
   - Two to three feet from the top.
   - Two to six weeks after making the pile.

2. Do not stack wet and dry litter within the same stack
   - Protect litter from rains with storage structure walls or covers

3. Monitor the stack for hotspots using a long-stem thermometer
   - If temperatures within the stack are above 160oF be prepared to act. However, if temperatures reach 190oF combustion is eminent. The manure should be removed from the stack and spread out on the ground. Ignition may occur during removal. Fire control equipment should on-site. Use water only if a flame occurs. Do not add water to the stack without removing the stack. The flame may be extinguished, but it will contribute to the gasification process resulting in a delayed re-ignition. .

4. Avoid stacking manure more than 3 feet deep near wooden walls and posts.

5. The site for the stacking area should allow access for fire-fighting equipment.

Manure / Litter Treatment Systems

This section will deal primarily with treatment of manure and litter as dry solids. Therefore, treatment of manure/litter solids through composting will be the focus. However, incineration of litter for energy production is a positive alternative. More information on incineration as an energy source may be obtained from publications such as Poultry Waste Management Handbook (NRAES-132). Lagoons and anaerobic digestion are liquid treatment processes which are address in the corresponding CAMM course for liquid manures.

Composting of poultry manure/litter

Composting is the aerobic decomposition and stabilization of organic matter under conditions which allow development of thermophilic temperatures as a result of biologically produced heat. It is a natural process that is enhanced and accelerated by the mixing of organic waste with other ingredients in a prescribed manner for optimum microbial growth. During the active phase of composting, the mixture of materials are maintained in an aerobic condition during which water vapor and heat is released. The material should then go through a curing process to produce the final compost product. Figure 4.8 shows a diagram of the composting process. The carbon, protein, and water in the finished compost is less than that in the raw materials. The finished compost has more humus. The volume of the finished compost ranges from 15 percent to more than 50 percent less than the volume of the raw materials according to the efficiency of the process.

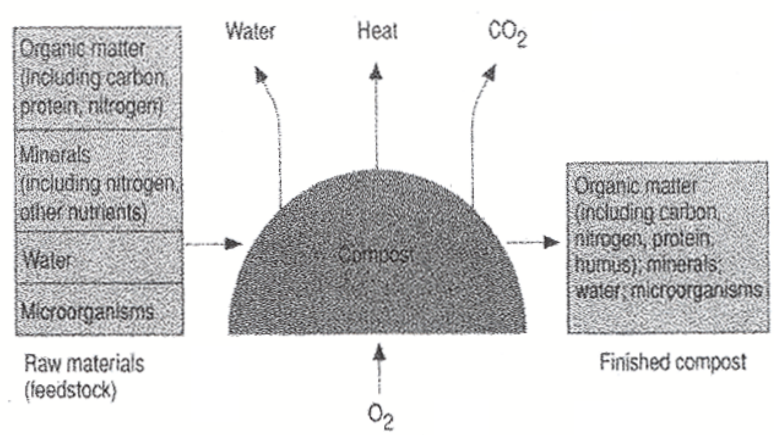

Figure 4.8. Aerobic composting: inputs and outputs. Source: Field Guide to On-Farm composting, NRAES-114.

Composting is accomplished by mixing an energy and structural component (carbonaceous material), a nutrient source (nitrogenous material), water, and oxygen in a prescribed manner to meet aerobic microbial metabolic requirements. The process is carried out under specific moisture and temperature conditions for a specified period of time. The composting process may become inhibited when moisture falls below approximately 40 percent. Correct proportions of the various compost ingredients are essential to minimize odors and to avoid attracting flies, rodents, and other small animals.   The final product is sufficiently stable for storage, land application, or marketing without adverse environmental effects. <u>The material improves soil fertility, tilth, and water holding capacity. Composting reduces the bulk organic material to be spread; improves its handling properties; and, can destroy weed seeds and pathogens.</u>

The composting facility shall be designed to provide storage for the maximum length of time anticipated between emptying events or storage period. The minimum storage period shall be based on the time required for the composting process and environmentally safe waste utilization considering the climate, crops, soil, equipment, and local, state, and Federal regulations.

