Poultry
By-Product Management
Handbook

- Manure Management and Utilization
- Disposal of Farm Mortalities
- Farm Planning and Enhancement
- Vector Control

Poultry By-Product Management Handbook
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FOR MORE INFORMATION...

Alabama Poultry & Egg Association, Inc.

Agency's Tie With The Poultry Industry

The Alabama Poultry & Egg Association is a not-for-profit trade organization representing all phases of the broiler, egg, and turkey industry in Alabama. The Association works for the industry in the areas of legislation, research, education, public relations, media relations, and product promotion to provide services and programs not available outside the Association. Programs are changed according to the needs of the industry.

AP&EA is committed to providing the services necessary to keep the poultry industry in Alabama a world leader in poultry production.

Services Available To Poultry Growers

AP&EA is the poultry producer's voice in the state legislature as the Association works to protect the interests of the poultry farmer especially in the areas of state sales tax exemptions and fair utility rates. In addition to the educational seminar held during the AP&EA convention, the Association sponsors other educational meetings as needed.

At present 14 county poultry and egg associations are affiliated with AP&EA. The purpose of these county organizations is to promote the poultry and egg industry and to provide the opportunity for exchange of information on the county level. AP&EA is acutely aware of the need for sound environmental programs and has been at the forefront of the effort to develop an acceptable plan for Alabama.

Contact

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FOR MORE INFORMATION...

Agricultural Stabilization and Conservation Service

Agency's Tie With The Poultry Industry

The National program objectives of the Agricultural Conservation Program (ACP) are to assure a continued supply of food and fiber necessary for a strong and healthy people and economy; and to facilitate sound resource management systems through:

- Conserving the soil, water, and related natural resources.
- Controlling erosion and sedimentation from agricultural land.
- Controlling polution from animal wastes.
- Encouraging voluntary compliance by agricultural producers with state and federal requirements to solve point and non-point sources of polution.
- Improving water quality: encouraging enduring conservation and environmental measures and practices rather than those that are primarily production oriented or that have little or no conservation or polution abatement benefits.
- Helping achieve national priorities as set forth in the National Environmental Act.

ASCS interfaces with producers involved in the poultry industry by offering through ACP a cost-sharing practice to assist in solving erosion and water quality problems as a result of non-point source polution.

Services Available To Poultry Growers

ASCS has the authority to offer cost-sharing up to 60 percent of the cost to construct facilities to handle and/or store poultry waste. The size of the facility is based on the operation and the number of acres on which to spread the waste. The purpose of the practice is to solve a water quality problem by permitting the waste to be returned to the land in the operation. Producers who have been in business less than five years or who have substantially enlarged their operation in the last five years are not eligible for assistance. Facilities include lagoons, dry-stacks, and composting units. Eligibility is based in part on those practices that are carried out on a voluntary basis. A practice installed as a result of a written advisory notice of a needed action (local, state, or national) would be considered voluntary. However, when the administering authority notifies the producer in writing that specific action, such as fines or closing the operation, will be taken, this is considered an *involuntary* action and would not be eligible for cost-sharing.

Contact

Contact the ASCS office in the county in which you reside, or contact the state office to obtain information for your county.

Joan G. Grider
Acting State Executive Director
Agricultural Stabilization and Conservation Service (ASCS)
United States Department of Agriculture
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FOR MORE INFORMATION...

Alabama Department of Agriculture and Industries

Agency's Tie With The Poultry Industry

The Alabama Department of Agriculture and Industries, through the Animal Industry Division, is charged with controlling, eradicating and preventing the spread of contagious and infectious diseases of poultry through the proper destruction and disposal of dead poultry, unhatched or unused eggs and other poultry waste by requiring commercial growers of poultry and commercial hatcheries to be equipped with and use disposal facilities. The authorizing legislation can be found in the Alabama Code (1975).

Services Available To Poultry Growers

The Department will provide information on the proper construction and use of disposal facilities. Disposal facilities for the disposal of poultry mortalities include approved disposal pits, composters, and incinerators. Disposal pits must meet the construction specifications as outlined by the State Board of Agriculture and Industries; other methods must meet the appoval of the State Veterinarian (Chapter 80-3-20 of the Alabama Administrative Code). Composters should be built according to specifications as outlined by the Alabama Cooperative Extension Service. Incinerators should meet both federal Environmental Protection Agency and Alabama Department of Environmental Management standards. Failure to meet these specifications for on-site disposal facilities or failure to use disposal facilities properly can result in the issuance of a quarantine. No poultry, eggs, or other poultry products can be moved from the quarantine premises until inspected and until approval to remove them has been given by the Commissioner of Agriculture, the State Veterinarian, or their agents. The Department also holds the authority to issue licenses to those who sell poultry litter as livestock feed. Licenses are issued through the Agricultural Chemistry Division.

Contact

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State Veterinarian and Director, Animal Industry Division
Alabama Department of Agriculture and Industries
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(205) 242-2647

FOR MORE INFORMATION...

Alabama
Department of Environmental Management

Agency's Tie With The Poultry Industry

The Alabama Department of Environmental Management (ADEM) is involved in the regulation of the poultry industry with respect to the discharge of pollutants and protection of the environment. Animal waste and dead bird disposal are two of Alabama's critical environmental concerns that require frequent interaction with the poultry industry.

Services Available To Poultry Growers

Interaction with the poultry industry is handled in two ways: Industrial facilities such as hatcheries and processing facilities are generally regulated under one or more permit programs, while broiler and layer operations are inspected on the basis of citizen complaints or known or suspected problems. Upon receipt of a complaint ADEM personnel will inspect a facility to determine the state of compliance with the appropriate environmental laws and regulations. Since producers are required to manage their facilities to prevent adverse environmental effects, problems observed during inspection must be resolved to prevent further legal liability.

ADEM also provides guidance in environmentally acceptable practices as well as providing interpretation of specific regulatory requirements. Growers are encouraged to contact ADEM for assistance whenever a question of environmental concern arises. ADEM has also provided a list of approved incinerators for the disposal of dead birds.

Contact

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Mining and Nonpoint Source Section
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FOR MORE INFORMATION...

Alabama Department of Public Health

Agency's Tie With The Poultry Industry

The health department interfaces with the poultry industry in abating public health nuisances, usually related to litter control and flies. The local health department should be the first local contact to assist the industry with complaint investigation and abatement.

Services Available To Poultry Growers

The Department consults with industry in the handling of eggs, litter, and dead bird disposal as they relate to public health nuisances; assists other agencies with coordinated approaches at individual sites for nuisance control; and assists with program development for industry training upon request.

Alabama Department of Public Health Contact

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Area Contacts

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FOR MORE INFORMATION...

Alabama
Soil and Water Conservation Committee

Agency's Tie With The Poultry Industry

The state Soil and Water Conservation Committee is responsible for providing coordination and leadership to each of the state's 67 Soil and Water Conservation Districts. The Committee advises the Alabama Agricultural and Conservation Development Commission (AACDC) on standards, specifications, and expected life of cost-share conservation practices eligible for grants under the AACDC Cost-Share Program. The state Committee provides assistance to the districts in carrying out their local programs. The Committee also keeps the districts informed and facilitates information exchange, coordinates programs, disseminates information, and secures cooperation with other agencies.

Each Soil and Water Conservation District determines the direction of its program at the local level. There is a district office in each of the 67 counties in the state. The local district is the contact point for the poultry producer to make application for cost-share and other assistance.

Services Available To Poultry Growers

Financial assistance for conservation practices is available to qualified applicants through the Alabama Agricultural and Conservation Development Commission's Cost-Share Program. Monies received by the Commission from legislative appropriations are allocated to the state's 67 Soil and Water Conservation Districts by the state Soil and Water Conservation Committee. Cost-share assistance is limited to $3,500 or 60 percent, whichever is less, per applicant, per program year. Cost-share practices available to poultry growers include dead bird disposal pits, small animal incinerators, manure dry stack facilities, dead bird composters, and animal waste control facilities. Technical assistance for these practices is provided by the USDA Soil Conservation Service. Also available is assistance in developing suitable waste management plans for poultry operators.

Under Section 319 of the Water Quality Act, several demonstrations will be implemented which will deal with poultry waste management during the next years.

Contact

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FOR MORE INFORMATION...

Tennessee Valley Authority Agricultural Institute

Agency's Tie With The Poultry Industry

The overall objective of the Tennessee Valley Authority's (TVA) Agricultural Institute, headquartered at Muscle Shoals, Alabama, is to develop and implement programs and activities that will further develop agriculture and agribusiness within the 16-county TVA region of northern Alabama. Much of the Institute's work is accomplished in cooperation with other agencies and institutions such as Auburn University's Extension and Research Divisions. The poultry industry is an integral part of the agricultural economy in the TVA region of northern Alabama. Institute programs and projects have been developed and implemented to ensure the continued expansion and success of the poultry industry in an environmentally sustainable manner.

Services Available To Poultry Growers

The Institute's programs and projects primarily deal with helping prevent or reduce impacts of the industry on the environment. This is being accomplished through educational workshops and demonstrations in cooperation with other state agencies to focus on preventing or reducing the environmental impacts of by-products produced by the poultry industry. Current project areas are: composting dead poultry; animal waste lagoon management; production and marketing of poultry litter products for use as a soil amendment, fertilizer, and cattle feed; creating agribusinesses that will produce and market poultry litter products; and conducting research and demonstrations that show correct use of poultry litter in various crop production systems. Much of this work is done in cooperation with the Alabama Cooperative Extension Service at Auburn University. The Institute has also supported several educational demonstrations on poultry producers' farms and with agribusiness firms to accomplish these described objectives.

Contact

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FOR MORE INFORMATION...

USDA
Soil Conservation Service

Agency's Tie With The Poultry Industry

The role of the Soil Conservation Service is to provide technical assistance to the poultry industry in the planning, design, and implementation of waste management systems and dead bird disposal practices on poultry farms in Alabama.

Services Available To Poultry Grower

The SCS provides planning, design, and construction assistance on waste treatment lagoons, manure dry stack facilities, composter units, incinerators, dead bird disposal pits, and waste disposal plans based upon soils, crops, and equipment available; serves as technical representative for cost-share programs to implement waste management and dead bird disposal systems; and provides financial assistance in special project areas in support of technical assistance described above.

Contact

District Conservationists are located in each county in state (Coosa/Tallapoosa Counties in joint office).

Ray E. Donaldson
Assistant State Conservationist (Operations)
USDA - Soil Conservation Service
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Manure Handling and Neighbor Relations

- don't stack manure next to roadways
- spread manure as far from neighbor's house as possible
- avoid spreading on higher ground if there are neighbors at a lower elevation
- prevent spilling on roadways or elsewhere
- always consider wind direction and weather conditions when spreading
- spread in the morning for better odor dissipation
- always incorporate manure into the soil as soon as possible
- be especially thoughtful of sensitive neighbors

Managing Poultry Manure

There has been a great deal of discussion about poultry manure of late. These discussions are concerned with its overabundance, difficulty in finding farmers to use it, and its potential effect on ground water. All of these concerns are important while definitive answers have not come easily.

These concerns differ depending on the point of view. The producers' primary concern is to move this product away from the farm, usually by spreading it on crop land. The purchaser is concerned about the nutrient value of this product to the crop being produced. All of us need to be concerned about its potential effect on ground water.

With proper manure management, concerns about ground water contamination should be alleviated. There are four basic steps to proper manure management and reduced possibility of undesirable runoff.

1. Have the soil tested in the area where the manure is to be spread. This provides baseline data to determine the nutrient needs necessary for maximum crop yields.

2. Determine the crop nutrient requirements so the proper amount of manure can be applied. Precise application will result in the highest crop yields.

3. Determine the nutrient levels in your poultry manure. This is a very important step because the nutrient value of poultry manure is highly variable. Differences occur due to litter type, moisture level, diet of the birds, and clean-out practices.

4. Storage and application of manure can make or break its usefulness. Ideally, manure should be stored either in a storage barn or under black plastic. In this way the nutrients are protected from the weather and remain in the manure instead of leaching into the soil, thus being lost to the crops and possibly contaminating the ground water. Money is available to help defray the cost of manure storage facilities. Contact the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS) for more information.

Manure must be applied correctly to obtain the maximum benefit of its nutrients. It must be applied at the proper time and at the proper rate for best results.

Keeping these practices in mind, proper manure management can benefit all concerned, poultry and crop grower alike.

—*J. C. Hermes*

Reference: Issacs and Harris, Proper Manure Management: A key to tomorrow's success. Delaware Cooperative Extension publication.

The University of Georgia
Cooperative Extension Service

College of Agriculture/Athens, Georgia 30602

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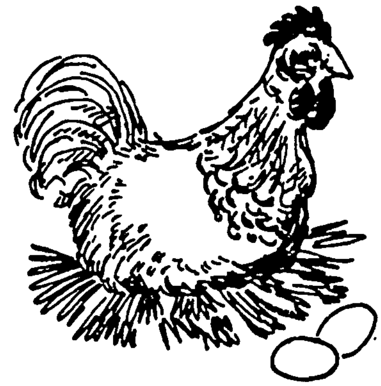
September, 1990



COMMERCIAL EGG TIP . . .

WASTE MANAGEMENT
COMPREHENSIVE PLANNING NEEDS

Disposing and using poultry waste is a major challenge to the poultry industry. It will continue to be an issue because the conflict between intensive animal agriculture and urban development shows no indication of lessening. Waste management involves three areas of environmental concern: **solid waste disposal, pollution of surface and ground water,** and **air pollution.** The shear volume of waste, plus its concentration on smaller land areas, magnify its environmental impact.

Odors from poultry facilities are not dangerous pollutants. When odors are a problem, we classify them as nuisance pollutants. Surburban neighbors, however, are using odors as a focal point to increase state and local regulations affecting agriculture.

Waste management must have high priority. Every animal-based agriculture operation must have a comprehensive waste management plan to contend with animal waste before it is produced by the animal. This not only reduces the risks associated with the use and disposal of animal wastes, but also provides both economic and environmental benefits such as:

*reduced commercial fertilizer costs,
*improved soil tilth and productivity,
*protected water resources and air quality.

Improperly managed wastes, however, sustain certain risks:

*pollute water resources and air,
*lose fertilizer value,
*generate removal expenses instead of financial benefit,
*create a negative social and regulatory environment for agriculture.

Organic wastes originating from poultry production have several potential end uses including land application, production of "biogas" for on site heating, and off-site use of wastes as fuel or feed. The most common practice at present is land application.

A sound waste management plan requires careful attention to details. It uses principles from agricultural engineering, agricultural economics, poultry science, and crop and soil sciences. Together they maximize the economic value of wastes and minimize the risk of environmental damage. The Cooperative Extension System and the Soil Conservation Service through local conservation districts, offer assistance in the development of these plans.

Animal Agriculture's Effect on Water Quality
Pastures and Feedlots
Alan L. Sutton, Department of Animal Sciences

Indiana's Farm Animal Industry

Animal agriculture in Indiana makes a significant contribution to the supply of meat, milk and eggs for consumption in our nation and abroad and supplies a considerable amount of revenue to the state. In 1988, sale of livestock and livestock products in Indiana equalled $1.74 billion. Livestock sales made up 42.5 percent of the $4.1 billion total of all agricultural commodities in the state (Figure 1).

Animal manures are a natural by-product of the livestock industry. Animal wastes must be handled, stored, utilized and/or disposed of in an efficient way while maintaining or improving the quality of the environment. Many factors affect the pollution potential of animal waste. Nutrient content of animal waste varies with collection, storage and application methods. Climate conditions also contribute to the effect animal waste might have on water supplies.

Possible contaminants from animal waste include: nitrogen, phosphorus, inorganic salts, carbon compounds and microorganisms. This bulletin discusses possible water pollution problems from pasture and feedlot systems and the management practices needed protect water supplies.

Pasture Systems

Pasture and range systems still make up a major portion of livestock production in Indiana. To illustrate: feeder calves are produced almost exclusively from cow-calf enterprises on pasture and range systems; a substantial portion of swine production (both feeder pig and farrow-to-finish) is still accomplished on pasture; most dairy farms utilize pasture when seasonal conditions permit; and sheep production is mainly a range and pasture operation.

Grazing animals deposit manure directly on the land in pasture management systems. Though a pasture may be relatively large, manure may become concentrated near feeding and watering areas. Often near flowing streams, these areas can quickly become barren of plant cover, increasing the possibility of contaminated runoff.

There is very little research on the extent of non-point pollution from pasture systems. From the few studies reported, streams near pastures and ponds where cattle had access, showed only a slight increase in bacteria and carbon compound levels.

Good management is the best insurance against pollution of water from pasture or range systems of livestock production. "Good management" guidelines include the following:

1. Prevent manure buildup in any one area by maintaining an adequate land-to-livestock ratio.
2. Maintain a highly productive forage on the land to slow runoff, entrap manure and utilize nutrients.
3. Plan a rotation system of grazing to prevent overgrazing and soil erosion.
4. Locate feeders and waterers a reasonable distance from streams and water courses. Move them to new locations before livestock wear paths by repeated trampling.
5. Provide shade in summer, using trees or artificial shelters, to reduce the need for animals to enter water for heat relief.
6. Fence animals away from ponds and streams if domestic water supplies use surface water.

Feedlots

Open feedlots are a potential point source of water pollution. Point source pollution problems can occur when an open feedlot makes no provisions for runoff control or if manure management facilities are mismanaged, poorly designed or constructed.

To protect Indiana's waterways, the state legislature in 1971 enacted the Indiana Confined Feeding Control Law requiring operations above certain sizes, or those identified as polluters, to obtain approval for their manure management systems. Approval is the responsibility of the Indiana Department of Environmental Management (IDEM). The law requires livestock operations, subject to the law, provide: (1) adequate storage capacity for feedlot runoff and manure to permit timely disposal on the land, and (2) adequate equipment and land for manure disposal.

Animal Waste Management

John M. Sweeten, Charles Baird and Leah Manning*

Livestock and poultry production can contribute to excess nutrients (nitrogen and phosphorus), organic matter, salts and pathogens in surface water and in underground aquifers. Potential sources of pollution include confinement buildings, unpaved feedlots, runoff holding ponds, manure treatment and storage lagoons, manure stockpiles and fields on which manure and wastewater are applied. Other sources are manure accumulations around livestock watering locations, intermittently used stock pens and insecticide spray equipment, dipping vats and disposal sites (for waste pesticide, rinsate or containers). Livestock grazing operations, from sparse rangelands to intensively stocked pastures, also may influence the water quality of streams and aquifers.

Best Management Practices

Best management practices (BMPs) for livestock are needed for a wide range of conditions: sparse rangelands; irrigated and grazed pastures; animals watering in or adjacent to streams; and cattle feedlots.
There is a vast difference in water pollution potential between (a) open rangeland on which annual manure deposition is about 1/10 ton of manure solids and 8 pounds of nitrogen per acre, versus (b) an open feedlot surface that receives about 300 tons of manure solids and 24,000 pounds of nitrogen per acre per year.

Unconfined Livestock Operations

In evaluating unconfined livestock operations, both the quality of runoff water, characterized as concentration (milligrams per liter, mg/l or ppm), and the annual mass yield (lbs/acre/year) of manure constituents should be considered. Pollutants become dissolved in runoff as rainfall erodes the soil surface. The concentration of pollutants is influenced by vegetative cover, which is affected by grazing density. The higher the volume of runoff from land with sparse vegetative cover, the greater its capacity to transport sediment, organic matter and nutrients. Another publication in this series deals with nonpoint source pollution from grazing land.

Runoff and drainage from open livestock lots, including barnyards, can increase phosphorus and potassium levels in the soil for a considerable distance downslope, as compared to the levels on sites not affected by livestock wastes. Research in Wisconsin showed soil phosphorus levels averaging 480 ppm at 300 feet downslope of two dairy barnyards in a drainage waterway soil, as compared to soil phosphorus levels averaging 200 ppm at the same distance but out of the waterway (Motschall and Daniel, 1982). And at 1,200 feet downslope from the dairy lots, waterway soils had 150 ppm phosphorus as compared to 70 ppm in the adjacent, unaffectedsoil areas.

Grazing livestock sometimes cause elevated bacterial counts in streams even though nutrient loads may be small (Robbins, 1978). Watering and feeding sites should be located away from streams and reservoirs, especially if they are used for recreation (Sweeten and Melvin, 1985).

When water high in nitrates filters through the soil, groundwater can become contaminated. Livestock producers should protect wellheads to prevent entry of surface contaminants. If cavities develop around the well head, contaminated surface drainage or soil water can enter the aquifer.

Concentrated Animal Feedlot Operations

Confined, concentrated animal feeding operations (feedlots) have far greater potential to cause water quality problems than pasture operations, unless properly designed water pollution abatement systems are installed

(Sweeten, 1990).

The Texas State Soil and Water Conservation Board (TSSWCB) lists the following BMPs for feeding operations considered to be nonpoint pollution sources (Texas Water Commission and Texas State Soil and Water Conservation Board, 1988):

1. Proper location of livestock concentrations

2. Proper management of solid and liquid manure

3. Runoff control

4. Land disposal of wastes

Site selection is one of the most important factors in preventing water and air quality problems from livestock feeding facilities. Key factors to consider in site selection are listed in Table 1. Proper site selection includes consideration of slope (topography), location relative to flood plains, geology, land area for manure and wastewater applications, land use, and proximity to neighbors.

Texas Water Commission Regulations

Livestock feeding operations considered to be point sources of pollution are subject to specific state and federal regulations. In April 1987, the Texas Water Commission (TWC) adopted a regulation that stated the following no-discharge policy: "...there shall be no discharge of waste and/or wastewater from concentrated animal feeding operations into the waters in the state, but rather that these materials shall be collected anddisposed of on agricultural land."

The TWC definition contains four visually-determined conditions necessary for a facility to be regulated as a feedlot (point source): (a) an enclosure--corral or building; (b) presence of livestock; (c) feeding of those livestock; and (d) sufficient animal density to prevent crop and forage growth. These characteristics integrate the effects of factors such as animal density, animal species, soils, slope and management practices.

The TWC regulation requires livestock and poultry producers to obtain a permit if they have more than 250 milking cows, 1,000 beef cattle, 1,500 swine, 600 horses, 6,000 sheep or goats or 30,000 laying hens in a concentrated animal feeding operation. Operators of smaller facilities are regulated by rule and must meet the same requirements of the TWC regulations for keeping manure and wastewater out of streams.

Specifically, the 1987 regulation requires producers to protect surface and groundwater and to apply manure and wastewater on land. Required surface water protection measures consist of diverting off-site drainage around the feeding facility, constructing minimum storage capacity for manure and process generated wastewater, and constructing adequate runoff storage capacity.

Rainfall runoff from open lots and other manure contaminated surfaces must be collected in holding ponds designed to contain all runoff from the 25-year, 24-hour duration storm, plus accumulated sediment and process generated wastewater. Minimum storage capacity for process generated wastewater was specified for different locations in the state. Runoff holding ponds and lagoons must be located out of the 100-year flood plain. They must be drained by irrigation, evaporation or some combination of the two to restore the design capacity within 21 days after a rain. Holding ponds and lagoons must be sealed with at least 1 foot of compacted clay that meets the TWC specifications based on soils engineering tests. Systems for runoff control, wastewater treatment and storage and irrigation should be designed by a professional engineer.

A water balance based on monthly inflows of wastewater, runoff and rainfall and monthly outflows of evaporation and irrigation should be used to check the adequacy of lagoon and holding pond capacity and adjust it if necessary. Similarly, a nutrient balance, using predicted crop uptake rates and soil nutrient status, is needed to determine proper application rates and the amount of land needed for application and utilization of manure and wastewater.

Regulations for Dairy Farms

The TWC adopted additional regulations in June, 1990 that require all dairies to register. In addition, TWC stipulated thatcertain best management practices be used on those dairies that do not need to get a permit at this time. One category of BMPs deals with decreasing lot runoff volume to reduce the size of required holding ponds and irrigation facilities. This can be done by diverting clean runoff around the facility with ditches and terraces, installing roof gutters, covering open lots with roofs and reducing open lot surface area. The latter may necessitate surfacing pens or collecting manure and more frequently, abandoning pens that do not allow wastewater collection. A second category of BMPs deals with decreasing wastewater volume by properly maintaining the watering system, reducing water used for cooling or cleanup and recycling wastewater from lagoons and holding ponds in lieu of using fresh water. A third kind of BMP is aimed at capturing rainfall runoff according to TWC stipulated design criteria and uniformly apply collected runoff on land. A fourth BMP category calls for minimizing solid manure transport by locating manure stockpiles (if used) away from waterways; installing adequate manure storage structures; using appropriate rates and times for manure application; providing grass filter strips along waterways; and using off-site areas for manure application. The fifth BMP mentioned is the protection of groundwater by locating lagoons and ponds at least 150 feet from water wells and leaving a buffer area around water wells.

In the interim until a permit is issued, the dairy is to install and manage runoff control facilities to contain at least 70 percent of the potential runoff from the 25-year, 24-hour storm. Some leeway is given for multiple storms within a 7-day period.

Other Design Considerations

While decreasing the size of open lots will reduce runoff volume by a proportionate amount, it also increases stocking density, moisture production and the potential for mud problems. It may also necessitate surfacing the pen and collecting manure more often.

Open lots should not be placed in areas where annual precipitation plus predicted manure moisture deposition equals or exceeds annual evaporation. Pasture operations or confinement buildings such as free stall barns are usually preferable to open lots in high rainfall areas. Proper system design is essential to meeting regulations and reducing pollution.

Literature Sited

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Texas Water Commission. 1990. "Control of certain activities by rule". Chapter 321,Subchapter B--Livestock and Poultry Production. Part IX, (31 TAC 321.42-321.46). Texas Register, June 22, 1990. pp. 3639-3640; and Texas Register, April 27, 1990. pp. 2420-2421.

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Avoiding Stream Pollution from Animal Manure

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Animal manure is well-recognized as a fertilizer and soil conditioner. Adding manure to the soil has agronomic benefits through the addition of plant nutrients (nitrogen, phosphorus and potash) and organic matter. These same nutrients that are beneficial in soil for plant growth are considered pollutants in water. The objective of any manure land application system must be to keep manure on the soil, where it has value /, and out of water where it is a pollutant.

Pollutant Types

Ammonia is the most damaging water pollutant in manure. If conditions are right, the effects of ammonia in a stream can be recognized within a few minutes. Ammonia is very toxic to fish. Even very small amounts of ammonia released to a stream can cause a fish kill.

The toxicity of ammonia to fish depends on three factors: pH, water temperature and oxygen content. The higher the pH of the water, the smaller the amount of ammonia needed to kill fish. The higher the temperature of the water, the smaller the amount of ammonia needed to kill fish. Because of the temperature factor, ammonia discharged to a stream that may not kill fish in the winter could result in a fish kill in the summer. In addition, the lower the dissolved oxygen content of the water, the smaller the amount of ammonia needed to kill fish.

Organic matter discharged to a stream may kill fish. However, the effect is slower than with ammonia. As organic matter is "broken down" or decomposes, the oxygen in the water is used up. Therefore, less oxygen is available to support fish and other aquatic life.

The rate at which a stream can recover from a discharge of organic matter depends on its volume, flow rate, turbulence and water temperature . Large streams can accept more organic matter without adverse affects than can small streams because of dilution. Rapidly flowing, turbulent streams can recover faster from a discharge of organic matter because of reaeration as the water moves downstream. The effect of adding organic matter to cold water is less than warm water because cold water can hold more oxygen. Also, decomposition of organic matter is slower at colder temperatures. The worst possible situation is to discharge organic matter into a small, slowly moving stream on a hot day.

Nutrients do impact the streams that receive them. The major damage or effect is most often noticed once the nutrients reach a stagnant portion of the stream, a lake or a pond. The plant nutrients nitrogen and phosphorus do a good job of growing plants both on land and in water. Lakes rich in nutrients are called eutrophic and are green with algae and aquatic plants.

Bacteria from livestock manure rarely causes health problems for people or animals, but the potential is there. Diseases are often transmitted in people and animals through the fecal/oral route. Disease-causing organisms may be present in the waste of an infected animal. If the organism is ingested by another animal, through food or water, the animal is exposed and risks being infected. Fortunately, disease-causing organisms do not thrive in the soil or water and are filtered out and die off. Therefore, it is important to maintain adequate separation distances between the

potential pollutant and the water source. This provides an opportunity for disease-causing organisms to be filtered out and die off before reaching food and drinking water supplies.

Color is a pollutant not often considered. Water can be stained by animal manure, giving it a brown or reddish appearance. The color may not pose a water quality problem, but may alarm people using the water for recreation or water supply.

Preventative Measures

Avoiding stream pollution from manure is not difficult. Common sense is the rule to follow when handling manure. The principles of proper manure management and land application are presented in AEX 704, Land Application of Manure and Wastewater (part 1). These principles include:

1 Maintain separation distances and buffer areas between land used for manure application and surface water drain-age. With no slope a minimum buffer distance of 10 feet of vegetated ground or 25 feet of bare ground from streams and 6 ditches is recommended (Figure 1). On frozen ground, 60 feet of vegetated ground or 150 feet of bare ground is recommended (Figure 2). Greater setbacks are recommended on sloping ground.

2. Restrict surface application of manure on sloping ground when it is frozen or just prior to rain.

3. Take care when applying manure to fields with subsurface drainage, especially when the soil is dry and cracked. It is advisable to till the soil prior to application if cracks are present. All "blow holes" in the drainage system must be repaired prior to application. Surface inlets and french drains must be avoided.

4. Limit one-time application volumes of liquid manure to the amount of moisture needed to bring the soil up to field capacity. Heavy applications can result in puddling and runoff.

5. Limit application of manure nutrients to crop need. Excess application results in buildup of soil nutrients.

6. Test manure and soil to determine appropriate application rates.

Ohio Regulations

The Ohio Water Quality Standards (Ohio Administrative Code 3746-1-04) specify that all surface waters of the state must be free from the following pollutants as a result of human activity. suspended solids, floating debris, color, odor, toxic substances and nutrients that create nuisance growths of aquatic weeds and algae.

The discharge of pollutants to the state's waters is regulated by the Ohio Environmental Protection Agency through the National Pollution Elimination permit system (NPDES). This applies to any controlled, direct discharges of animal waste to waters of the state regardless of operation size.

Dischargers of pollutants may be liable for civil penalties of up to $10,000 for each day of violation (Ohio Revised Code 6111.07). In addition, criminal penalties can be assessed upto $25,000 or up to one year of imprisonment or both (Ohio Revised Code 6111.99). The Ohio Environmental Protection Agency also issues Permits to Install (PTI) on all

livestock operations of more than 1,000 animal units.

The Ohio Department of Natural Resources has pollution abatement responsibilities for livestock operations of less than 1,000 animal units. This program is administered through the Division of Soil and Water and the Soil and Water Conservation Districts.

The legislature has also directed the Ohio Department of Natural Resources Division of Wildlife to protect the wild animals of the state. Anyone found to be discharging pollutants to the state's water can be found in violation of the "Stream Litter Act" and fined up to $500 or sentenced to 60 days in jail, or both, for a first offense. If fish are killed as the result of a pollutant discharge, the party responsible is charged for all damages including the value of the wildlife killed, environmental damages and the costs of investigation. Current market prices are used to set the value of the animals.

In 1989,1 6 fish kills in Ohio were caused by animal manure, resulting in the death of more than 20,000 fish and animals. Animal manure was also cited in 19 other pollution investigations that did not result in wild animal deaths. In 1989, agriculture led industry, transportation, municipal government and public service enterprises in the number of wild animals killed.

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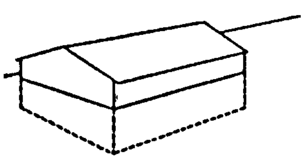
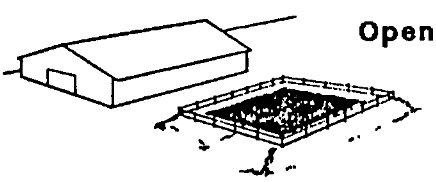
Agricultural Engineering

Livestock Safety – Manure Handling and Storage

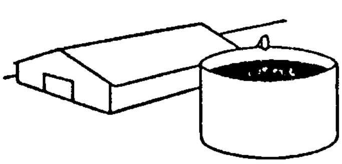
The use of large capacity, on-farm, liquid manure storage facilities has become a common practice in recent years. These include tanks located directly underneath the livestock housing area, storage located away from the livestock housing area in open lagoons or ponds, and above ground silo-type storage tanks. While this practice has greatly increased the efficiency of manure handling, it has also introduced many potential hazards. Of these three types, underground storage is the most hazardous.



Underground Storage



Open Lagoon Storage



Above Ground Storage

Safety Hazards

When animal waste of any type is being stored in large volumes, a number of hazards exist for both the animals and the handler.

The most obvious is the potential danger of drowning. There is also the danger from gases which are produced as the manure is decomposed by bacterial action. This includes gases that are toxic (ammonia), corrosive (hydrogen sulfide), asphyxiant (carbon dioxide), and explosive (methane). Anyone working around animals should be aware of the physical effects of these various gases released during manure decomposition so that a hazardous situation can be recognized immediately.

Designing a Safe Manure Storage Facility

Many safety hazards can be avoided by careful planning when designing or reconstructing a manure handling facility.

The most important consideration when building a manure storage facility is keeping storage volume to a minimum. Also, dividing pits into smaller sections will reduce the amount of agitation necessary.

Pump-out openings for manure pits should be located outside of buildings, and access points should be covered by a heavy cover or gate. These covers should be kept in place at all times. Gas traps should be used in pipelines emptying into outside storages to keep gases from flowing back into the buildings.

North Carolina
Cooperative Extension Service
North Carolina State University
College of Agriculture & Life Sciences

AGRI-WASTE MANAGEMENT

Components of a Complete Manure Management Plan

Existing regulations for animal waste management are generally invoked by the North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management (DEM), in response to citizen complaints about water quality problems after degradation has occurred. DEM believes a more proactive mechanism is needed to help farmers plan and operate animal waste management systems to protect surface and ground water before problems occur. Therefore, DEM is proposing to amend existing nondischarge regulations by establishing minimum criteria to be met before waste management systems serving animal operations are deemed permitted.

While the wording of the above statements is still in the draft stage and subject to be amended, the implication is clear. Within the next few years, every livestock and poultry farmer who has more than 100 animal units will be required to have a complete farm manure management plan utilizing available technology. For many producers this will simply mean documenting those practices already being employed. For others, it will mean proper management or upgrading existing components into a complete and environmentally safe system for managing manure, residuals such as lagoon liquid and sludge, field runoff, and animal mortality. Some components of this plan are briefly outlined as follows.

SITE SELECTION

For new producers or those anticipating significant expansion, site selection is probably the most important single consideration associated with the entire operation. Adjacent land use should remove from consideration those sites near residential developments, commercial enterprises, recreational areas, or other prime areas for non-agricultural uses. Wind direction probability diagrams will help to locate facilities downwind of warm season prevailing winds. The strategic planting of hedge rows or tree barriers at property boundaries serves to shield the production and manure management facilities from direct sight and to reduce wind speed across the facilities allowing any emitted gases more opportunity to rise vertically and dissipate into the atmosphere. A site may seem ideal with respect to transportation, feed supply, accessibility or land ownership, but may be inappropriate because of existing or proposed development.

Soil properties and limitations should be investigated. Soil types with limited permeability which will rapidly seal are desirable for lagoon construction. Coarse sands will probably need to be amended to speed up the sealing process. An erosion control plan to stabilize and maintain a site during construction should be considered. When possible, locate production facilities near the center of a tract of land large enough to allow manure to be applied at agronomic rates. Pollution control and manure management facilities should be located as remotely as possible from areas of high environmental sensitivity such as drainage canals, streams, or natural wetlands. Buildings in flat, high water table areas should be built on pads of earth excavated from the lagoon. Elevating these buildings several feet above ground routes surface drainage away from them and allows flushed manure to flow by gravity to a lagoon built above the water table. Upland

facilities should be built on high ground and as far away fr om water sources as possible to allow wastewater management options.

TYPE OF OPERATION AND ANIMAL INVENTORY

The type of operation (dairy - lactating cow, dry cow, heifer, calf ; swine - farrow-to-weanling, farrow-to-feeder, nursery, finishing, farrow-to-finish ; turkey - brooder flock, grower, breeder ; etc.) affects most manure management practices. The maximum number of animals and corresponding total live weight expected on the farm on any given day is also necessary for most manure management calculations.

TYPE OF PRODUCTION FACILITIES

Different environmental management practices are required for different production facilities and systems. Stock trails and improved stream crossings may be required in vulnerable pasture areas. Fencing of animals from streams in intensively used areas where animals tend to congregate or along highly erodible reaches may be required. Animals maintained on unpaved lounging areas or drylots not supporting vegetation will in some instances require conservation practices to minimize the effects of lot runoff. These animals will most likely be denied direct access to surface waters or wetlands. Partially enclosed facilities with animals on open slabs will also be subject to runoff control. Totally enclosed facilities can affect the production performance as well as potential odors emitted depending on floor surface, ventilation, and manure management. In-house manure collection methods and frequency affect gas and odor levels. Modern manure removal methods such as flushing, pit recharge, and mechanical scr aping have drastically reduced the gas and odor levels inside production facilities.

MANURE STORAGE / TREATMENT FACILITIES

Producers must decide whether their objective is manure nutrient conservation for maximum fertilization or nutrient reduction for ease of management. If nutrient conservation is desired, then scrapers moving manure to outdoor holding tanks or basins, or settling basins prior to lagoons for flushed waste will be needed. Liquid manure spreaders or slurry irrigation systems will move the manure nutrients to large field crop acreages for spreading. If, on the other hand, nutrient reduction prior to land application is desired, then solids separation and/or anaerobic lagoons become very important parts of the overall treatment system. Lagoons, storage basins and holding ponds must be properly sized according to USDA-Soil Conservation Service specifications using correct construction, start-up, and management procedures. When properly planned and managed, lagoons can reduce overall odor levels around a production facility, reduce nutrients to be land applied by up to 85%, provide flexibility for land applica tion scheduling, and have minimal impact on shallow groundwater.

AGRONOMIC PLAN

Manure Characterization Summaries and estimates of manure quantities and nutrient content are available from the N.C. Cooperative Extension Service, USDA-Soil Conservation Service, N.C. Dept of Agriculture, N.C. Agricultural Chemicals Manual, as well as other sources. When no other information is available, such as when planning a new operation, these averages provide "ball park" figures and should be utilized. Existing operations are encouraged to develop individual estimates of the volume of manure, litter, feedlot runoff or lagoon liquid to be land applied, e.g., using water meters to measure the amount of water used in a production facility or by recording the lagoon levels periodically and determining the

accumulated volume. Representative samples of the material to be land applied should be analyzed twice annually for nutrient and mineral content. The N.C. Department of Agriculture provides this service with interpretations of results for a nominal fee.

Crop / Soil Selection Soil types should be mapped for each field on the farm to receive manure. Soil infiltration rates will often determine maximum irrigation rates or how much lagoon liquid can be applied before runoff occurs. Soil types also determine the fate of unused nutrients. Well-drained sandy soils provide more potential for unused nitrogen to convert to nitrates and leach downward. Heavy soils or poorly-drained soils reduce infiltration rates and water-holding capacity but provide more potential for unused nitrogen to denitrify harmlessly. Clay soils have more capacity to tie-up and hold phosphorus in place than do coarse soils.