The composting method must fit the individual farm operation. <u>Several methods include aerated windrow, static pile and in-vessel (bin).</u> Compost piles for windrowed and static piles should be triangular to parabolic in cross-sectional form with a base width to height ratio of approximately 2 to 1. When composting manure or litter the static pile method is most commonly used. Figures 4.9 through 4.12 show various alterations of the static pile method. Passive or mechanical areation may be used. However, the greater the intensity of management and technology that is put into the process, the shorter the amount of time for composting to be completed. For example, a passively araeted static pile may require one to two years for the material to compost; but the process could be completed in as little as three months when some type of mechanical aeration is employed. Mechanically turning is the most common aeration method. Compost production time will typically be four to eight months when using this method.

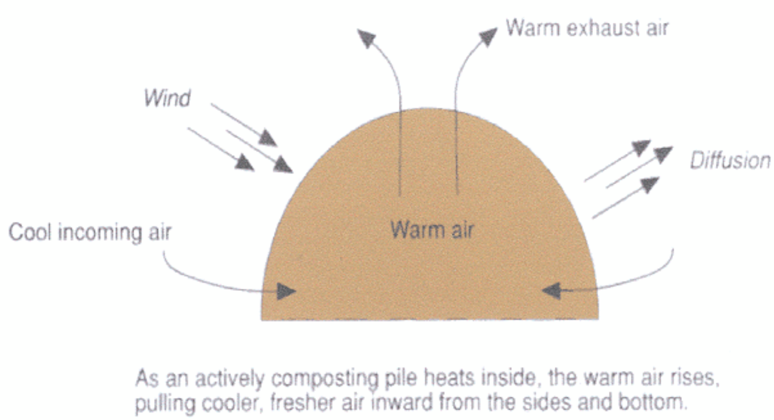

Figure 4.9. Passive aeration composting. Source: Field Guide to On-Farm composting, NRAES-114.

Composting facilities shall be located as near the source of organic waste as practical. Composting operations shall be located where movement of any odors toward neighbors will be minimized. Setback distances should be in accordance to the South Carolina Department of Health and Environmental Control (SCDHEC) specifications. Typically for composting structures it will be equal to the setback(s) for the facility.

Site paving needs should be evaluated in terms of effects of equipment operation on trafficability, soil compaction, and potential for contamination from compost and petrol products. Special consideration should be given to designing high traffic areas in front of the primary bins which must be used daily in all weather conditions. One alternative for supporting traffic may be the installation of a geotextile fabric with crusher run gravel on top.

Buffer area(s), vegetative screens, and natural landscape features can help minimize the effects of odors.

The facility should be located as near the source of organic material as practical with consideration given to:

- the location of neighboring dwellings and how they will be affected by prevailing winds.
- location of ingress and egress so as not to interfere with traffic flow or utilities.
- location of the access for easy loading and unloading of compost. consideration given to:
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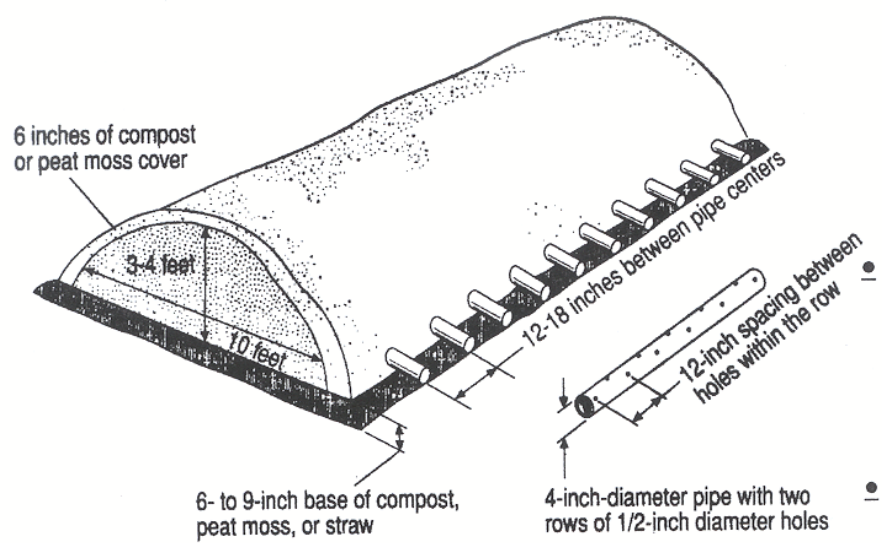

Figure 4.10. Passively aerated compost pile. Source: On-Farm Composting Handbook, NRAES-54.