Soil types also influence the yield potential of selected crops. If a corn crop, e.g., only has a yield potential of 100 bu/A on a given soil type, then it should only be fertilized for 100 bu/A, since any more nutrients would be wasted and become potential pollutants. Crop types should be selected for their nutrient requirements. A range of fertilization rates from 50 lbs of available nitrogen per acre on stands of pine trees to 400 lbs of available N on bermudagrass hayland allow flexibility depending on land availability and farm objectives.

Application Rates Application rates of manure, litter or wastewater should only supply the fertilizer needs of the crops. Since the manure nutrients are not a balanced blend for most crops, some nutrients will either be under- or over-applied. Some overapplication of phosphorus and potassium may be tolerated, however significant and prolonged overapplication of P and K should be avoided. Supplemental fertilizer will be needed if rates supply only the P and K requirements of the crop. Under no circumstances should available nitrogen be overapplied. Plant available nitrogen is currently estimated to be half of the total nitrogen in irrigated lagoon liquid and 70% of the total N in manure slurries that are soil incorporated. Worksheets are available from the Cooperative Extension Service to help calculate available nutrients and application rates.

Scheduling of Manure Application Manure nutrients should be applied as near to the period of plant uptake as possible. Nutrients that are readily available, such as in lagoon liquid, are more efficiently utilized by the crop in several small applications throughout the growing season. Nutrients should only be applied to crops during their normal growing season. For example, bermudagrass normally thrives from May to September and should not receive manure at other times of year except when overseeded with a cool season grass such as rye. Cool season crops are necessary to allow application to proceed during the cool season, or enough storage is necessary to avoid having to spread. Land application of manure nutrients on fallow soil or onto dormant crops will only lead to nitrate leaching downward toward ground water.

Manure Application Equipment Most manures will either be hauled with farm liquid manure spreaders, spread with irrigation systems, or applied by a custom applicator. Costs and time required for hauling, additional acreages required for concentrated slurries, soil compaction, odor considerations, and availability of custom applicators need to be considered for slurry management. It is not cost effective to haul wastewater. Most farms with lagoons will use simple farm irrigation systems, use portable company irrigation equipment, or hire custom irrigators. Those farms with field crops or tree stands will probably find portable systems such as travellers or center pivots most advantageous. Also, if portability to several different fields or large acreages are to be irrigated, travellers will be

selected. On the other hand, if small acreages of grass are to be irrigated and equipment portability is not necessary, small-nozzle, moderate-pressure, permanent irrigation systems provide low-labor and mo re uniform distribution of lagoon liquids. All manure equipment should be calibrated periodically for application rate and uniformity. Appropriate equipment or contractual arrangements must be available whenever manure or lagoon liquid needs to be land applied.

Crop Management Utilization It is important to remember that regardless of what crops are grown on land application sites, they all must be regularly harvested and removed from the site. Otherwise, nutrients will simply recycle back into the soil system and eventually become pollutants. For most field crops, readily established markets are available for the products. For grass crops, markets for hay may not be readily available and may need to be developed. Consideration should be given to marketing a particular crop before selecting that crop for land application.

Labor Availability / Accessibility The availability of labor and the ability to use that labor in the most efficient manner for manure management and farming chores outside of the production facilities should be considered. An irrigation system, e.g., that requires sprinklers to be moved or changed every two hours might require a laborer to shower out/in of the production complex for biosecurity reasons each time attention is given to the system. Would different irrigation equipment or management plans allow the labor to be used more efficiently? The same applies to crop establishment, maintenance, and harvest.

ANIMAL MORTALITY MANAGEMENT

Dead animals are required to be properly disposed of within 24 hours. On-farm mortality management options have consisted of below ground disposal or incineration. Below ground burial or pit disposal of animal and bird mortality may contribute nutrients to ground water in areas with coarse textured soils or high water tables. Mortality management alternatives currently being explored are collection for rendering or on-site composting. These alternatives would reduce below-ground point-sources of nutrients and produce a safe and marketable end product.

CONSERVATION PLAN

Erosion Control Soil as well as manure nutrients should be kept on the field where they are applied. Some nutrients such as phosphorus adhere to soil particles and only move when the soil particles move. Fields where manure is to be applied should have sound conservation practices where appropriate such as terraces, strip cropping, and conservation tillage.

Runoff and Drainage Management It is difficult to avoid occasional applications of manure that are immediately followed by a rainfall event. When this happens, conservation practices such as field borders, grassed waterways, sediment basins, and vegetative filters help to minimize the transport of nutrients and organics off-site. Fields receiving manure that have artificial drainage systems should have a water management plan in action. Some nitrates that have formed in the upper soil layers will be collected in the tile drainage and will be delivered to the drainage ditches or canals. Management of the water levels in these ditches and canals by water control structures can accelerate the denitrification of these nitrates harmlessly.

Cover Crops   Double cropping or cover crops after harvest can help hold soil in place and remove some of the unused nutrients left in the upper soil layers. Crop rotation also tends to use certain nutrients or elements that otherwise would remain in the soil or be lost.

Planning a group of buildings and their surroundings to present a wholesome image is as important as planning for productive efficiency. When the public sees a livestock or poultry farm, they see much more than buildings and grounds. They see an attitude -- an attitude of pride in the business or an attitude of indifference. They see an environmental protector or an environmental polluter. Farm operators who take pride in maintaining the farmstead are generally better managers than those who practice poor housekeeping. Employees take more pride in their jobs and work output improves (Morris et al., 1973).

After weighing the important points of alternative manure management systems, a producer must decide which system appears best, then commit to providing the attention and management necessary to make the system function. No production or manure management system will take care of itself. An ounce of prevention is worth a pound of cure. The appearance of buildings and grounds on farms constantly generates images of the product, good or bad. A good farm image helps sell the product. Portraying an attitude of success is contagious -- to employees, to neighbors, to consumers and to the general public (Morris et al., 1973).

REFERENCE

Morris, T.B., W.C. Mills,Jr. and D.G. Harwood. 1973. Profit From Improving Your Image. PS&T Guide #17, N.C. Agricultural Extension Service, Raleigh, NC. 2 pp.

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Interim Criteria for Nutrient Management Planning
(Adapted from the Pennsylvania Bulletin, Vol. 24, No. 3, January 15, 1994, p 427-28)

Introduction

The Nutrient Management Act, Act 6 of 1993, requires the Pennsylvania State Conservation Commission to develop interim criteria for nutrient management planning as set forth in the Act. These criteria are not regulations, but give direction to the Department of Agriculture for the development of a nutrient management specialist certification program. In addition, the criteria provide the first statement of the basic elements of nutrient management plans to be developed by certified nutrient management specialists. The following interim criteria were prepared under Section 4(4) of the Act.

Interim Criteria

Nutrient management plans shall be developed to manage the use of plant nutrients for crop production and to protect the quality of surface and ground water. The plans shall include, but not be limited to, the following core components: nutrient application, manure management, excess manure utilization and/or disposal, stormwater runoff control and selection of other appropriate best management practices necessary to protect surface water and ground water quality. Plans developed under the Act shall address the following:

I. Nutrient Application - Formulation of an accurate nutrient application plan to assure appropriate plant utilization of nutrients and protection of surface and ground water. The basic components include:

(1) Determination of the cropping system and the crop acreage of specific lands suitable to receive nutrients. The land must be capable of receiving nutrients at the times and rates for proper application and utilization.

(2) Determination of all sources of nutrients available to the soil on the farm. Nitrogen is the nutrient of primary concern, but phosphorus, potassium and other nutrients would be reviewed. This determination would include amounts of nutrient materials available at specific times, determining nutrient content of materials intended to be used as plant fertilizer and determining nutrient availability for plant growth of nutrient residuals in the soil and in materials applied. The determination of nutrients produced would be based on an inventory of the annual animal equivalent units for each animal group on the farm, and/or available manure production data. Nutrient material testing and soil testing for suitable crop acreage will assist with development of assessment data.

(3) Determination of what additional nutrients would be required for crop growth to be applied only in the amounts necessary to achieve realistic expected crop yields. Nitrogen would receive primary consideration. Other nutrients will not be used as a limiting factor, unless appropriate to do so under specific criteria established by the Commission. As appropriate, additional testing of soil and nutrient materials would be scheduled.

(4) Determination and documentation of proper rates, amounts, application dates and methods for all nutrient source applications by field or crop group. Also, the adequacy of nutrient spreading methods and equipment would be determined.

II. Manure Management - The plan would evaluate the adequacy of the existing manure management system for the protection of surface and ground water and for proper nutrient utilization. The evaluation would consider the handling, collection, storage and spreading of manure. Manure storage facilities would not be required unless they are needed for the protection of surface and ground water as part of an integrated nutrient management system. The plan would identify appropriate practices, although engineering design work would not be included.

III. Excess Manure - The plan would determine the amount and type of any animal manure which exceeds the nutrient needs of projected crops. It would also select environmentally sound methods for the use or disposal of excess manure.

IV. Stormwater Runoff Control - The adequacy of existing stormwater runoff control practices to minimize erosion and sedimentation, and nutrient loss from cropland, pastures and animal concentration areas would be evaluated. Additional controls would be required if they are necessary for the protection of surface and ground water. Ordinarily, the existence of a current, implemented Conservation Plan would be adequate to address erosion and sedimentation control. However, conflicting plan components would be resolved, such as utilization of both manure incorporation and conservation tillage. The plan would identify appropriate practices, although engineering design work would not be included.

V. Laws, Regulations, Ordinances - Nutrient Management Plans developed under the Act shall comply with all relevant Federal and State laws, regulations and standards relating to water quality and the management of nutrients.

Input Needed

As noted in the introduction above, these interim criteria for nutrient management are the first public statement by the State Conservation Commission of the basic elements of nutrient management plans to be developed under this act. Thus, while these are not the regulations, it is likely that the regulations will be developed around these criteria. This provides an important opportunity for everyone to react to this preliminary statement of the criterial for nutrient management plans and provide input to the nutrient management advisory board which is drafting the final regulations. Input can be provided to any member of the nutrient management advisory board. The board members are listed below.

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Agronomy Facts # 40 RNutrient Management Legislation in PennsylvaniaS which describes the nutrient management law is available from all Penn State Cooperative Extension offices.

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Poultry By-Product Management

AGRONOMY

ALABAMA COOPERATIVE EXTENSION SERVICE, AUBURN UNIVERSITY, ALABAMA 36849-5633

The Value And Use Of Poultry Waste As Fertilizer

Charles C. Mitchell, Jr., *Extension Agronomist*
James O. Donald, *Extension Agricultural Engineer*
John Martin, *Consulting Agronomist*

The Alabama poultry industry (broilers and layers) produces more than 735 million birds a year. These birds produce about 1.7 million tons of manure and litter.

The nutrients in this manure could adequately fertilize every acre of corn, cotton, wheat, and sorghum produced in Alabama or 800,000 acres of bermuda or fescue pasture.* In fact, the nitrogen (N), phosphate (P_2O_5), and potash (K_2O) in poultry manure represent about 40 percent of the N, 90 percent of the P_2O_5, and 40 percent of the K_2O spread each year in commercial fertilizers in Alabama.

Poultry manure, if properly handled, is the most valuable of all manures produced by livestock. It has historically been used as a source of plant nutrients and soil amendment. However, in areas of intense poultry production, excess manure represents a waste problem for producers.

In some areas, over-fertilizing pastureland with poultry manure has resulted in groundwater and surface water problems. These problems developed as excess nutrients washed off the land or leached into groundwater supplies.

To obtain the maximum economic value of the plant nutrients in poultry manure and to protect the water supply from excessive nutrient run-off or leaching, apply poultry manure to match the nutrient needs of the crop.

Nutrient Analysis

Two basic types of poultry wastes are produced in Alabama—broiler litter and caged layer manure (Table 1). Broiler litter, for fertilizing purposes, includes all floor-type birds such as broilers, pullets, and floor layers. Some type of bedding or litter material is used on the floor of these houses.

Caged layer manure is free from litter materia... generally has a higher moisture content than manu... broiler houses. Both types of waste will contain feat... and some wasted food.

The chemical analysis of either type of manure is ...ly variable due to several factors. These include

Table 1. Estimation Of Poultry Manure Production.

Type Of Poultry	Percent Moisture	Grow-Out Time Interval	Tons Produced Per 1,000 Birds
Broilers*	20	6 to 7 weeks	2
Caged layers	75	1 year	35 to 44

*Based on six grow-out cycles per year on pine shavings or peanut h... bedding.

moisture, temperature, amount and kind of litter, amo... of soil picked up in cleaning a house, the numbe... batches of broilers fed on the litter, and the condi... under which the manure was stored and handled ... spreading.

Table 2 shows both the average and range ... composition of broiler litter sampled in Al... 1977 through 1987. During this 11-year p... from 147 broiler houses had an averag... of 19.7 percent and an average fertil... weight basis of 3.9 percent N, 3... percent K_2O.

Table 2. Nutrient Comp... Basis) From 147 Broile... 1977-1987.

Moisture	
Nitrogen	
Phosp...	
Pot...	

lit...
breed...

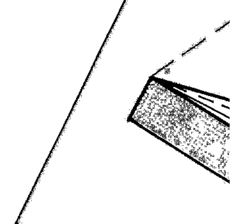

Figure 1. Availability of ni...

...gen (N), phosphate (P_2O_5), and potash (K_2O) in manure ...dation for a soil testing *medium* in P and K.

Agriculture & Natural Resources
AGRONOMY
ALABAMA COOPERATIVE EXTENSION SERVICE, AUBURN UNIVERSITY, ALABAMA, 36849-5612

Worksheet

Poultry Waste As A Fertilizer

To calculate the amount of poultry waste (manure or litter) to use on a crop, you need to know the percentages of total N, organic N, and ammonium N in the waste on a wet-weight basis. If you have your litter or manure analyzed by a commercial laboratory, you can find these percetages on the lab report. Ammonium N may be referred to as mineral N or readily available N. Organic N is total N minus ammonium N.

Commercial laboratories usually report results on a dry-weight (oven dried) basis. Therefore, you will need to multiply lab results by the percentage of dry matter (DM) reported. For example, if 3.9% ammonium N and 20% moisture (80% DM) is on the lab report, 3.9% × 0.8 = 3.1% ammonium N in the fresh sample.

If you do not have a laboratory analysis done, you can use the following estimates for nitrogen on a wet-weight basis:

Total N = 3.1%
Ammonium N = 0.9%
Organic N = 2.2%

Step 1. Determine the amount of N available from poultry waste the first year of application.

1. Multiply the percentage of ammonium N in your waste sample by pounds per ton.

EXAMPLE:
0.009 ammonium N × 2,000 lb./ton = 18 lb. ammonium N in 1 ton of poultry waste.

YOUR ANALYSIS:
____ ammonium N × 2,000 lb./ton = ____ lb./ton.

2. Calculate the amount of ammonium N remaining after gaseous losses due to spreading. This is based on your method of application. Use the following factors to calculate the loss:

Factor	Method Of Application
0.75	Broadcast with no incorporation or incorporated after 7 days
0.80	Incorporated within 7 days
0.90	Incorporated within 4 days
0.95	Incorporated within 2 days

EXAMPLE (using broadcast with no incorporation):
18 lb./ton × 0.75 = 13.5 lb. ammonium N available per ton of waste applied.

YOUR FACTOR:
____ lb./ton × ____ (your factor) = ____ lb./ton.

3. Calculate the amount of organic N available the first year. Since only half of the organic N becomes available during the year of application, multiply the percentage of organic N in your waste sample by pounds per ton and by 0.5 (one-half).

EXAMPLE:
0.022 organic N × 2,000 lb./ton × 0.5 = 22 lb. organic N in 1 ton of poultry waste available the first year.

YOUR ANALYSIS:
____ organic N × 2,000 lb./ton × 0.5 = ____ lb./ton.

4. Add the factored amount of ammonium N available to the amount of organic N available the first year. This gives you the total amount of N available to your crop from poultry waste the first year you apply it.

EXAMPLE:
13.5 lb./ton ammonium N + 22 lb./ton organic N = 35.5 lb. total N in 1 ton of poultry waste available the first year it is applied.

YOUR TOTAL:
____ lb./ton ammonium N + ____ lb./ton organic N = ____ lb./ton.

If you have not applied poultry manure to your fields before this crop year, move to Step 3. If you have applied poultry manure the preceding year, complete Step 2.

Step 2. Determine the amount of N available from the previous years of application.

Only 50 percent of the organic N in poultry waste is available for use the first year. The remainder becomes tied up in the soil organic matter. However, another 12 percent becomes available as residual N the second year, and 5 percent becomes available two years after application. Calculate the amounts of residual N available in your fields from previous poultry waste applications.

1. Multiply the percentage of organic N in your waste sample by pounds per ton.

EXAMPLE:
0.022 organic N × 2,000 lb./ton = 44 lb. organic N in 1 ton of poultry waste.

YOUR ANALYSIS:
____ organic N × 2,000 lb./ton = ____ lb./ton.

2. Multiply the tons per acre of poultry waste applied to your field during the previous year by the pounds per acre organic N by 12 percent to find how much residual

Poultry By-Product Management

AGRONOMY

ALABAMA COOPERATIVE EXTENSION SERVICE, AUBURN UNIVERSITY, ALABAMA 36849-5633

Managing Broiler Litter and Fertilizers

Charles C. Mitchell, *Extension Agronomist*
James O. Donald, *Extension Agricultural Engineer*

Much has been said and written about the tremendous quantities of broiler wastes produced in Alabama and the potential problems and opportunities created by this agricultural resource. The use of broiler litter as a feed source for beef cattle has given cattlemen an abundant, inexpensive source of protein and minerals. However, the greatest opportunities exist in the proper use of broiler litter as an alternative source of plant nutrients on cropland, hayfields and pastures. This is where most of it has been applied in the past. However, excessive application of broiler litter on some soils overlying shallow aquifers or near streams has led to suspected water quality problems. High levels of nitrates and bacteria have been found in some wells, springs and surface waters in northern Alabama. Nutrient enrichment of surface waters with phosphorus can also occur where excessive phosphates have been applied in broiler litter and the land is not protected from erosion.

Figure 1 emphasizes the fact that broiler litter production has increased dramatically since the mid-70s. Broiler production is expected to experience even more growth within the next few years in Alabama. At the same time, fertilizer consumption has decreased to the lowest level in more than 20 years as cropland acreage drops.

Nitrogen Needs and Use

Nitrogen (N) is the primary nutrient of environmental concern in poultry waste. Nitrogen applied in excess of crop uptake is ultimately susceptible to leaching into ground water or runoff into streams. Nitrogen is also the most expensive fertilizer nutrient growers must apply and the nutrient needed in largest quantities by non-legume crops. We know where poultry production is concentrated (Figure 2). This happens to be in some counties where little cropland exists for disposal. Table 1 shows that of the 12 leading broiler producing counties in Alabama, 6 produce more than twice as much nitrogen in broiler litter as the total crop needs in that county.

The 12 leading poultry producing counties except Covington and Lawrence produce more nitrogen in broiler litter than is used annually in all the fertilizers applied in that county. For the entire state, 37 percent as much nitrogen is produced in broiler wastes as in all the commercial fertilizers used. For the state as a whole, we are not using enough nitrogen fertilizers to meet the demand for the major row crops and hay crops. This nitrogen deficit would be magnified considerably if pastures and non-farm uses were considered. However, the crop nitrogen needs in Table 1 do not take into consideration pastureland and non-farm uses of fertilizer nitrogen because statistics are not available for these demands. Nevertheless, when nitrogen in broiler litter is added to nitrogen used as fertilizer, there is a surplus of almost 28 thousand tons of nitrogen in Alabama. This figure grows much larger when other animal wastes from poultry layers and breeders, swine, dairies, and cattle feedlots are added.