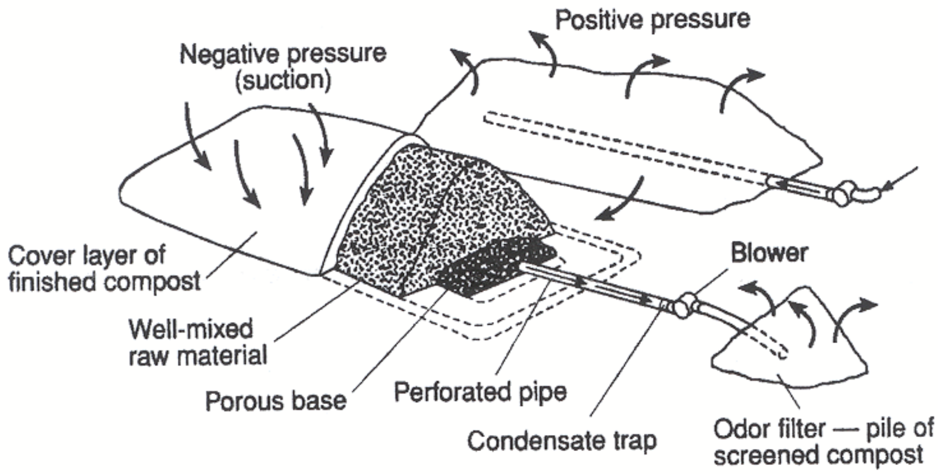

Figure 4.11. Mechanically aerated static pile. Source: On-Farm Composting Handbook, NRAES-54.

Moisture

<u>A water source must be available for compost pile moisture control from start-up through completion. The moisture content of the blended material at start-up of the composting process</u>

<u>should be approximately 55 percent (wet weight basis) and maintained between 40 and 60 percent during the composting process</u>.

Proper moisture content is critical in a carcass composting process and varies greatly with carcass species and size. <u>Water is also a by-product of aerobic decomposition of animal and poultry carcasses.</u> Moisture is important in initiating the composting process. Learning to control moisture is a trial and error process for each size and species of carcass. For poultry, a good rule of thumb for moisture is to spray the carcasses with a light mist roughly equivalent to an autumn morning dew. The composting of large swine carcasses requires a larger quantity of water to initiate the process.

Carbon-Nitrogen (C:N) Ratio

The amounts of the various ingredients shall be calculated to establish the C:N ratio of the mix to be composted. <u>For composting typical organic matter or typical manure, the C:N ratio should be between 25:1 and 30:1.</u> Typical C:N ratios for composting amendments are found in the USDA-NRCS Agricultural Waste Management Field Handbook or the On-Farm Composting Handbook by the Northeast Regional Agricultural Engineering Service (NRAES). Organic materials with higher C:N ratios should be used for materials that decompose at a high rate (or are highly unstable) and result in greater odor production.