Phosphate and Potash Needs and Uses

A similar story is revealed for fertilizer phosphate, potash, and broiler litter (Table 2). Again, all major broiler producing counties except Covington and Lawrence produce more phosphate (P_2O_5) in broiler litter than is used in commercial fertilizers. Soil samples from these broiler producing counties indicate a high per-

Poultry By-Product Management Handbook

- Manure Management and Utilization
- Disposal of Farm Mortalities
- Farm Planning and Enhancement
- Vector Control

Poultry By-Product Management Handbook
Contributing Authors

Section 1

Policy and Resource Information

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Alabama Department of Public Health

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Soil Conservation Service

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Alabama Department of Environmental Management

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Agricultural Stabilization and Conservation Service

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Section 6

Poultry Waste Management and Environmental Protection Manual

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Soil Conservation Service

FOR MORE INFORMATION...

Alabama Poultry & Egg Association, Inc.

Agency's Tie With The Poultry Industry

The Alabama Poultry & Egg Association is a not-for-profit trade organization representing all phases of the broiler, egg, and turkey industry in Alabama. The Association works for the industry in the areas of legislation, research, education, public relations, media relations, and product promotion to provide services and programs not available outside the Association. Programs are changed according to the needs of the industry.

AP&EA is committed to providing the services necessary to keep the poultry industry in Alabama a world leader in poultry production.

Services Available To Poultry Growers

AP&EA is the poultry producer's voice in the state legislature as the Association works to protect the interests of the poultry farmer especially in the areas of state sales tax exemptions and fair utility rates. In addition to the educational seminar held during the AP&EA convention, the Association sponsors other educational meetings as needed.

At present 14 county poultry and egg associations are affiliated with AP&EA. The purpose of these county organizations is to promote the poultry and egg industry and to provide the opportunity for exchange of information on the county level. AP&EA is acutely aware of the need for sound environmental programs and has been at the forefront of the effort to develop an acceptable plan for Alabama.

Contact

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Executive Director
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(205) 734-3353

FOR MORE INFORMATION...

Agricultural
Stabilization and Conservation Service

Agency's Tie With The Poultry Industry

The National program objectives of the Agricultural Conservation Program (ACP) are to assure a continued supply of food and fiber necessary for a strong and healthy people and economy; and to facilitate sound resource management systems through:

- Conserving the soil, water, and related natural resources.
- Controlling erosion and sedimentation from agricultural land.
- Controlling polution from animal wastes.
- Encouraging voluntary compliance by agricultural producers with state and federal requirements to solve point and non-point sources of polution.
- Improving water quality: encouraging enduring conservation and environmental measures and practices rather than those that are primarily production oriented or that have little or no conservation or polution abatement benefits.
- Helping achieve national priorities as set forth in the National Environmental Act.

ASCS interfaces with producers involved in the poultry industry by offering through ACP a cost-sharing practice to assist in solving erosion and water quality problems as a result of non-point source polution.

Services Available To Poultry Growers

ASCS has the authority to offer cost-sharing up to 60 percent of the cost to construct facilities to handle and/or store poultry waste. The size of the facility is based on the operation and the number of acres on which to spread the waste. The purpose of the practice is to solve a water quality problem by permitting the waste to be returned to the land in the operation. Producers who have been in business less than five years or who have substantially enlarged their operation in the last five years are not eligible for assistance. Facilities include lagoons, dry-stacks, and composting units. Eligibility is based in part on those practices that are carried out on a voluntary basis. A practice installed as a result of a written advisory notice of a needed action (local, state, or national) would be considered voluntary. However, when the administering authority notifies the producer in writing that specific action, such as fines or closing the operation, will be taken, this is considered an *involuntary* action and would not be eligible for cost-sharing.

Contact

Contact the ASCS office in the county in which you reside, or contact the state office to obtain information for your county.

Joan G. Grider
Acting State Executive Director
Agricultural Stabilization and Conservation Service (ASCS)
United States Department of Agriculture
P. O. Box 891
Montgomery, AL 36101-0891
(205) 223-7230

FOR MORE INFORMATION...

Alabama Department of Agriculture and Industries

Agency's Tie With The Poultry Industry

The Alabama Department of Agriculture and Industries, through the Animal Industry Division, is charged with controlling, eradicating and preventing the spread of contagious and infectious diseases of poultry through the proper destruction and disposal of dead poultry, unhatched or unused eggs and other poultry waste by requiring commercial growers of poultry and commercial hatcheries to be equipped with and use disposal facilities. The authorizing legislation can be found in the Alabama Code (1975).

Services Available To Poultry Growers

The Department will provide information on the proper construction and use of disposal facilities. Disposal facilities for the disposal of poultry mortalities include approved disposal pits, composters, and incinerators. Disposal pits must meet the construction specifications as outlined by the State Board of Agriculture and Industries; other methods must meet the appoval of the State Veterinarian (Chapter 80-3-20 of the Alabama Administrative Code). Composters should be built according to specifications as outlined by the Alabama Cooperative Extension Service. Incinerators should meet both federal Environmental Protection Agency and Alabama Department of Environmental Management standards. Failure to meet these specifications for on-site disposal facilities or failure to use disposal facilities properly can result in the issuance of a quarantine. No poultry, eggs, or other poultry products can be moved from the quarantine premises until inspected and until approval to remove them has been given by the Commissioner of Agriculture, the State Veterinarian, or their agents. The Department also holds the authority to issue licenses to those who sell poultry litter as livestock feed. Licenses are issued through the Agricultural Chemistry Division.

Contact

Dr. J. Lee Alley
State Veterinarian and Director, Animal Industry Division
Alabama Department of Agriculture and Industries
P. O. Box 3336
Montgomery, AL 36109
(205) 242-2647

FOR MORE INFORMATION. . .

Alabama
Department of Environmental Management

Agency's Tie With The Poultry Industry

The Alabama Department of Environmental Management (ADEM) is involved in the regulation of the poultry industry with respect to the discharge of pollutants and protection of the environment. Animal waste and dead bird disposal are two of Alabama's critical environmental concerns that require frequent interaction with the poultry industry.

Services Available To Poultry Growers

Interaction with the poultry industry is handled in two ways: Industrial facilities such as hatcheries and processing facilities are generally regulated under one or more permit programs, while broiler and layer operations are inspected on the basis of citizen complaints or known or suspected problems. Upon receipt of a complaint ADEM personnel will inspect a facility to determine the state of compliance with the appropriate environmental laws and regulations. Since producers are required to manage their facilities to prevent adverse environmental effects, problems observed during inspection must be resolved to prevent further legal liability.

ADEM also provides guidance in environmentally acceptable practices as well as providing interpretation of specific regulatory requirements. Growers are encouraged to contact ADEM for assistance whenever a question of environmental concern arises. ADEM has also provided a list of approved incinerators for the disposal of dead birds.

Contact

Timothy S. Forester, Chief
Mining and Nonpoint Source Section
Alabama Department of Environmental Management
1751 Cong. W. L. Dickinson Drive
Montgomery, AL 36109
(205) 271-7825

FOR MORE INFORMATION...

Alabama Department of Public Health

Agency's Tie With The Poultry Industry

The health department interfaces with the poultry industry in abating public health nuisances, usually related to litter control and flies. The local health department should be the first local contact to assist the industry with complaint investigation and abatement.

Services Available To Poultry Growers

The Department consults with industry in the handling of eggs, litter, and dead bird disposal as they relate to public health nuisances; assists other agencies with coordinated approaches at individual sites for nuisance control; and assists with program development for industry training upon request.

Alabama Department of Public Health Contact

James W. Cooper
Director, Bureau of Environmental & Health Service Standards
434 Monroe Street, Room 250
Montgomery, AL 36130-1701
(205) 242-5004

Area Contacts

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FOR MORE INFORMATION...

Alabama
Soil and Water Conservation Committee

Agency's Tie With The Poultry Industry

The state Soil and Water Conservation Committee is responsible for providing coordination and leadership to each of the state's 67 Soil and Water Conservation Districts. The Committee advises the Alabama Agricultural and Conservation Development Commission (AACDC) on standards, specifications, and expected life of cost-share conservation practices eligible for grants under the AACDC Cost-Share Program. The state Committee provides assistance to the districts in carrying out their local programs. The Committee also keeps the districts informed and facilitates information exchange, coordinates programs, disseminates information, and secures cooperation with other agencies.

Each Soil and Water Conservation District determines the direction of its program at the local level. There is a district office in each of the 67 counties in the state. The local district is the contact point for the poultry producer to make application for cost-share and other assistance.

Services Available To Poultry Growers

Financial assistance for conservation practices is available to qualified applicants through the Alabama Agricultural and Conservation Development Commission's Cost-Share Program. Monies received by the Commission from legislative appropriations are allocated to the state's 67 Soil and Water Conservation Districts by the state Soil and Water Conservation Committee. Cost-share assistance is limited to $3,500 or 60 percent, whichever is less, per applicant, per program year. Cost-share practices available to poultry growers include dead bird disposal pits, small animal incinerators, manure dry stack facilities, dead bird composters, and animal waste control facilities. Technical assistance for these practices is provided by the USDA Soil Conservation Service. Also available is assistance in developing suitable waste management plans for poultry operators.

Under Section 319 of the Water Quality Act, several demonstrations will be implemented which will deal with poultry waste management during the next years.

Contact

James J. Plaster, Executive Secretary
State Soil & Water Conservation Committee
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FOR MORE INFORMATION...

Tennessee Valley Authority Agricultural Institute

Agency's Tie With The Poultry Industry

The overall objective of the Tennessee Valley Authority's (TVA) Agricultural Institute, headquartered at Muscle Shoals, Alabama, is to develop and implement programs and activities that will further develop agriculture and agribusiness within the 16-county TVA region of northern Alabama. Much of the Institute's work is accomplished in cooperation with other agencies and institutions such as Auburn University's Extension and Research Divisions. The poultry industry is an integral part of the agricultural economy in the TVA region of northern Alabama. Institute programs and projects have been developed and implemented to ensure the continued expansion and success of the poultry industry in an environmentally sustainable manner.

Services Available To Poultry Growers

The Institute's programs and projects primarily deal with helping prevent or reduce impacts of the industry on the environment. This is being accomplished through educational workshops and demonstrations in cooperation with other state agencies to focus on preventing or reducing the environmental impacts of by-products produced by the poultry industry. Current project areas are: composting dead poultry; animal waste lagoon management; production and marketing of poultry litter products for use as a soil amendment, fertilizer, and cattle feed; creating agribusinesses that will produce and market poultry litter products; and conducting research and demonstrations that show correct use of poultry litter in various crop production systems. Much of this work is done in cooperation with the Alabama Cooperative Extension Service at Auburn University. The Institute has also supported several educational demonstrations on poultry producers' farms and with agribusiness firms to accomplish these described objectives.

Contact

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Tennessee Valley Authority
NFE 2L
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(205) 386-2887

FOR MORE INFORMATION. . .

USDA
Soil Conservation Service

Agency's Tie With The Poultry Industry

The role of the Soil Conservation Service is to provide technical assistance to the poultry industry in the planning, design, and implementation of waste management systems and dead bird disposal practices on poultry farms in Alabama.

Services Available To Poultry Grower

The SCS provides planning, design, and construction assistance on waste treatment lagoons, manure dry stack facilities, composter units, incinerators, dead bird disposal pits, and waste disposal plans based upon soils, crops, and equipment available; serves as technical representative for cost-share programs to implement waste management and dead bird disposal systems; and provides financial assistance in special project areas in support of technical assistance described above.

Contact

District Conservationists are located in each county in state (Coosa/Tallapoosa Counties in joint office).

Ray E. Donaldson
Assistant State Conservationist (Operations)
USDA - Soil Conservation Service
P. O. Box 311
Auburn, AL 36830
(205) 821-8070

Manure Handling and Neighbor Relations

- don't stack manure next to roadways
- spread manure as far from neighbor's house as possible
- avoid spreading on higher ground if there are neighbors at a lower elevation
- prevent spilling on roadways or elsewhere
- always consider wind direction and weather conditions when spreading
- spread in the morning for better odor dissipation
- always incorporate manure into the soil as soon as possible
- be especially thoughtful of sensitive neighbors

Managing Poultry Manure

There has been a great deal of discussion about poultry manure of late. These discussions are concerned with its overabundance, difficulty in finding farmers to use it, and its potential effect on ground water. All of these concerns are important while definitive answers have not come easily.

These concerns differ depending on the point of view. The producers' primary concern is to move this product away from the farm, usually by spreading it on crop land. The purchaser is concerned about the nutrient value of this product to the crop being produced. All of us need to be concerned about its potential effect on ground water.

With proper manure management, concerns about ground water contamination should be alleviated. There are four basic steps to proper manure management and reduced possibility of undesirable runoff.

1. Have the soil tested in the area where the manure is to be spread. This provides baseline data to determine the nutrient needs necessary for maximum crop yields.

2. Determine the crop nutrient requirements so the proper amount of manure can be applied. Precise application will result in the highest crop yields.

3. Determine the nutrient levels in your poultry manure. This is a very important step because the nutrient value of poultry manure is highly variable. Differences occur due to litter type, moisture level, diet of the birds, and clean-out practices.

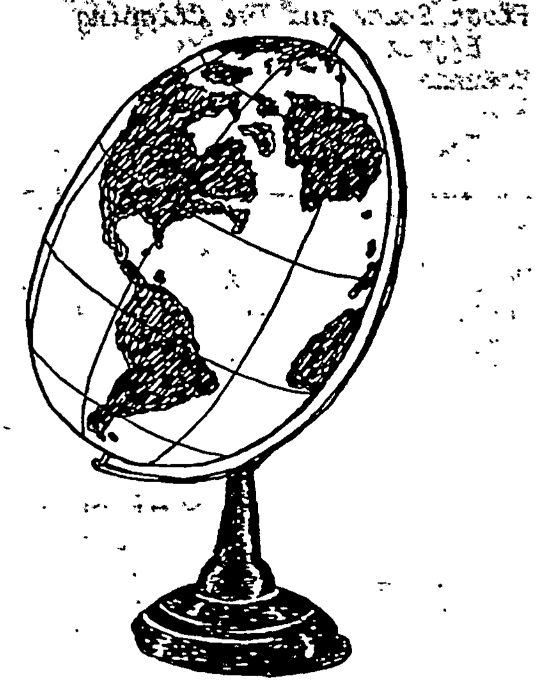
4. Storage and application of manure can make or break its usefulness. Ideally, manure should be stored either in a storage barn or under black plastic. In this way the nutrients are protected from the weather and remain in the manure instead of leaching into the soil, thus being lost to the crops and possibly contaminating the ground water. Money is available to help defray the cost of manure storage facilities. Contact the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS) for more information.

Manure must be applied correctly to obtain the maximum benefit of its nutrients. It must be applied at the proper time and at the proper rate for best results.

Keeping these practices in mind, proper manure management can benefit all concerned, poultry and crop grower alike.

— J. C. Hermes

Reference: Issacs and Harris, Proper Manure Management: A key to tomorrow's success. Delaware Cooperative Extension publication.



The University of Georgia
Cooperative Extension Service
College of Agriculture/Athens, Georgia 30602

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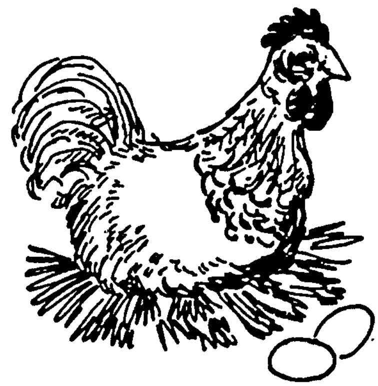

COMMERCIAL EGG TIP . . .

WASTE MANAGEMENT COMPREHENSIVE PLANNING NEEDS

Disposing and using poultry waste is a major challenge to the poultry industry. It will continue to be an issue because the conflict between intensive animal agriculture and urban development shows no indication of lessening. Waste management involves three areas of environmental concern: **solid waste disposal, pollution of surface and ground water,** and **air pollution.** The shear volume of waste, plus its concentration on smaller land areas, magnify its environmental impact.

Odors from poultry facilities are not dangerous pollutants. When odors are a problem, we classify them as nuisance pollutants. Surburban neighbors, however, are using odors as a focal point to increase state and local regulations affecting agriculture.

Waste management must have high priority. Every animal-based agriculture operation must have a comprehensive waste management plan to contend with animal waste before it is produced by the animal. This not only reduces the risks associated with the use and disposal of animal wastes, but also provides both economic and environmental benefits such as:

*reduced commercial fertilizer costs,
*improved soil tilth and productivity,
*protected water resources and air quality.

Improperly managed wastes, however, sustain certain risks:
*pollute water resources and air,
*lose fertilizer value,
*generate removal expenses instead of financial benefit,
*create a negative social and regulatory environment for agriculture.

Organic wastes originating from poultry production have several potential end uses including land application, production of "biogas" for on site heating, and off-site use of wastes as fuel or feed. The most common practice at present is land application.

A sound waste management plan requires careful attention to details. It uses principles from agricultural engineering, agricultural economics, poultry science, and crop and soil sciences. Together they maximize the economic value of wastes and minimize the risk of environmental damage. The Cooperative Extension System and the Soil Conservation Service through local conservation districts, offer assistance in the development of these plans.

Animal Agriculture's Effect on Water Quality
Pastures and Feedlots

Alan L. Sutton, Department of Animal Sciences

Indiana's Farm Animal Industry

Animal agriculture in Indiana makes a significant contribution to the supply of meat, milk and eggs for consumption in our nation and abroad and supplies a considerable amount of revenue to the state. In 1988, sale of livestock and livestock products in Indiana equalled $1.74 billion. Livestock sales made up 42.5 percent of the $4.1 billion total of all agricultural commodities in the state (Figure 1).

Animal manures are a natural by-product of the livestock industry. Animal wastes must be handled, stored, utilized and/or disposed of in an efficient way while maintaining or improving the quality of the environment. Many factors affect the pollution potential of animal waste. Nutrient content of animal waste varies with collection, storage and application methods. Climate conditions also contribute to the effect animal waste might have on water supplies.

Possible contaminants from animal waste include: nitrogen, phosphorus, inorganic salts, carbon compounds and microorganisms. This bulletin discusses possible water pollution problems from pasture and feedlot systems and the management practices needed protect water supplies.

Pasture Systems

Pasture and range systems still make up a major portion of livestock production in Indiana. To illustrate: feeder calves are produced almost exclusively from cow-calf enterprises on pasture and range systems; a substantial portion of swine production (both feeder pig and farrow-to-finish) is still accomplished on pasture; most dairy farms utilize pasture when seasonal conditions permit; and sheep production is mainly a range and pasture operation.

Grazing animals deposit manure directly on the land in pasture management systems. Though a pasture may be relatively large, manure may become concentrated near feeding and watering areas. Often near flowing streams, these areas can quickly become barren of plant cover, increasing the possibility of contaminated runoff.

There is very little research on the extent of non-point pollution from pasture systems. From the few studies reported, streams near pastures and ponds where cattle had access, showed only a slight increase in bacteria and carbon compound levels.

Good management is the best insurance against pollution of water from pasture or range systems of livestock production. "Good management" guidelines include the following:

1. Prevent manure buildup in any one area by maintaining an adequate land-to-livestock ratio.
2. Maintain a highly productive forage on the land to slow runoff, entrap manure and utilize nutrients.
3. Plan a rotation system of grazing to prevent overgrazing and soil erosion.
4. Locate feeders and waterers a reasonable distance from streams and water courses. Move them to new locations before livestock wear paths by repeated trampling.
5. Provide shade in summer, using trees or artificial shelters, to reduce the need for animals to enter water for heat relief.
6. Fence animals away from ponds and streams if domestic water supplies use surface water.

Feedlots

Open feedlots are a potential point source of water pollution. Point source pollution problems can occur when an open feedlot makes no provisions for runoff control or if manure management facilities are mismanaged, poorly designed or constructed.

To protect Indiana's waterways, the state legislature in 1971 enacted the Indiana Confined Feeding Control Law requiring operations above certain sizes, or those identified as polluters, to obtain approval for their manure management systems. Approval is the responsibility of the Indiana Department of Environmental Management (IDEM). The law requires livestock operations, subject to the law, provide: (1) adequate storage capacity for feedlot runoff and manure to permit timely disposal on the land, and (2) adequate equipment and land for manure disposal.

Animal Waste Management

John M. Sweeten, Charles Baird and Leah Manning*

Livestock and poultry production can contribute to excess nutrients (nitrogen and phosphorus), organic matter, salts and pathogens in surface water and in underground aquifers. Potential sources of pollution include confinement buildings, unpaved feedlots, runoff holding ponds, manure treatment and storage lagoons, manure stockpiles and fields on which manure and wastewater are applied. Other sources are manure accumulations around livestock watering locations, intermittently used stock pens and insecticide spray equipment, dipping vats and disposal sites (for waste pesticide, rinsate or containers). Livestock grazing operations, from sparse rangelands to intensively stocked pastures, also may influence the water quality of streams and aquifers.

Best Management Practices

Best management practices (BMPs) for livestock are needed for a wide range of conditions: sparse rangelands; irrigated and grazed pastures; animals watering in or adjacent to streams; and cattle feedlots.
There is a vast difference in water pollution potential between (a) open rangeland on which annual manure deposition is about 1/10 ton of manure solids and 8 pounds of nitrogen per acre, versus (b) an open feedlot surface that receives about 300 tons of manure solids and 24,000 pounds of nitrogen per acre per year.

Unconfined Livestock Operations

In evaluating unconfined livestock operations, both the quality of runoff water, characterized as concentration (milligrams per liter, mg/l or ppm), and the annual mass yield (lbs/acre/year) of manure constituents should be considered. Pollutants become dissolved in runoff as rainfall erodes the soil surface. The concentration of pollutants is influenced by vegetative cover, which is affected by grazing density. The higher the volume of runoff from land with sparse vegetative cover, the greater its capacity to transport sediment, organic matter and nutrients. Another publication in this series deals with nonpoint source pollution from grazing land.

Runoff and drainage from open livestock lots, including barnyards, can increase phosphorus and potassium levels in the soil for a considerable distance downslope, as compared to the levels on sites not affected by livestock wastes. Research in Wisconsin showed soil phosphorus levels averaging 480 ppm at 300 feet downslope of two dairy barnyards in a drainage waterway soil, as compared to soil phosphorus levels averaging 200 ppm at the same distance but out of the waterway (Motschall and Daniel, 1982). And at 1,200 feet downslope from the dairy lots, waterway soils had 150 ppm phosphorus as compared to 70 ppm in the adjacent, unaffectedsoil areas.

Grazing livestock sometimes cause elevated bacterial counts in streams even though nutrient loads may be small (Robbins, 1978). Watering and feeding sites should be located away from streams and reservoirs, especially if they are used for recreation (Sweeten and Melvin, 1985).

When water high in nitrates filters through the soil, groundwater can become contaminated. Livestock producers should protect wellheads to prevent entry of surface contaminants. If cavities develop around the well head, contaminated surface drainage or soil water can enter the aquifer.

Concentrated Animal Feedlot Operations

Confined, concentrated animal feeding operations (feedlots) have far greater potential to cause water quality problems than pasture operations, unless properly designed water pollution abatement systems are installed

(Sweeten, 1990).

The Texas State Soil and Water Conservation Board (TSSWCB) lists the following BMPs for feeding operations considered to be nonpoint pollution sources (Texas Water Commission and Texas State Soil and Water Conservation Board, 1988):

1. Proper location of livestock concentrations

2. Proper management of solid and liquid manure

3. Runoff control

4. Land disposal of wastes

Site selection is one of the most important factors in preventing water and air quality problems from livestock feeding facilities. Key factors to consider in site selection are listed in Table 1. Proper site selection includes consideration of slope (topography), location relative to flood plains, geology, land area for manure and wastewater applications, land use, and proximity to neighbors.

Texas Water Commission Regulations

Livestock feeding operations considered to be point sources of pollution are subject to specific state and federal regulations. In April 1987, the Texas Water Commission (TWC) adopted a regulation that stated the following no-discharge policy: "...there shall be no discharge of waste and/or wastewater from concentrated animal feeding operations into the waters in the state, but rather that these materials shall be collected anddisposed of on agricultural land."

The TWC definition contains four visually-determined conditions necessary for a facility to be regulated as a feedlot (point source): (a) an enclosure--corral or building; (b) presence of livestock; (c) feeding of those livestock; and (d) sufficient animal density to prevent crop and forage growth. These characteristics integrate the effects of factors such as animal density, animal species, soils, slope and management practices.

The TWC regulation requires livestock and poultry producers to obtain a permit if they have more than 250 milking cows, 1,000 beef cattle, 1,500 swine, 600 horses, 6,000 sheep or goats or 30,000 laying hens in a concentrated animal feeding operation. Operators of smaller facilities are regulated by rule and must meet the same requirements of the TWC regulations for keeping manure and wastewater out of streams.

Specifically, the 1987 regulation requires producers to protect surface and groundwater and to apply manure and wastewater on land. Required surface water protection measures consist of diverting off-site drainage around the feeding facility, constructing minimum storage capacity for manure and process generated wastewater, and constructing adequate runoff storage capacity.

Rainfall runoff from open lots and other manure contaminated surfaces must be collected in holding ponds designed to contain all runoff from the 25-year, 24-hour duration storm, plus accumulated sediment and process generated wastewater. Minimum storage capacity for process generated wastewater was specified for different locations in the state. Runoff holding ponds and lagoons must be located out of the 100-year flood plain. They must be drained by irrigation, evaporation or some combination of the two to restore the design capacity within 21 days after a rain. Holding ponds and lagoons must be sealed with at least 1 foot of compacted clay that meets the TWC specifications based on soils engineering tests. Systems for runoff control, wastewater treatment and storage and irrigation should be designed by a professional engineer.

A water balance based on monthly inflows of wastewater, runoff and rainfall and monthly outflows of evaporation and irrigation should be used to check the adequacy of lagoon and holding pond capacity and adjust it if necessary. Similarly, a nutrient balance, using predicted crop uptake rates and soil nutrient status, is needed to determine proper application rates and the amount of land needed for application and utilization of manure and wastewater.

Regulations for Dairy Farms

The TWC adopted additional regulations in June, 1990 that require all dairies to register. In addition, TWC stipulated thatcertain best management practices be used on those dairies that do not need to get a permit at this time. One category of BMPs deals with decreasing lot runoff volume to reduce the size of required holding ponds and irrigation facilities. This can be done by diverting clean runoff around the facility with ditches and terraces, installing roof gutters, covering open lots with roofs and reducing open lot surface area. The latter may necessitate surfacing pens or collecting manure and more frequently, abandoning pens that do not allow wastewater collection. A second category of BMPs deals with decreasing wastewater volume by properly maintaining the watering system, reducing water used for cooling or cleanup and recycling wastewater from lagoons and holding ponds in lieu of using fresh water. A third kind of BMP is aimed at capturing rainfall runoff according to TWC stipulated design criteria and uniformly apply collected runoff on land. A fourth BMP category calls for minimizing solid manure transport by locating manure stockpiles (if used) away from waterways; installing adequate manure storage structures; using appropriate rates and times for manure application; providing grass filter strips along waterways; and using off-site areas for manure application. The fifth BMP mentioned is the protection of groundwater by locating lagoons and ponds at least 150 feet from water wells and leaving a buffer area around water wells.

In the interim until a permit is issued, the dairy is to install and manage runoff control facilities to contain at least 70 percent of the potential runoff from the 25-year, 24-hour storm. Some leeway is given for multiple storms within a 7-day period.

Other Design Considerations

While decreasing the size of open lots will reduce runoff volume by a proportionate amount, it also increases stocking density, moisture production and the potential for mud problems. It may also necessitate surfacing the pen and collecting manure more often.

Open lots should not be placed in areas where annual precipitation plus predicted manure moisture deposition equals or exceeds annual evaporation. Pasture operations or confinement buildings such as free stall barns are usually preferable to open lots in high rainfall areas. Proper system design is essential to meeting regulations and reducing pollution.

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Avoiding Stream Pollution from Animal Manure

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Animal manure is well-recognized as a fertilizer and soil conditioner. Adding manure to the soil has agronomic benefits through the addition of plant nutrients (nitrogen, phosphorus and potash) and organic matter. These same nutrients that are beneficial in soil for plant growth are considered pollutants in water. The objective of any manure land application system must be to keep manure on the soil, where it has value /, and out of water where it is a pollutant.

Pollutant Types

Ammonia is the most damaging water pollutant in manure. If conditions are right, the effects of ammonia in a stream can be recognized within a few minutes. Ammonia is very toxic to fish. Even very small amounts of ammonia released to a stream can cause a fish kill.

The toxicity of ammonia to fish depends on three factors: pH, water temperature and oxygen content. The higher the pH of the water, the smaller the amount of ammonia needed to kill fish. The higher the temperature of the water, the smaller the amount of ammonia needed to kill fish. Because of the temperature factor, ammonia discharged to a stream that may not kill fish in the winter could result in a fish kill in the summer. In addition, the lower the dissolved oxygen content of the water, the smaller the amount of ammonia needed to kill fish.

Organic matter discharged to a stream may kill fish. However, the effect is slower than with ammonia. As organic matter is "broken down" or decomposes, the oxygen in the water is used up. Therefore, less oxygen is available to support fish and other aquatic life.

The rate at which a stream can recover from a discharge of organic matter depends on its volume, flow rate, turbulence and water temperature . Large streams can accept more organic matter without adverse affects than can small streams because of dilution. Rapidly flowing, turbulent streams can recover faster from a discharge of organic matter because of reaeration as the water moves downstream. The effect of adding organic matter to cold water is less than warm water because cold water can hold more oxygen. Also, decomposition of organic matter is slower at colder temperatures. The worst possible situation is to discharge organic matter into a small, slowly moving stream on a hot day.

Nutrients do impact the streams that receive them. The major damage or effect is most often noticed once the nutrients reach a stagnant portion of the stream, a lake or a pond. The plant nutrients nitrogen and phosphorus do a good job of growing plants both on land and in water. Lakes rich in nutrients are called eutrophic and are green with algae and aquatic plants.

Bacteria from livestock manure rarely causes health problems for people or animals, but the potential is there. Diseases are often transmitted in people and animals through the fecal/oral route. Disease-causing organisms may be present in the waste of an infected animal. If the organism is ingested by another animal, through food or water, the animal is exposed and risks being infected. Fortunately, disease-causing organisms do not thrive in the soil or water and are filtered out and die off. Therefore, it is important to maintain adequate separation distances between the

potential pollutant and the water source. This provides an opportunity for disease-causing organisms to be filtered out and die off before reaching food and drinking water supplies.

Color is a pollutant not often considered. Water can be stained by animal manure, giving it a brown or reddish appearance. The color may not pose a water quality problem, but may alarm people using the water for recreation or water supply.

Preventative Measures

Avoiding stream pollution from manure is not difficult. Common sense is the rule to follow when handling manure. The principles of proper manure management and land application are presented in AEX 704, Land Application of Manure and Wastewater (part 1). These principles include:

1 Maintain separation distances and buffer areas between land used for manure application and surface water drain-age. With no slope a minimum buffer distance of 10 feet of vegetated ground or 25 feet of bare ground from streams and 6 ditches is recommended (Figure 1). On frozen ground, 60 feet of vegetated ground or 150 feet of bare ground is recommended (Figure 2). Greater setbacks are recommended on sloping ground.

2. Restrict surface application of manure on sloping ground when it is frozen or just prior to rain.

3. Take care when applying manure to fields with subsurface drainage, especially when the soil is dry and cracked. It is advisable to till the soil prior to application if cracks are present. All "blow holes" in the drainage system must be repaired prior to application. Surface inlets and french drains must be avoided.

4. Limit one-time application volumes of liquid manure to the amount of moisture needed to bring the soil up to field capacity. Heavy applications can result in puddling and runoff.

5. Limit application of manure nutrients to crop need. Excess application results in buildup of soil nutrients.

6. Test manure and soil to determine appropriate application rates.

Ohio Regulations

The Ohio Water Quality Standards (Ohio Administrative Code 3746-1-04) specify that all surface waters of the state must be free from the following pollutants as a result of human activity. suspended solids, floating debris, color, odor, toxic substances and nutrients that create nuisance growths of aquatic weeds and algae.

The discharge of pollutants to the state's waters is regulated by the Ohio Environmental Protection Agency through the National Pollution Elimination permit system (NPDES). This applies to any controlled, direct discharges of animal waste to waters of the state regardless of operation size.

Dischargers of pollutants may be liable for civil penalties of up to $10,000 for each day of violation (Ohio Revised Code 6111.07). In addition, criminal penalties can be assessed upto $25,000 or up to one year of imprisonment or both (Ohio Revised Code 6111.99). The Ohio Environmental Protection Agency also issues Permits to Install (PTI) on all

livestock operations of more than 1,000 animal units.

The Ohio Department of Natural Resources has pollution abatement responsibilities for livestock operations of less than 1,000 animal units. This program is administered through the Division of Soil and Water and the Soil and Water Conservation Districts.

The legislature has also directed the Ohio Department of Natural Resources Division of Wildlife to protect the wild animals of the state. Anyone found to be discharging pollutants to the state's water can be found in violation of the "Stream Litter Act" and fined up to $500 or sentenced to 60 days in jail, or both, for a first offense. If fish are killed as the result of a pollutant discharge, the party responsible is charged for all damages including the value of the wildlife killed, environmental damages and the costs of investigation. Current market prices are used to set the value of the animals.

In 1989,1 6 fish kills in Ohio were caused by animal manure, resulting in the death of more than 20,000 fish and animals. Animal manure was also cited in 19 other pollution investigations that did not result in wild animal deaths. In 1989, agriculture led industry, transportation, municipal government and public service enterprises in the number of wild animals killed.

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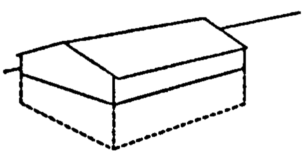
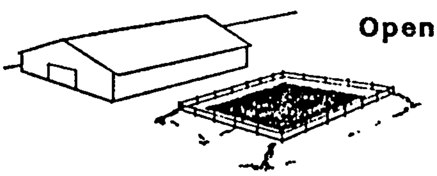
Agricultural Engineering

Livestock Safety – Manure Handling and Storage

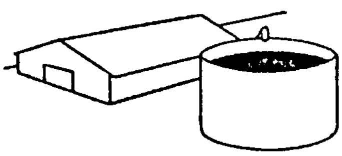
The use of large capacity, on-farm, liquid manure storage facilities has become a common practice in recent years. These include tanks located directly underneath the livestock housing area, storage located away from the livestock housing area in open lagoons or ponds, and above ground silo-type storage tanks. While this practice has greatly increased the efficiency of manure handling, it has also introduced many potential hazards. Of these three types, underground storage is the most hazardous.



Underground Storage



Open Lagoon Storage



Above Ground Storage

Safety Hazards

When animal waste of any type is being stored in large volumes, a number of hazards exist for both the animals and the handler.

The most obvious is the potential danger of drowning. There is also the danger from gases which are produced as the manure is decomposed by bacterial action. This includes gases that are toxic (ammonia), corrosive (hydrogen sulfide), asphyxiant (carbon dioxide), and explosive (methane). Anyone working around animals should be aware of the physical effects of these various gases released during manure decomposition so that a hazardous situation can be recognized immediately.

Designing a Safe Manure Storage Facility

Many safety hazards can be avoided by careful planning when designing or reconstructing a manure handling facility.

The most important consideration when building a manure storage facility is keeping storage volume to a minimum. Also, dividing pits into smaller sections will reduce the amount of agitation necessary.

Pump-out openings for manure pits should be located outside of buildings, and access points should be covered by a heavy cover or gate. These covers should be kept in place at all times. Gas traps should be used in pipelines emptying into outside storages to keep gases from flowing back into the buildings.

North Carolina
Cooperative Extension Service
North Carolina State University
College of Agriculture & Life Sciences

AGRI-WASTE MANAGEMENT

Components of a Complete Manure Management Plan

Existing regulations for animal waste management are generally invoked by the North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management (DEM), in response to citizen complaints about water quality problems after degradation has occurred. DEM believes a more proactive mechanism is needed to help farmers plan and operate animal waste management systems to protect surface and ground water before problems occur. Therefore, DEM is proposing to amend existing nondischarge regulations by establishing minimum criteria to be met before waste management systems serving animal operations are deemed permitted.

While the wording of the above statements is still in the draft stage and subject to be amended, the implication is clear. Within the next few years, every livestock and poultry farmer who has more than 100 animal units will be required to have a complete farm manure management plan utilizing available technology. For many producers this will simply mean documenting those practices already being employed. For others, it will mean proper management or upgrading existing components into a complete and environmentally safe system for managing manure, residuals such as lagoon liquid and sludge, field runoff, and animal mortality. Some components of this plan are briefly outlined as follows.

SITE SELECTION

For new producers or those anticipating significant expansion, site selection is probably the most important single consideration associated with the entire operation. Adjacent land use should remove from consideration those sites near residential developments, commercial enterprises, recreational areas, or other prime areas for non-agricultural uses. Wind direction probability diagrams will help to locate facilities downwind of warm season prevailing winds. The strategic planting of hedge rows or tree barriers at property boundaries serves to shield the production and manure management facilities from direct sight and to reduce wind speed across the facilities allowing any emitted gases more opportunity to rise vertically and dissipate into the atmosphere. A site may seem ideal with respect to transportation, feed supply, accessibility or land ownership, but may be inappropriate because of existing or proposed development.

Soil properties and limitations should be investigated. Soil types with limited permeability which will rapidly seal are desirable for lagoon construction. Coarse sands will probably need to be amended to speed up the sealing process. An erosion control plan to stabilize and maintain a site during construction should be considered. When possible, locate production facilities near the center of a tract of land large enough to allow manure to be applied at agronomic rates. Pollution control and manure management facilities should be located as remotely as possible from areas of high environmental sensitivity such as drainage canals, streams, or natural wetlands. Buildings in flat, high water table areas should be built on pads of earth excavated from the lagoon. Elevating these buildings several feet above ground routes surface drainage away from them and allows flushed manure to flow by gravity to a lagoon built above the water table. Upland

facilities should be built on high ground and as far away fr om water sources as possible to allow wastewater management options.

TYPE OF OPERATION AND ANIMAL INVENTORY

The type of operation (dairy - lactating cow, dry cow, heifer, calf ; swine - farrow-to-weanling, farrow-to-feeder, nursery, finishing, farrow-to-finish ; turkey - brooder flock, grower, breeder ; etc.) affects most manure management practices. The maximum number of animals and corresponding total live weight expected on the farm on any given day is also necessary for most manure management calculations.

TYPE OF PRODUCTION FACILITIES

Different environmental management practices are required for different production facilities and systems. Stock trails and improved stream crossings may be required in vulnerable pasture areas. Fencing of animals from streams in intensively used areas where animals tend to congregate or along highly erodible reaches may be required. Animals maintained on unpaved lounging areas or drylots not supporting vegetation will in some instances require conservation practices to minimize the effects of lot runoff. These animals will most likely be denied direct access to surface waters or wetlands. Partially enclosed facilities with animals on open slabs will also be subject to runoff control. Totally enclosed facilities can affect the production performance as well as potential odors emitted depending on floor surface, ventilation, and manure management. In-house manure collection methods and frequency affect gas and odor levels. Modern manure removal methods such as flushing, pit recharge, and mechanical scr aping have drastically reduced the gas and odor levels inside production facilities.