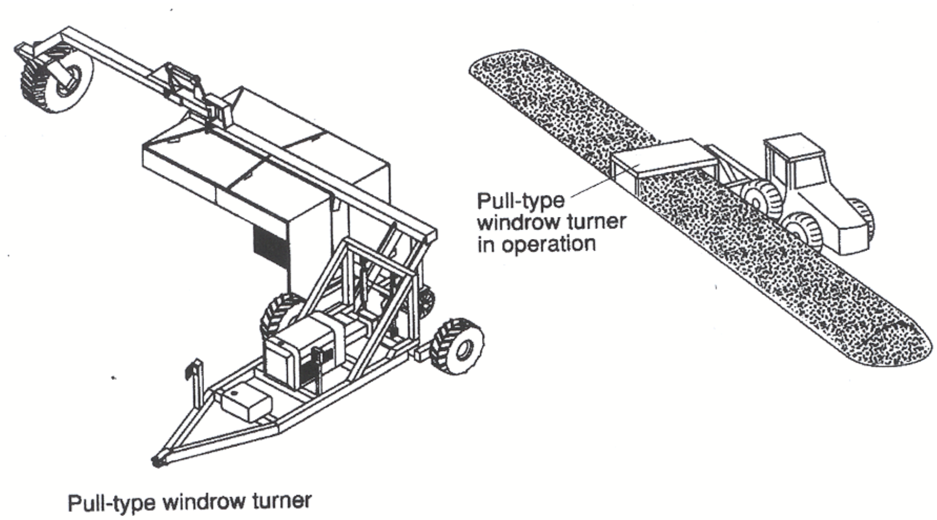

Figure 4.12. Special compost turning machines can be used to turn windrows. Source: Adapted from Field Guide to On-Farm Composting, NRAES-114.

Carbon Source

A dependable source of carbonaceous material must be available. The material should have a high carbon content and high carbon-nitrogen (C:N) ratio. Wood chips, sawdust, leaves, peanut hulls, straw, corn cobs, peat moss, and well bedded horse manure are good sources of carbon.

Aeration and Oxygen

Aerobic composting consumes large amounts of oxygen. Thus, aeration in the process is critical. Aeration also removes excess heat generated by microorganisms, gases within the material, and excess moisture. Proper aeration may be achieved by passive air exchange, forcing air through the material, mechanical turning, or a combination of any of these methods.

Heat generated by the process causes the compost pile to dehydrate. As the process proceeds, material consolidates, and the volume of voids through which air flows decreases. Materials selected for the composting mix should provide for adequate air movement throughout the composting process. Periodically turning the pile and maintaining proper moisture levels for windrows and static piles will normally provide adequate aeration.

Proper aeration minimizes nitrogen loss by denitrification. Maintaining the pH at neutral (7.0) or slightly lower avoids nitrogen loss by ammonification. High amounts of available carbon will aid nitrogen immobilization. Phosphorus losses will be minimized when the composting process is managed according to the requirements of this standard.

Increased surface area favorably affects evaporation and natural aeration and increases the area exposed to infiltration from precipitation in uncovered stacks. Aligning uncovered stacks north to south and maintaining moderate side slopes maximizes solar warming. Windrows should be aligned to avoid accumulation of precipitation.

Bulking materials should be added to provide the porosity, structure, and texture to enhance air flow within the composting material. Piles that are too compact will inhibit the composting process. The optimum bulk density of compost should be about 55 percent of the density of water. Good results are usually obtained when the bulking agent has particle sizes ranging from 1/8 to 2 inches in diameter. The carbonaceous material can be considered as a bulking agent. Where it is desirable to salvage carbonaceous material, provisions for removing the material, such as screening, must be made.

Temperature

Temperature is the primary indicator to determine if the composting process is working properly. A minimum temperature of 130° F shall be reached during the composting process. A temperature of 140° F is optimum; however, temperatures may range up to 160° F. If the minimum temperature is not reached, the resulting compost shall be incorporated immediately after land application or recomposted by turning and adding moisture as needed. Compost managed at the required temperatures will favor destruction of any pathogens and weed seeds.

A good carcass compost should heat up to ±140 within a few days. Failure of the compost material to heat up properly normally results from two causes. First, the nitrogen source is inadequate (example wet or leached litter). A pound of commercial fertilizer spread over a carcass layer will usually solve this problem. Secondly, the compost fails when too much water has been added and the compost pile becomes anaerobic. An anaerobic compost bin is characterized by temperatures less than 120 , offensive odors, and black oozing compound flowing from the bottom of the compost bin.

It is possible, though unlikely, for the temperature to rise above the normal range and create conditions suitable for spontaneous combustion. If temperature rises above 170° F, the material should be removed from the bin and cooled. If temperature falls significantly during the composting period and odors develop, or if material does not reach operating temperature, investigate piles for moisture content, porosity, and thoroughness of mixing.