MANURE STORAGE / TREATMENT FACILITIES

Producers must decide whether their objective is manure nutrient conservation for maximum fertilization or nutrient reduction for ease of management. If nutrient conservation is desired, then scrapers moving manure to outdoor holding tanks or basins, or settling basins prior to lagoons for flushed waste will be needed. Liquid manure spreaders or slurry irrigation systems will move the manure nutrients to large field crop acreages for spreading. If, on the other hand, nutrient reduction prior to land application is desired, then solids separation and/or anaerobic lagoons become very important parts of the overall treatment system. Lagoons, storage basins and holding ponds must be properly sized according to USDA-Soil Conservation Service specifications using correct construction, start-up, and management procedures. When properly planned and managed, lagoons can reduce overall odor levels around a production facility, reduce nutrients to be land applied by up to 85%, provide flexibility for land applica tion scheduling, and have minimal impact on shallow groundwater.

AGRONOMIC PLAN

Manure Characterization Summaries and estimates of manure quantities and nutrient content are available from the N.C. Cooperative Extension Service, USDA-Soil Conservation Service, N.C. Dept of Agriculture, N.C. Agricultural Chemicals Manual, as well as other sources. When no other information is available, such as when planning a new operation, these averages provide "ball park" figures and should be utilized. Existing operations are encouraged to develop individual estimates of the volume of manure, litter, feedlot runoff or lagoon liquid to be land applied, e.g., using water meters to measure the amount of water used in a production facility or by recording the lagoon levels periodically and determining the

accumulated volume. Representative samples of the material to be land applied should be analyzed twice annually for nutrient and mineral content. The N.C. Department of Agriculture provides this service with interpretations of results for a nominal fee.

Crop / Soil Selection   Soil types should be mapped for each field on the farm to receive manure. Soil infiltration rates will often determine maximum irrigation rates or how much lagoon liquid can be applied before runoff occurs. Soil types also determine the fate of unused nutrients. Well-drained sandy soils provide more potential for unused nitrogen to convert to nitrates and leach downward. Heavy soils or poorly-drained soils reduce infiltration rates and water-holding capacity but provide more potential for unused nitrogen to denitrify harmlessly. Clay soils have more capacity to tie-up and hold phosphorus in place than do coarse soils.

Soil types also influence the yield potential of selected crops. If a corn crop, e.g., only has a yield potential of 100 bu/A on a given soil type, then it should only be fertilized for 100 bu/A, since any more nutrients would be wasted and become potential pollutants. Crop types should be selected for their nutrient requirements. A range of fertilization rates from 50 lbs of available nitrogen per acre on stands of pine trees to 400 lbs of available N on bermudagrass hayland allow flexibility depending on land availability and farm objectives.

Application Rates   Application rates of manure, litter or wastewater should only supply the fertilizer needs of the crops. Since the manure nutrients are not a balanced blend for most crops, some nutrients will either be under- or over-applied. Some overapplication of phosphorus and potassium may be tolerated, however significant and prolonged overapplication of P and K should be avoided. Supplemental fertilizer will be needed if rates supply only the P and K requirements of the crop. Under no circumstances should available nitrogen be overapplied. Plant available nitrogen is currently estimated to be half of the total nitrogen in irrigated lagoon liquid and 70% of the total N in manure slurries that are soil incorporated. Worksheets are available from the Cooperative Extension Service to help calculate available nutrients and application rates.

Scheduling of Manure Application   Manure nutrients should be applied as near to the period of plant uptake as possible. Nutrients that are readily available, such as in lagoon liquid, are more efficiently utilized by the crop in several small applications throughout the growing season. Nutrients should only be applied to crops during their normal growing season. For example, bermudagrass normally thrives from May to September and should not receive manure at other times of year except when overseeded with a cool season grass such as rye. Cool season crops are necessary to allow application to proceed during the cool season, or enough storage is necessary to avoid having to spread. Land application of manure nutrients on fallow soil or onto dormant crops will only lead to nitrate leaching downward toward ground water.

Manure Application Equipment   Most manures will either be hauled with farm liquid manure spreaders, spread with irrigation systems, or applied by a custom applicator. Costs and time required for hauling, additional acreages required for concentrated slurries, soil compaction, odor considerations, and availability of custom applicators need to be considered for slurry management. It is not cost effective to haul wastewater. Most farms with lagoons will use simple farm irrigation systems, use portable company irrigation equipment, or hire custom irrigators. Those farms with field crops or tree stands will probably find portable systems such as travellers or center pivots most advantageous. Also, if portability to several different fields or large acreages are to be irrigated, travellers will be

selected. On the other hand, if small acreages of grass are to be irrigated and equipment portability is not necessary, small-nozzle, moderate-pressure, permanent irrigation systems provide low-labor and mo re uniform distribution of lagoon liquids. All manure equipment should be calibrated periodically for application rate and uniformity. Appropriate equipment or contractual arrangements must be available whenever manure or lagoon liquid needs to be land applied.

Crop Management Utilization It is important to remember that regardless of what crops are grown on land application sites, they all must be regularly harvested and removed from the site. Otherwise, nutrients will simply recycle back into the soil system and eventually become pollutants. For most field crops, readily established markets are available for the products. For grass crops, markets for hay may not be readily available and may need to be developed. Consideration should be given to marketing a particular crop before selecting that crop for land application.

Labor Availability / Accessibility The availability of labor and the ability to use that labor in the most efficient manner for manure management and farming chores outside of the production facilities should be considered. An irrigation system, e.g., that requires sprinklers to be moved or changed every two hours might require a laborer to shower out/in of the production complex for biosecurity reasons each time attention is given to the system. Would different irrigation equipment or management plans allow the labor to be used more efficiently? The same applies to crop establishment, maintenance, and harvest.

ANIMAL MORTALITY MANAGEMENT

Dead animals are required to be properly disposed of within 24 hours. On-farm mortality management options have consisted of below ground disposal or incineration. Below ground burial or pit disposal of animal and bird mortality may contribute nutrients to ground water in areas with coarse textured soils or high water tables. Mortality management alternatives currently being explored are collection for rendering or on-site composting. These alternatives would reduce below-ground point-sources of nutrients and produce a safe and marketable end product.

CONSERVATION PLAN

Erosion Control Soil as well as manure nutrients should be kept on the field where they are applied. Some nutrients such as phosphorus adhere to soil particles and only move when the soil particles move. Fields where manure is to be applied should have sound conservation practices where appropriate such as terraces, strip cropping, and conservation tillage.

Runoff and Drainage Management It is difficult to avoid occasional applications of manure that are immediately followed by a rainfall event. When this happens, conservation practices such as field borders, grassed waterways, sediment basins, and vegetative filters help to minimize the transport of nutrients and organics off-site. Fields receiving manure that have artificial drainage systems should have a water management plan in action. Some nitrates that have formed in the upper soil layers will be collected in the tile drainage and will be delivered to the drainage ditches or canals. Management of the water levels in these ditches and canals by water control structures can accelerate the denitrification of these nitrates harmlessly.

Cover Crops   Double cropping or cover crops after harvest can help hold soil in place and remove some of the unused nutrients left in the upper soil layers. Crop rotation also tends to use certain nutrients or elements that otherwise would remain in the soil or be lost.

Planning a group of buildings and their surroundings to present a wholesome image is as important as planning for productive efficiency. When the public sees a livestock or poultry farm, they see much more than buildings and grounds. They see an attitude -- an attitude of pride in the business or an attitude of indifference. They see an environmental protector or an environmental polluter. Farm operators who take pride in maintaining the farmstead are generally better managers than those who practice poor housekeeping. Employees take more pride in their jobs and work output improves (Morris et al., 1973).

After weighing the important points of alternative manure management systems, a producer must decide which system appears best, then commit to providing the attention and management necessary to make the system function. No production or manure management system will take care of itself. An ounce of prevention is worth a pound of cure. The appearance of buildings and grounds on farms constantly generates images of the product, good or bad. A good farm image helps sell the product. Portraying an attitude of success is contagious -- to employees, to neighbors, to consumers and to the general public (Morris et al., 1973).

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Interim Criteria for Nutrient Management Planning
(Adapted from the Pennsylvania Bulletin, Vol. 24, No. 3, January 15, 1994, p 427-28)

Introduction

The Nutrient Management Act, Act 6 of 1993, requires the Pennsylvania State Conservation Commission to develop interim criteria for nutrient management planning as set forth in the Act. These criteria are not regulations, but give direction to the Department of Agriculture for the development of a nutrient management specialist certification program. In addition, the criteria provide the first statement of the basic elements of nutrient management plans to be developed by certified nutrient management specialists. The following interim criteria were prepared under Section 4(4) of the Act.

Interim Criteria

Nutrient management plans shall be developed to manage the use of plant nutrients for crop production and to protect the quality of surface and ground water. The plans shall include, but not be limited to, the following core components: nutrient application, manure management, excess manure utilization and/or disposal, stormwater runoff control and selection of other appropriate best management practices necessary to protect surface water and ground water quality. Plans developed under the Act shall address the following:

I. Nutrient Application - Formulation of an accurate nutrient application plan to assure appropriate plant utilization of nutrients and protection of surface and ground water. The basic components include:

(1) Determination of the cropping system and the crop acreage of specific lands suitable to receive nutrients. The land must be capable of receiving nutrients at the times and rates for proper application and utilization.

(2) Determination of all sources of nutrients available to the soil on the farm. Nitrogen is the nutrient of primary concern, but phosphorus, potassium and other nutrients would be reviewed. This determination would include amounts of nutrient materials available at specific times, determining nutrient content of materials intended to be used as plant fertilizer and determining nutrient availability for plant growth of nutrient residuals in the soil and in materials applied. The determination of nutrients produced would be based on an inventory of the annual animal equivalent units for each animal group on the farm, and/or available manure production data. Nutrient material testing and soil testing for suitable crop acreage will assist with development of assessment data.

(3) Determination of what additional nutrients would be required for crop growth to be applied only in the amounts necessary to achieve realistic expected crop yields. Nitrogen would receive primary consideration. Other nutrients will not be used as a limiting factor, unless appropriate to do so under specific criteria established by the Commission. As appropriate, additional testing of soil and nutrient materials would be scheduled.

(4) Determination and documentation of proper rates, amounts, application dates and methods for all nutrient source applications by field or crop group. Also, the adequacy of nutrient spreading methods and equipment would be determined.

II. Manure Management - The plan would evaluate the adequacy of the existing manure management system for the protection of surface and ground water and for proper nutrient utilization. The evaluation would consider the handling, collection, storage and spreading of manure. Manure storage facilities would not be required unless they are needed for the protection of surface and ground water as part of an integrated nutrient management system. The plan would identify appropriate practices, although engineering design work would not be included.

III. Excess Manure - The plan would determine the amount and type of any animal manure which exceeds the nutrient needs of projected crops. It would also select environmentally sound methods for the use or disposal of excess manure.

IV. Stormwater Runoff Control - The adequacy of existing stormwater runoff control practices to minimize erosion and sedimentation, and nutrient loss from cropland, pastures and animal concentration areas would be evaluated. Additional controls would be required if they are necessary for the protection of surface and ground water. Ordinarily, the existence of a current, implemented Conservation Plan would be adequate to address erosion and sedimentation control. However, conflicting plan components would be resolved, such as utilization of both manure incorporation and conservation tillage. The plan would identify appropriate practices, although engineering design work would not be included.

V. Laws, Regulations, Ordinances - Nutrient Management Plans developed under the Act shall comply with all relevant Federal and State laws, regulations and standards relating to water quality and the management of nutrients.

Input Needed

As noted in the introduction above, these interim criteria for nutrient management are the first public statement by the State Conservation Commission of the basic elements of nutrient management plans to be developed under this act. Thus, while these are not the regulations, it is likely that the regulations will be developed around these criteria. This provides an important opportunity for everyone to react to this preliminary statement of the criterial for nutrient management plans and provide input to the nutrient management advisory board which is drafting the final regulations. Input can be provided to any member of the nutrient management advisory board. The board members are listed below.

Livestock Producer
Irk A. McConnell
Washington County (1 yr.)
RR 1 Box 141
Cecil, PA 15321
412-745-8906

Swine Producer
Dennis Zimmerman
Snyder County (2 yr.)
RR 1 Box 163
Beaver Springs, PA 17812
717-658-4641

Fertilizer Industry Representative
William Brubaker
Lancaster County (2 yr.)
1408 Mission Road
Lancaster, PA 17601-5238
717-392-7577

Agriculture Lender Official
Bobby R. Jones
Union County (3 yr.)
PO Box 49
Lewisburg, PA 17837
717-523-1201

Meat Poultry Producer
Donald L. Bollinger
Lebanon County (3 yr.)
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Millbach Road
Newmanstown, PA 17073
717-949-3866

Hydrologist
Jerrald R. Hollowell
Susquehanna River Basin Comm (2 yr)
Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102
717-238-0422

Egg Poultry Producer
Ronald L. Meck
Lancaster County (1 yr.)
275 Creamery Road
Denver, PA 17517
717-336-2631

Nonfarmer
Mary Lehman
Cumberland County (3 yr.)
8 Matthew Court
PO Box 312
Carlisle, PA 17013
717-532-1502

Dairy Producer
Joel Rotz
Franklin County (2 yr.)
3272 Guilford Springs Road
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Nonfarmer
William Ebel
Lancaster County (1 yr.)
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Lancaster, PA 17601
717-393-5179

Veterinary Nutrition Specialist
Charles F. Ramberg, Jr.
University of Pennsylvania
School of Veterinary Medicine
(3 yr.)
378 West Street Road
Kennett Square, PA 19348
215-444-5800 Ext. 2317

Representative of Local Government
Eugene Billhime
Montour County (3 yr.)
161 Billhime Road
Danville, PA 17821
717-437-2742 or 717-271-3000

Feed Industry Official
George Robinson
Snyder County (1 yr.)
Kreamer Feed Store, Inc.
Route 522, PO Box 38
Kreamer, PA 17833
717-374-8148

Academic, Either an Agronomist or a
Plant Scientist from the School of
Agriculture of Penn College or
University
Lawrence D. Hepner, Jr.
Delaware Valley College (1 yr.)
100 Teal Drive
New Britain, PA 18901
215-345-4550

Environmentalist
Lamonte Garber
Lancaster County (2 yr.)
311 N. Lime Street
Lancaster, PA 17602
717-234-5550

Agronomy Facts # 40 RNutrient Management Legislation in PennsylvaniaS which describes the nutrient management law is available from all Penn State Cooperative Extension offices.

Dr. Douglas Beegle, Assoc. Prof. Agronomy
Dr. Les Lanyon, Assoc. Prof. Soil Fertility
Penn State College of Agricultural Sciences
116 ASI, University Park, PA
(814) 863-1016
(814) 863-1614

Agriculture & Natural Resources
AGRONOMY
ALABAMA COOPERATIVE EXTENSION SERVICE, AUBURN UNIVERSITY, ALABAMA 36849-5612

Worksheet

Poultry Waste As A Fertilizer

To calculate the amount of poultry waste (manure or litter) to use on a crop, you need to know the percentages of total N, organic N, and ammonium N in the waste on a wet-weight basis. If you have your litter or manure analyzed by a commercial laboratory, you can find these percetages on the lab report. Ammonium N may be referred to as mineral N or readily available N. Organic N is total N minus ammonium N.

Commercial laboratories usually report results on a dry-weight (oven dried) basis. Therefore, you will need to multiply lab results by the percentage of dry matter (DM) reported. For example, if 3.9% ammonium N and 20% moisture (80% DM) is on the lab report, 3.9% × 0.8 = 3.1% ammonium N in the fresh sample.

If you do not have a laboratory analysis done, you can use the following estimates for nitrogen on a wet-weight basis:

Total N = 3.1%
Ammonium N = 0.9%
Organic N = 2.2%

Step 1. Determine the amount of N available from poultry waste the first year of application.

1. Multiply the percentage of ammonium N in your waste sample by pounds per ton.

EXAMPLE:
0.009 ammonium N × 2,000 lb./ton = 18 lb. ammonium N in 1 ton of poultry waste.

YOUR ANALYSIS:
____ ammonium N × 2,000 lb./ton = ____ lb./ton.

2. Calculate the amount of ammonium N remaining after gaseous losses due to spreading. This is based on your method of application. Use the following factors to calculate the loss:

Factor	Method Of Application
0.75	Broadcast with no incorporation or incorporated after 7 days
0.80	Incorporated within 7 days
0.90	Incorporated within 4 days
0.95	Incorporated within 2 days

EXAMPLE (using broadcast with no incorporation):
18 lb./ton × 0.75 = 13.5 lb. ammonium N available per ton of waste applied.

YOUR FACTOR:
____ lb./ton × ____ (your factor) = ____ lb./ton.

3. Calculate the amount of organic N available the first year. Since only half of the organic N becomes available during the year of application, multiply the percentage of organic N in your waste sample by pounds per ton and by 0.5 (one-half).

EXAMPLE:
0.022 organic N × 2,000 lb./ton × 0.5 = 22 lb. organic N in 1 ton of poultry waste available the first year.

YOUR ANALYSIS:
____ organic N × 2,000 lb./ton × 0.5 = ____ lb./ton.

4. Add the factored amount of ammonium N available to the amount of organic N available the first year. This gives you the total amount of N available to your crop from poultry waste the first year you apply it.

EXAMPLE:
13.5 lb./ton ammonium N + 22 lb./ton organic N = 35.5 lb. total N in 1 ton of poultry waste available the first year it is applied.

YOUR TOTAL:
____ lb./ton ammonium N + ____ lb./ton organic N = ____ lb./ton.

If you have not applied poultry manure to your fields before this crop year, move to Step 3. If you have applied poultry manure the preceding year, complete Step 2.

Step 2. Determine the amount of N available from the previous years of application.

Only 50 percent of the organic N in poultry waste is available for use the first year. The remainder becomes tied up in the soil organic matter. However, another 12 percent becomes available as residual N the second year, and 5 percent becomes available two years after application. Calculate the amounts of residual N available in your fields from previous poultry waste applications.

1. Multiply the percentage of organic N in your waste sample by pounds per ton.

EXAMPLE:
0.022 organic N × 2,000 lb./ton = 44 lb. organic N in 1 ton of poultry waste.

YOUR ANALYSIS:
____ organic N × 2,000 lb./ton = ____ lb./ton.

2. Multiply the tons per acre of poultry waste applied to your field during the previous year by the pounds per acre organic N by 12 percent to find how much residual

Poultry By-Product Management Handbook

- Manure Management and Utilization
- Disposal of Farm Mortalities
- Farm Planning and Enhancement
- Vector Control

Poultry By-Product Management Handbook
Contributing Authors

Section 1

Policy and Resource Information

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Section 2

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Section 5

Vector Control

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Section 6

Poultry Waste Management and Environmental Protection Manual

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FOR MORE INFORMATION...

Alabama Poultry & Egg Association, Inc.

Agency's Tie With The Poultry Industry

The Alabama Poultry & Egg Association is a not-for-profit trade organization representing all phases of the broiler, egg, and turkey industry in Alabama. The Association works for the industry in the areas of legislation, research, education, public relations, media relations, and product promotion to provide services and programs not available outside the Association. Programs are changed according to the needs of the industry.

AP&EA is committed to providing the services necessary to keep the poultry industry in Alabama a world leader in poultry production.

Services Available To Poultry Growers

AP&EA is the poultry producer's voice in the state legislature as the Association works to protect the interests of the poultry farmer especially in the areas of state sales tax exemptions and fair utility rates. In addition to the educational seminar held during the AP&EA convention, the Association sponsors other educational meetings as needed.

At present 14 county poultry and egg associations are affiliated with AP&EA. The purpose of these county organizations is to promote the poultry and egg industry and to provide the opportunity for exchange of information on the county level. AP&EA is acutely aware of the need for sound environmental programs and has been at the forefront of the effort to develop an acceptable plan for Alabama.

Contact

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FOR MORE INFORMATION...

Agricultural Stabilization and Conservation Service

Agency's Tie With The Poultry Industry

The National program objectives of the Agricultural Conservation Program (ACP) are to assure a continued supply of food and fiber necessary for a strong and healthy people and economy; and to facilitate sound resource management systems through:

- Conserving the soil, water, and related natural resources.
- Controlling erosion and sedimentation from agricultural land.
- Controlling polution from animal wastes.
- Encouraging voluntary compliance by agricultural producers with state and federal requirements to solve point and non-point sources of polution.
- Improving water quality: encouraging enduring conservation and environmental measures and practices rather than those that are primarily production oriented or that have little or no conservation or polution abatement benefits.
- Helping achieve national priorities as set forth in the National Environmental Act.

ASCS interfaces with producers involved in the poultry industry by offering through ACP a cost-sharing practice to assist in solving erosion and water quality problems as a result of non-point source polution.

Services Available To Poultry Growers

ASCS has the authority to offer cost-sharing up to 60 percent of the cost to construct facilities to handle and/or store poultry waste. The size of the facility is based on the operation and the number of acres on which to spread the waste. The purpose of the practice is to solve a water quality problem by permitting the waste to be returned to the land in the operation. Producers who have been in business less than five years or who have substantially enlarged their operation in the last five years are not eligible for assistance. Facilities include lagoons, dry-stacks, and composting units. Eligibility is based in part on those practices that are carried out on a voluntary basis. A practice installed as a result of a written advisory notice of a needed action (local, state, or national) would be considered voluntary. However, when the administering authority notifies the producer in writing that specific action, such as fines or closing the operation, will be taken, this is considered an *involuntary* action and would not be eligible for cost-sharing.

Contact

Contact the ASCS office in the county in which you reside, or contact the state office to obtain information for your county.

Joan G. Grider
Acting State Executive Director
Agricultural Stabilization and Conservation Service (ASCS)
United States Department of Agriculture
P. O. Box 891
Montgomery, AL 36101-0891
(205) 223-7230

FOR MORE INFORMATION...

Alabama
Department of Agriculture and Industries

Agency's Tie With The Poultry Industry

The Alabama Department of Agriculture and Industries, through the Animal Industry Division, is charged with controlling, eradicating and preventing the spread of contagious and infectious diseases of poultry through the proper destruction and disposal of dead poultry, unhatched or unused eggs and other poultry waste by requiring commercial growers of poultry and commercial hatcheries to be equipped with and use disposal facilities. The authorizing legislation can be found in the Alabama Code (1975).

Services Available To Poultry Growers

The Department will provide information on the proper construction and use of disposal facilities. Disposal facilities for the disposal of poultry mortalities include approved disposal pits, composters, and incinerators. Disposal pits must meet the construction specifications as outlined by the State Board of Agriculture and Industries; other methods must meet the appoval of the State Veterinarian (Chapter 80-3-20 of the Alabama Administrative Code). Composters should be built according to specifications as outlined by the Alabama Cooperative Extension Service. Incinerators should meet both federal Environmental Protection Agency and Alabama Department of Environmental Management standards. Failure to meet these specifications for on-site disposal facilities or failure to use disposal facilities properly can result in the issuance of a quarantine. No poultry, eggs, or other poultry products can be moved from the quarantine premises until inspected and until approval to remove them has been given by the Commissioner of Agriculture, the State Veterinarian, or their agents. The Department also holds the authority to issue licenses to those who sell poultry litter as livestock feed. Licenses are issued through the Agricultural Chemistry Division.

Contact

Dr. J. Lee Alley
State Veterinarian and Director, Animal Industry Division
Alabama Department of Agriculture and Industries
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Montgomery, AL 36109
(205) 242-2647

FOR MORE INFORMATION. . .

Alabama Department of Environmental Management

Agency's Tie With The Poultry Industry

The Alabama Department of Environmental Management (ADEM) is involved in the regulation of the poultry industry with respect to the discharge of pollutants and protection of the environment. Animal waste and dead bird disposal are two of Alabama's critical environmental concerns that require frequent interaction with the poultry industry.

Services Available To Poultry Growers

Interaction with the poultry industry is handled in two ways: Industrial facilities such as hatcheries and processing facilities are generally regulated under one or more permit programs, while broiler and layer operations are inspected on the basis of citizen complaints or known or suspected problems. Upon receipt of a complaint ADEM personnel will inspect a facility to determine the state of compliance with the appropriate environmental laws and regulations. Since producers are required to manage their facilities to prevent adverse environmental effects, problems observed during inspection must be resolved to prevent further legal liability.

ADEM also provides guidance in environmentally acceptable practices as well as providing interpretation of specific regulatory requirements. Growers are encouraged to contact ADEM for assistance whenever a question of environmental concern arises. ADEM has also provided a list of approved incinerators for the disposal of dead birds.

Contact

Timothy S. Forester, Chief
Mining and Nonpoint Source Section
Alabama Department of Environmental Management
1751 Cong. W. L. Dickinson Drive
Montgomery, AL 36109
(205) 271-7825

FOR MORE INFORMATION...

Alabama Department of Public Health

Agency's Tie With The Poultry Industry.

The health department interfaces with the poultry industry in abating public health nuisances, usually related to litter control and flies. The local health department should be the first local contact to assist the industry with complaint investigation and abatement.

Services Available To Poultry Growers

The Department consults with industry in the handling of eggs, litter, and dead bird disposal as they relate to public health nuisances; assists other agencies with coordinated approaches at individual sites for nuisance control; and assists with program development for industry training upon request.

Alabama Department of Public Health Contact

James W. Cooper
Director, Bureau of Environmental & Health Service Standards
434 Monroe Street, Room 250
Montgomery, AL 36130-1701
(205) 242-5004

Area Contacts

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FOR MORE INFORMATION...

Alabama
Soil and Water Conservation Committee

Agency's Tie With The Poultry Industry

The state Soil and Water Conservation Committee is responsible for providing coordination and leadership to each of the state's 67 Soil and Water Conservation Districts. The Committee advises the Alabama Agricultural and Conservation Development Commission (AACDC) on standards, specifications, and expected life of cost-share conservation practices eligible for grants under the AACDC Cost-Share Program. The state Committee provides assistance to the districts in carrying out their local programs. The Committee also keeps the districts informed and facilitates information exchange, coordinates programs, disseminates information, and secures cooperation with other agencies.

Each Soil and Water Conservation District determines the direction of its program at the local level. There is a district office in each of the 67 counties in the state. The local district is the contact point for the poultry producer to make application for cost-share and other assistance.

Services Available To Poultry Growers

Financial assistance for conservation practices is available to qualified applicants through the Alabama Agricultural and Conservation Development Commission's Cost-Share Program. Monies received by the Commission from legislative appropriations are allocated to the state's 67 Soil and Water Conservation Districts by the state Soil and Water Conservation Committee. Cost-share assistance is limited to $3,500 or 60 percent, whichever is less, per applicant, per program year. Cost-share practices available to poultry growers include dead bird disposal pits, small animal incinerators, manure dry stack facilities, dead bird composters, and animal waste control facilities. Technical assistance for these practices is provided by the USDA Soil Conservation Service. Also available is assistance in developing suitable waste management plans for poultry operators.

Under Section 319 of the Water Quality Act, several demonstrations will be implemented which will deal with poultry waste management during the next years.

Contact

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State Soil & Water Conservation Committee
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FOR MORE INFORMATION...

Tennessee Valley Authority Agricultural Institute

Agency's Tie With The Poultry Industry

The overall objective of the Tennessee Valley Authority's (TVA) Agricultural Institute, headquartered at Muscle Shoals, Alabama, is to develop and implement programs and activities that will further develop agriculture and agribusiness within the 16-county TVA region of northern Alabama. Much of the Institute's work is accomplished in cooperation with other agencies and institutions such as Auburn University's Extension and Research Divisions. The poultry industry is an integral part of the agricultural economy in the TVA region of northern Alabama. Institute programs and projects have been developed and implemented to ensure the continued expansion and success of the poultry industry in an environmentally sustainable manner.

Services Available To Poultry Growers

The Institute's programs and projects primarily deal with helping prevent or reduce impacts of the industry on the environment. This is being accomplished through educational workshops and demonstrations in cooperation with other state agencies to focus on preventing or reducing the environmental impacts of by-products produced by the poultry industry. Current project areas are: composting dead poultry; animal waste lagoon management; production and marketing of poultry litter products for use as a soil amendment, fertilizer, and cattle feed; creating agribusinesses that will produce and market poultry litter products; and conducting research and demonstrations that show correct use of poultry litter in various crop production systems. Much of this work is done in cooperation with the Alabama Cooperative Extension Service at Auburn University. The Institute has also supported several educational demonstrations on poultry producers' farms and with agribusiness firms to accomplish these described objectives.

Contact

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Tennessee Valley Authority
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Muscle Shoals, Alabama 35660-1010
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FOR MORE INFORMATION. . .

USDA
Soil Conservation Service

Agency's Tie With The Poultry Industry

The role of the Soil Conservation Service is to provide technical assistance to the poultry industry in the planning, design, and implementation of waste management systems and dead bird disposal practices on poultry farms in Alabama.

Services Available To Poultry Grower

The SCS provides planning, design, and construction assistance on waste treatment lagoons, manure dry stack facilities, composter units, incinerators, dead bird disposal pits, and waste disposal plans based upon soils, crops, and equipment available; serves as technical representative for cost-share programs to implement waste management and dead bird disposal systems; and provides financial assistance in special project areas in support of technical assistance described above.

Contact

District Conservationists are located in each county in state (Coosa/Tallapoosa Counties in joint office).

Ray E. Donaldson
Assistant State Conservationist (Operations)
USDA - Soil Conservation Service
P. O. Box 311
Auburn, AL 36830
(205) 821-8070

Manure Handling and Neighbor Relations

- don't stack manure next to roadways
- spread manure as far from neighbor's house as possible
- avoid spreading on higher ground if there are neighbors at a lower elevation
- prevent spilling on roadways or elsewhere
- always consider wind direction and weather conditions when spreading
- spread in the morning for better odor dissipation
- always incorporate manure into the soil as soon as possible
- be especially thoughtful of sensitive neighbors

Managing Poultry Manure

There has been a great deal of discussion about poultry manure of late. These discussions are concerned with its overabundance, difficulty in finding farmers to use it, and its potential effect on ground water. All of these concerns are important while definitive answers have not come easily.

These concerns differ depending on the point of view. The producers' primary concern is to move this product away from the farm, usually by spreading it on crop land. The purchaser is concerned about the nutrient value of this product to the crop being produced. All of us need to be concerned about its potential effect on ground water.

With proper manure management, concerns about ground water contamination should be alleviated. There are four basic steps to proper manure management and reduced possibility of undesirable runoff.

1. Have the soil tested in the area where the manure is to be spread. This provides baseline data to determine the nutrient needs necessary for maximum crop yields.

2. Determine the crop nutrient requirements so the proper amount of manure can be applied. Precise application will result in the highest crop yields.

3. Determine the nutrient levels in your poultry manure. This is a very important step because the nutrient value of poultry manure is highly variable. Differences occur due to litter type, moisture level, diet of the birds, and clean-out practices.

4. Storage and application of manure can make or break its usefulness. Ideally, manure should be stored either in a storage barn or under black plastic. In this way the nutrients are protected from the weather and remain in the manure instead of leaching into the soil, thus being lost to the crops and possibly contaminating the ground water. Money is available to help defray the cost of manure storage facilities. Contact the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS) for more information.

Manure must be applied correctly to obtain the maximum benefit of its nutrients. It must be applied at the proper time and at the proper rate for best results.

Keeping these practices in mind, proper manure management can benefit all concerned, poultry and crop grower alike.

—*J. C. Hermes*

Reference: Issacs and Harris, Proper Manure Management: A key to tomorrow's success. Delaware Cooperative Extension publication.

The University of Georgia
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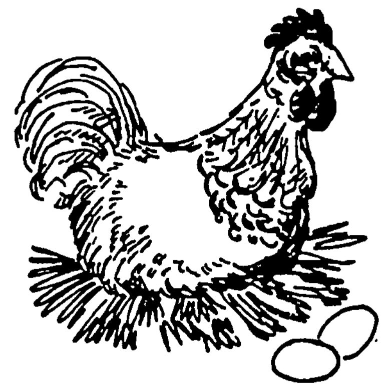
College of Agriculture/Athens, Georgia 30602
1785

PS 2-1

September, 1990



COMMERCIAL EGG TIP . . .

WASTE MANAGEMENT COMPREHENSIVE PLANNING NEEDS

Disposing and using poultry waste is a major challenge to the poultry industry. It will continue to be an issue because the conflict between intensive animal agriculture and urban development shows no indication of lessening. Waste management involves three areas of environmental concern: **solid waste disposal, pollution of surface and ground water,** and **air pollution.** The shear volume of waste, plus its concentration on smaller land areas, magnify its environmental impact.

Odors from poultry facilities are not dangerous pollutants. When odors are a problem, we classify them as nuisance pollutants. Surburban neighbors, however, are using odors as a focal point to increase state and local regulations affecting agriculture.

Waste management must have high priority. Every animal-based agriculture operation must have a comprehensive waste management plan to contend with animal waste before it is produced by the animal. This not only reduces the risks associated with the use and disposal of animal wastes, but also provides both economic and environmental benefits such as:

*reduced commercial fertilizer costs,
*improved soil tilth and productivity,
*protected water resources and air quality.

Improperly managed wastes, however, sustain certain risks:
*pollute water resources and air,
*lose fertilizer value,
*generate removal expenses instead of financial benefit,
*create a negative social and regulatory environment for agriculture.

Organic wastes originating from poultry production have several potential end uses including land application, production of "biogas" for on site heating, and off-site use of wastes as fuel or feed. The most common practice at present is land application.

A sound waste management plan requires careful attention to details. It uses principles from agricultural engineering, agricultural economics, poultry science, and crop and soil sciences. Together they maximize the economic value of wastes and minimize the risk of environmental damage. The Cooperative Extension System and the Soil Conservation Service through local conservation districts, offer assistance in the development of these plans.

Animal Agriculture's Effect on Water Quality
Pastures and Feedlots
Alan L. Sutton, Department of Animal Sciences

Indiana's Farm Animal Industry

Animal agriculture in Indiana makes a significant contribution to the supply of meat, milk and eggs for consumption in our nation and abroad and supplies a considerable amount of revenue to the state. In 1988, sale of livestock and livestock products in Indiana equalled $1.74 billion. Livestock sales made up 42.5 percent of the $4.1 billion total of all agricultural commodities in the state (Figure 1).

Animal manures are a natural by-product of the livestock industry. Animal wastes must be handled, stored, utilized and/or disposed of in an efficient way while maintaining or improving the quality of the environment. Many factors affect the pollution potential of animal waste. Nutrient content of animal waste varies with collection, storage and application methods. Climate conditions also contribute to the effect animal waste might have on water supplies.

Possible contaminants from animal waste include: nitrogen, phosphorus, inorganic salts, carbon compounds and microorganisms. This bulletin discusses possible water pollution problems from pasture and feedlot systems and the management practices needed protect water supplies.

Pasture Systems

Pasture and range systems still make up a major portion of livestock production in Indiana. To illustrate: feeder calves are produced almost exclusively from cow-calf enterprises on pasture and range systems; a substantial portion of swine production (both feeder pig and farrow-to-finish) is still accomplished on pasture; most dairy farms utilize pasture when seasonal conditions permit; and sheep production is mainly a range and pasture operation.

Grazing animals deposit manure directly on the land in pasture management systems. Though a pasture may be relatively large, manure may become concentrated near feeding and watering areas. Often near flowing streams, these areas can quickly become barren of plant cover, increasing the possibility of contaminated runoff.

There is very little research on the extent of non-point pollution from pasture systems. From the few studies reported, streams near pastures and ponds where cattle had access, showed only a slight increase in bacteria and carbon compound levels.

Good management is the best insurance against pollution of water from pasture or range systems of livestock production. "Good management" guidelines include the following:

1. Prevent manure buildup in any one area by maintaining an adequate land-to-livestock ratio.
2. Maintain a highly productive forage on the land to slow runoff, entrap manure and utilize nutrients.
3. Plan a rotation system of grazing to prevent overgrazing and soil erosion.
4. Locate feeders and waterers a reasonable distance from streams and water courses. Move them to new locations before livestock wear paths by repeated trampling.
5. Provide shade in summer, using trees or artificial shelters, to reduce the need for animals to enter water for heat relief.
6. Fence animals away from ponds and streams if domestic water supplies use surface water.

Feedlots

Open feedlots are a potential point source of water pollution. Point source pollution problems can occur when an open feedlot makes no provisions for runoff control or if manure management facilities are mismanaged, poorly designed or constructed.

To protect Indiana's waterways, the state legislature in 1971 enacted the Indiana Confined Feeding Control Law requiring operations above certain sizes, or those identified as polluters, to obtain approval for their manure management systems. Approval is the responsibility of the Indiana Department of Environmental Management (IDEM). The law requires livestock operations, subject to the law, provide: (1) adequate storage capacity for feedlot runoff and manure to permit timely disposal on the land, and (2) adequate equipment and land for manure disposal.

Animal Waste Management

John M. Sweeten, Charles Baird and Leah Manning*

Livestock and poultry production can contribute to excess nutrients (nitrogen and phosphorus), organic matter, salts and pathogens in surface water and in underground aquifers. Potential sources of pollution include confinement buildings, unpaved feedlots, runoff holding ponds, manure treatment and storage lagoons, manure stockpiles and fields on which manure and wastewater are applied. Other sources are manure accumulations around livestock watering locations, intermittently used stock pens and insecticide spray equipment, dipping vats and disposal sites (for waste pesticide, rinsate or containers). Livestock grazing operations, from sparse rangelands to intensively stocked pastures, also may influence the water quality of streams and aquifers.

Best Management Practices

Best management practices (BMPs) for livestock are needed for a wide range of conditions: sparse rangelands; irrigated and grazed pastures; animals watering in or adjacent to streams; and cattle feedlots.
There is a vast difference in water pollution potential between (a) open rangeland on which annual manure deposition is about 1/10 ton of manure solids and 8 pounds of nitrogen per acre, versus (b) an open feedlot surface that receives about 300 tons of manure solids and 24,000 pounds of nitrogen per acre per year.

Unconfined Livestock Operations

In evaluating unconfined livestock operations, both the quality of runoff water, characterized as concentration (milligrams per liter, mg/l or ppm), and the annual mass yield (lbs/acre/year) of manure constituents should be considered. Pollutants become dissolved in runoff as rainfall erodes the soil surface. The concentration of pollutants is influenced by vegetative cover, which is affected by grazing density. The higher the volume of runoff from land with sparse vegetative cover, the greater its capacity to transport sediment, organic matter and nutrients. Another publication in this series deals with nonpoint source pollution from grazing land.

Runoff and drainage from open livestock lots, including barnyards, can increase phosphorus and potassium levels in the soil for a considerable distance downslope, as compared to the levels on sites not affected by livestock wastes. Research in Wisconsin showed soil phosphorus levels averaging 480 ppm at 300 feet downslope of two dairy barnyards in a drainage waterway soil, as compared to soil phosphorus levels averaging 200 ppm at the same distance but out of the waterway (Motschall and Daniel, 1982). And at 1,200 feet downslope from the dairy lots, waterway soils had 150 ppm phosphorus as compared to 70 ppm in the adjacent, unaffectedsoil areas.

Grazing livestock sometimes cause elevated bacterial counts in streams even though nutrient loads may be small (Robbins, 1978). Watering and feeding sites should be located away from streams and reservoirs, especially if they are used for recreation (Sweeten and Melvin, 1985).

When water high in nitrates filters through the soil, groundwater can become contaminated. Livestock producers should protect wellheads to prevent entry of surface contaminants. If cavities develop around the well head, contaminated surface drainage or soil water can enter the aquifer.