Composting Period

Sufficient time shall be planned to complete the compost process. The time needed for completion of the composting process varies with the material and must continue until the material reaches a stability level at which it can be safely stored without creating undesirable odors and poor handling features. Acceptable stability occurs when microbial activity diminishes to a low level. For typical manure and other organic matter, the initial decomposition process (active composting phase) can be completed in about 21-28 days. However, the material will reach stability after a 90 or more day curing process. After curing the compost may have the desired quality for a marketable soil amendment.

The time required for composting is directly proportional to the aeration used in the process. If passive aeration is used the material may take several years to compost. However, mechanical aeration can cut the time considerably. Aeration through mechanical turning is the most common method used on poultry farms. Using this process, composting and curing will usually take four to eight months.

Compost Utilization

Land application of compost shall be based upon the compost and soil analysis, as well as crop nutrient requirements (based on crop yield). The compost should be applied to the land at recommended agronomic rates. The compost should be analyzed to determine the nutrient content.

An alternative utilization method for compost is marketing it as a value-added product. The material has excellent properties for increasing soil organic matter, soil water holding capacity and soil tilth. As well as selling the material, a producer might consider giving the compost to neighbors and those in the local area as a goodwill gesture.

Water Quality Considerations

Composting may take place under roof or in the open. In either case, management of the runoff water is the primary water quality concern. In the roofed structure, this is generally not a concern. However, when composting in the open, runoff and leaching are significant design considerations. When using windrows for composting, the windrow should be parallel with the slope so that water will be able to flow away from the composting piles. The area surrounding the composting area should have sufficient vegetation to serve as a filter for nutrients in the runoff. The base of each windrow should be one-half to one foot of carbon source (sawdust, wood shavings, etc.) to soak up any moisture that might come from the manure/litter and to inhibit leaching of nutrients into the soil. If the active composting area will have daily traffic, especially during inclement weather, the facility should have a concrete or compacted soil base.

Composting of waste organic materials should improve water quality by eliminating alternative methods of disposal which could pollute ground and surface water. Soil amended with compost will have an increased available moisture content, which will result in some additional storage of water in the soil profile resulting in less leaching. The compost material must be properly managed to prevent movement of soluble substances and of items attached to solids carried by water runoff. Caution must be taken to prevent spreading compost near surface waters because high organic matter content and an increase nutrient loading could cause eutrophication of the water bodies.

Odor Considerations

When odor is a concern, select carbonaceous material that, when blended with the nitrogenous material, will result in the desired pH. The blended material should have a pH at or slightly below neutral for best odor control. Where odors do not present a problem, pH of 8 to 9 is acceptable, but strong ammonia and amine related odors will be present for up to the first 2 weeks.

Another method of minimizing odor is to design a mix that results in desired C:N ratios as given above. When the C:N ratio is very low, 10:1 or less, a loss of nitrogen generally occurs through rapid decomposition and volatilization of ammonia.

Management

The composting process must be managed properly in order to achieve good results. It is a biological process that can have excellent results or it can be a catastrophe. Temperature is the primary indicator that the process is working. If adequate temperatures are not achieved the process must be evaluated to correct the problem.

Loading the composter with the correct materials at the proper ratios is critical. The addition of water is the most crucial. Inadequate water will slow the process, while too much water will fill the pore space and will not allow air to permeate throughout the pile resulting in an anaerobic condition. Odor is generally a good indicator of anerobic conditions.

Other troubleshooting methods are to test compost material for carbon, nitrogen, moisture, and pH if compost fails to reach desired temperature or if odor problems develop. The finished compost material should be periodically tested for constituents that could cause plant phytotoxicity as the result of application to crops.

Biosecurity.

Anyone working on or about an animal production facility shall follow biosecurity techniques to prevent the spread of diseases. If possible, entry into poultry houses or other animal production facilities should be avoided. However, if entry is necessary, the farm operator's permission is required.

In order for proper pathogen kill to occur in the composting process, it is necessary to maintain a temperature of 135 degrees F for a minimum of three days within the active composting area. Other than testing, monitoring temperatures is a good indicator of pathogen kill.

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