Concentrated Animal Feedlot Operations

Confined, concentrated animal feeding operations (feedlots) have far greater potential to cause water quality problems than pasture operations, unless properly designed water pollution abatement systems are installed

(Sweeten, 1990).

The Texas State Soil and Water Conservation Board (TSSWCB) lists the following BMPs for feeding operations considered to be nonpoint pollution sources (Texas Water Commission and Texas State Soil and Water Conservation Board, 1988):

1. Proper location of livestock concentrations

2. Proper management of solid and liquid manure

3. Runoff control

4. Land disposal of wastes

Site selection is one of the most important factors in preventing water and air quality problems from livestock feeding facilities. Key factors to consider in site selection are listed in Table 1. Proper site selection includes consideration of slope (topography), location relative to flood plains, geology, land area for manure and wastewater applications, land use, and proximity to neighbors.

Texas Water Commission Regulations

Livestock feeding operations considered to be point sources of pollution are subject to specific state and federal regulations. In April 1987, the Texas Water Commission (TWC) adopted a regulation that stated the following no-discharge policy: "...there shall be no discharge of waste and/or wastewater from concentrated animal feeding operations into the waters in the state, but rather that these materials shall be collected anddisposed of on agricultural land."

The TWC definition contains four visually-determined conditions necessary for a facility to be regulated as a feedlot (point source): (a) an enclosure--corral or building; (b) presence of livestock; (c) feeding of those livestock; and (d) sufficient animal density to prevent crop and forage growth. These characteristics integrate the effects of factors such as animal density, animal species, soils, slope and management practices.

The TWC regulation requires livestock and poultry producers to obtain a permit if they have more than 250 milking cows, 1,000 beef cattle, 1,500 swine, 600 horses, 6,000 sheep or goats or 30,000 laying hens in a concentrated animal feeding operation. Operators of smaller facilities are regulated by rule and must meet the same requirements of the TWC regulations for keeping manure and wastewater out of streams.

Specifically, the 1987 regulation requires producers to protect surface and groundwater and to apply manure and wastewater on land. Required surface water protection measures consist of diverting off-site drainage around the feeding facility, constructing minimum storage capacity for manure and process generated wastewater, and constructing adequate runoff storage capacity.

Rainfall runoff from open lots and other manure contaminated surfaces must be collected in holding ponds designed to contain all runoff from the 25-year, 24-hour duration storm, plus accumulated sediment and process generated wastewater. Minimum storage capacity for process generated wastewater was specified for different locations in the state. Runoff holding ponds and lagoons must be located out of the 100-year flood plain. They must be drained by irrigation, evaporation or some combination of the two to restore the design capacity within 21 days after a rain. Holding ponds and lagoons must be sealed with at least 1 foot of compacted clay that meets the TWC specifications based on soils engineering tests. Systems for runoff control, wastewater treatment and storage and irrigation should be designed by a professional engineer.

A water balance based on monthly inflows of wastewater, runoff and rainfall and monthly outflows of evaporation and irrigation should be used to check the adequacy of lagoon and holding pond capacity and adjust it if necessary. Similarly, a nutrient balance, using predicted crop uptake rates and soil nutrient status, is needed to determine proper application rates and the amount of land needed for application and utilization of manure and wastewater.

Regulations for Dairy Farms

The TWC adopted additional regulations in June, 1990 that require all dairies to register. In addition, TWC stipulated thatcertain best management practices be used on those dairies that do not need to get a permit at this time. One category of BMPs deals with decreasing lot runoff volume to reduce the size of required holding ponds and irrigation facilities. This can be done by diverting clean runoff around the facility with ditches and terraces, installing roof gutters, covering open lots with roofs and reducing open lot surface area. The latter may necessitate surfacing pens or collecting manure and more frequently, abandoning pens that do not allow wastewater collection. A second category of BMPs deals with decreasing wastewater volume by properly maintaining the watering system, reducing water used for cooling or cleanup and recycling wastewater from lagoons and holding ponds in lieu of using fresh water. A third kind of BMP is aimed at capturing rainfall runoff according to TWC stipulated design criteria and uniformly apply collected runoff on land. A fourth BMP category calls for minimizing solid manure transport by locating manure stockpiles (if used) away from waterways; installing adequate manure storage structures; using appropriate rates and times for manure application; providing grass filter strips along waterways; and using off-site areas for manure application. The fifth BMP mentioned is the protection of groundwater by locating lagoons and ponds at least 150 feet from water wells and leaving a buffer area around water wells.

In the interim until a permit is issued, the dairy is to install and manage runoff control facilities to contain at least 70 percent of the potential runoff from the 25-year, 24-hour storm. Some leeway is given for multiple storms within a 7-day period.

Other Design Considerations

While decreasing the size of open lots will reduce runoff volume by a proportionate amount, it also increases stocking density, moisture production and the potential for mud problems. It may also necessitate surfacing the pen and collecting manure more often.

Open lots should not be placed in areas where annual precipitation plus predicted manure moisture deposition equals or exceeds annual evaporation. Pasture operations or confinement buildings such as free stall barns are usually preferable to open lots in high rainfall areas. Proper system design is essential to meeting regulations and reducing pollution.

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Avoiding Stream Pollution from Animal Manure

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Animal manure is well-recognized as a fertilizer and soil conditioner. Adding manure to the soil has agronomic benefits through the addition of plant nutrients (nitrogen, phosphorus and potash) and organic matter. These same nutrients that are beneficial in soil for plant growth are considered pollutants in water. The objective of any manure land application system must be to keep manure on the soil, where it has value /, and out of water where it is a pollutant.

Pollutant Types

Ammonia is the most damaging water pollutant in manure. If conditions are right, the effects of ammonia in a stream can be recognized within a few minutes. Ammonia is very toxic to fish. Even very small amounts of ammonia released to a stream can cause a fish kill.

The toxicity of ammonia to fish depends on three factors: pH, water temperature and oxygen content. The higher the pH of the water, the smaller the amount of ammonia needed to kill fish. The higher the temperature of the water, the smaller the amount of ammonia needed to kill fish. Because of the témperature factor, ammonia discharged to a stream that may not kill fish in the winter could result in a fish kill in the summer. In addition, the lower the dissolved oxygen content of the water, the smaller the amount of ammonia needed to kill fish.

Organic matter discharged to a stream may kill fish. However, the effect is slower than with ammonia. As organic matter is "broken down" or decomposes, the oxygen in the water is used up. Therefore, less oxygen is available to support fish and other aquatic life.

The rate at which a stream can recover from a discharge of organic matter depends on its volume, flow rate, turbulence and water temperature . Large streams can accept more organic matter without adverse affects than can small streams because of dilution. Rapidly flowing, turbulent streams can recover faster from a discharge of organic matter because of reaeration as the water moves downstream. The effect of adding organic matter to cold water is less than warm water because cold water can hold more oxygen. Also, decomposition of organic matter is slower at colder temperatures. The worst possible situation is to discharge organic matter into a small, slowly moving stream on a hot day.

Nutrients do impact the streams that receive them. The major damage or effect is most often noticed once the nutrients reach a stagnant portion of the stream, a lake or a pond. The plant nutrients nitrogen and phosphorus do a good job of growing plants both on land and in water. Lakes rich in nutrients are called eutrophic and are green with algae and aquatic plants.

Bacteria from livestock manure rarely causes health problems for people or animals, but the potential is there. Diseases are often transmitted in people and animals through the fecal/oral route. Disease-causing organisms may be present in the waste of an infected animal. If the organism is ingested by another animal, through food or water, the animal is exposed and risks being infected. Fortunately, disease-causing organisms do not thrive in the soil or water and are filtered out and die off. Therefore, it is important to maintain adequate separation distances between the

potential pollutant and the water source. This provides an opportunity for disease-causing organisms to be filtered out and die off before reaching food and drinking water supplies.

Color is a pollutant not often considered. Water can be stained by animal manure, giving it a brown or reddish appearance. The color may not pose a water quality problem, but may alarm people using the water for recreation or water supply.

Preventative Measures

Avoiding stream pollution from manure is not difficult. Common sense is the rule to follow when handling manure. The principles of proper manure management and land application are presented in AEX 704, Land Application of Manure and Wastewater (part 1). These principles include:

1 Maintain separation distances and buffer areas between land used for manure application and surface water drain-age. With no slope a minimum buffer distance of 10 feet of vegetated ground or 25 feet of bare ground from streams and 6 ditches is recommended (Figure 1). On frozen ground, 60 feet of vegetated ground or 150 feet of bare ground is recommended (Figure 2). Greater setbacks are recommended on sloping ground.

2. Restrict surface application of manure on sloping ground when it is frozen or just prior to rain.

3. Take care when applying manure to fields with subsurface drainage, especially when the soil is dry and cracked. It is advisable to till the soil prior to application if cracks are present. All "blow holes" in the drainage system must be repaired prior to application. Surface inlets and french drains must be avoided.

4. Limit one-time application volumes of liquid manure to the amount of moisture needed to bring the soil up to field capacity. Heavy applications can result in puddling and runoff.

5. Limit application of manure nutrients to crop need. Excess application results in buildup of soil nutrients.

6. Test manure and soil to determine appropriate application rates.

Ohio Regulations

The Ohio Water Quality Standards (Ohio Administrative Code 3746-1-04) specify that all surface waters of the state must be free from the following pollutants as a result of human activity. suspended solids, floating debris, color, odor, toxic substances and nutrients that create nuisance growths of aquatic weeds and algae.

The discharge of pollutants to the state's waters is regulated by the Ohio Environmental Protection Agency through the National Pollution Elimination permit system (NPDES). This applies to any controlled, direct discharges of animal waste to waters of the state regardless of operation size.

Dischargers of pollutants may be liable for civil penalties of up to $10,000 for each day of violation (Ohio Revised Code 6111.07). In addition, criminal penalties can be assessed upto $25,000 or up to one year of imprisonment or both (Ohio Revised Code 6111.99). The Ohio Environmental Protection Agency also issues Permits to Install (PTI) on all

livestock operations of more than 1,000 animal units.

The Ohio Department of Natural Resources has pollution abatement responsibilities for livestock operations of less than 1,000 animal units. This program is administered through the Division of Soil and Water and the Soil and Water Conservation Districts.

The legislature has also directed the Ohio Department of Natural Resources Division of Wildlife to protect the wild animals of the state. Anyone found to be discharging pollutants to the state's water can be found in violation of the "Stream Litter Act" and fined up to $500 or sentenced to 60 days in jail, or both, for a first offense. If fish are killed as the result of a pollutant discharge, the party responsible is charged for all damages including the value of the wildlife killed, environmental damages and the costs of investigation. Current market prices are used to set the value of the animals.

In 1989,1 6 fish kills in Ohio were caused by animal manure, resulting in the death of more than 20,000 fish and animals. Animal manure was also cited in 19 other pollution investigations that did not result in wild animal deaths. In 1989, agriculture led industry, transportation, municipal government and public service enterprises in the number of wild animals killed.

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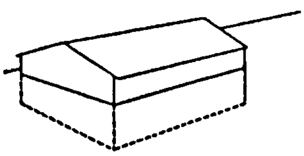
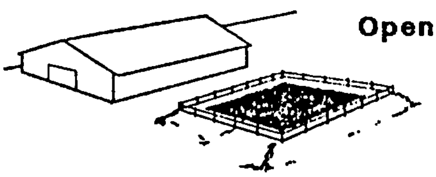
Agricultural Engineering

Livestock Safety – Manure Handling and Storage

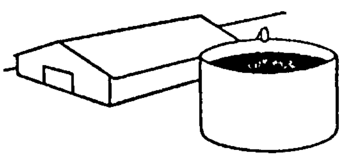
The use of large capacity, on-farm, liquid manure storage facilities has become a common practice in recent years. These include tanks located directly underneath the livestock housing area, storage located away from the livestock housing area in open lagoons or ponds, and above ground silo-type storage tanks. While this practice has greatly increased the efficiency of manure handling, it has also introduced many potential hazards. Of these three types, underground storage is the most hazardous.



Underground Storage



Open Lagoon Storage



Above Ground Storage

Safety Hazards

When animal waste of any type is being stored in large volumes, a number of hazards exist for both the animals and the handler.

The most obvious is the potential danger of drowning. There is also the danger from gases which are produced as the manure is decomposed by bacterial action. This includes gases that are toxic (ammonia), corrosive (hydrogen sulfide), asphyxiant (carbon dioxide), and explosive (methane). Anyone working around animals should be aware of the physical effects of these various gases released during manure decomposition so that a hazardous situation can be recognized immediately.

Designing a Safe Manure Storage Facility

Many safety hazards can be avoided by careful planning when designing or reconstructing a manure handling facility.

The most important consideration when building a manure storage facility is keeping storage volume to a minimum. Also, dividing pits into smaller sections will reduce the amount of agitation necessary.

Pump-out openings for manure pits should be located outside of buildings, and access points should be covered by a heavy cover or gate. These covers should be kept in place at all times. Gas traps should be used in pipelines emptying into outside storages to keep gases from flowing back into the buildings.

North Carolina
Cooperative Extension Service
North Carolina State University
College of Agriculture & Life Sciences

AGRI-WASTE MANAGEMENT

Components of a Complete Manure Management Plan

Existing regulations for animal waste management are generally invoked by the North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management (DEM), in response to citizen complaints about water quality problems after degradation has occurred. DEM believes a more proactive mechanism is needed to help farmers plan and operate animal waste management systems to protect surface and ground water before problems occur. Therefore, DEM is proposing to amend existing nondischarge regulations by establishing minimum criteria to be met before waste management systems serving animal operations are deemed permitted.

While the wording of the above statements is still in the draft stage and subject to be amended, the implication is clear. Within the next few years, every livestock and poultry farmer who has more than 100 animal units will be required to have a complete farm manure management plan utilizing available technology. For many producers this will simply mean documenting those practices already being employed. For others, it will mean proper management or upgrading existing components into a complete and environmentally safe system for managing manure, residuals such as lagoon liquid and sludge, field runoff, and animal mortality. Some components of this plan are briefly outlined as follows.

SITE SELECTION

For new producers or those anticipating significant expansion, site selection is probably the most important single consideration associated with the entire operation. Adjacent land use should remove from consideration those sites near residential developments, commercial enterprises, recreational areas, or other prime areas for non-agricultural uses. Wind direction probability diagrams will help to locate facilities downwind of warm season prevailing winds. The strategic planting of hedge rows or tree barriers at property boundaries serves to shield the production and manure management facilities from direct sight and to reduce wind speed across the facilities allowing any emitted gases more opportunity to rise vertically and dissipate into the atmosphere. A site may seem ideal with respect to transportation, feed supply, accessibility or land ownership, but may be inappropriate because of existing or proposed development.

Soil properties and limitations should be investigated. Soil types with limited permeability which will rapidly seal are desirable for lagoon construction. Coarse sands will probably need to be amended to speed up the sealing process. An erosion control plan to stabilize and maintain a site during construction should be considered. When possible, locate production facilities near the center of a tract of land large enough to allow manure to be applied at agronomic rates. Pollution control and manure management facilities should be located as remotely as possible from areas of high environmental sensitivity such as drainage canals, streams, or natural wetlands. Buildings in flat, high water table areas should be built on pads of earth excavated from the lagoon. Elevating these buildings several feet above ground routes surface drainage away from them and allows flushed manure to flow by gravity to a lagoon built above the water table. Upland

facilities should be built on high ground and as far away fr om water sources as possible to allow wastewater management options.

TYPE OF OPERATION AND ANIMAL INVENTORY

The type of operation (dairy - lactating cow, dry cow, heifer, calf ; swine - farrow-to-weanling, farrow-to-feeder, nursery, finishing, farrow-to-finish ; turkey - brooder flock, grower, breeder ; etc.) affects most manure management practices. The maximum number of animals and corresponding total live weight expected on the farm on any given day is also necessary for most manure management calculations.

TYPE OF PRODUCTION FACILITIES

Different environmental management practices are required for different production facilities and systems. Stock trails and improved stream crossings may be required in vulnerable pasture areas. Fencing of animals from streams in intensively used areas where animals tend to congregate or along highly erodible reaches may be required. Animals maintained on unpaved lounging areas or drylots not supporting vegetation will in some instances require conservation practices to minimize the effects of lot runoff. These animals will most likely be denied direct access to surface waters or wetlands. Partially enclosed facilities with animals on open slabs will also be subject to runoff control. Totally enclosed facilities can affect the production performance as well as potential odors emitted depending on floor surface, ventilation, and manure management. In-house manure collection methods and frequency affect gas and odor levels. Modern manure removal methods such as flushing, pit recharge, and mechanical scr aping have drastically reduced the gas and odor levels inside production facilities.

MANURE STORAGE / TREATMENT FACILITIES

Producers must decide whether their objective is manure nutrient conservation for maximum fertilization or nutrient reduction for ease of management. If nutrient conservation is desired, then scrapers moving manure to outdoor holding tanks or basins, or settling basins prior to lagoons for flushed waste will be needed. Liquid manure spreaders or slurry irrigation systems will move the manure nutrients to large field crop acreages for spreading. If, on the other hand, nutrient reduction prior to land application is desired, then solids separation and/or anaerobic lagoons become very important parts of the overall treatment system. Lagoons, storage basins and holding ponds must be properly sized according to USDA-Soil Conservation Service specifications using correct construction, start-up, and management procedures. When properly planned and managed, lagoons can reduce overall odor levels around a production facility, reduce nutrients to be land applied by up to 85%, provide flexibility for land applica tion scheduling, and have minimal impact on shallow groundwater.

AGRONOMIC PLAN

Manure Characterization Summaries and estimates of manure quantities and nutrient content are available from the N.C. Cooperative Extension Service, USDA-Soil Conservation Service, N.C. Dept of Agriculture, N.C. Agricultural Chemicals Manual, as well as other sources. When no other information is available, such as when planning a new operation, these averages provide "ball park" figures and should be utilized. Existing operations are encouraged to develop individual estimates of the volume of manure, litter, feedlot runoff or lagoon liquid to be land applied, e.g., using water meters to measure the amount of water used in a production facility or by recording the lagoon levels periodically and determining the

accumulated volume. Representative samples of the material to be land applied should be analyzed twice annually for nutrient and mineral content. The N.C. Department of Agriculture provides this service with interpretations of results for a nominal fee.

Crop / Soil Selection Soil types should be mapped for each field on the farm to receive manure. Soil infiltration rates will often determine maximum irrigation rates or how much lagoon liquid can be applied before runoff occurs. Soil types also determine the fate of unused nutrients. Well-drained sandy soils provide more potential for unused nitrogen to convert to nitrates and leach downward. Heavy soils or poorly-drained soils reduce infiltration rates and water-holding capacity but provide more potential for unused nitrogen to denitrify harmlessly. Clay soils have more capacity to tie-up and hold phosphorus in place than do coarse soils.

Soil types also influence the yield potential of selected crops. If a corn crop, e.g., only has a yield potential of 100 bu/A on a given soil type, then it should only be fertilized for 100 bu/A, since any more nutrients would be wasted and become potential pollutants. Crop types should be selected for their nutrient requirements. A range of fertilization rates from 50 lbs of available nitrogen per acre on stands of pine trees to 400 lbs of available N on bermudagrass hayland allow flexibility depending on land availability and farm objectives.

Application Rates Application rates of manure, litter or wastewater should only supply the fertilizer needs of the crops. Since the manure nutrients are not a balanced blend for most crops, some nutrients will either be under- or over-applied. Some overapplication of phosphorus and potassium may be tolerated, however significant and prolonged overapplication of P and K should be avoided. Supplemental fertilizer will be needed if rates supply only the P and K requirements of the crop. Under no circumstances should available nitrogen be overapplied. Plant available nitrogen is currently estimated to be half of the total nitrogen in irrigated lagoon liquid and 70% of the total N in manure slurries that are soil incorporated. Worksheets are available from the Cooperative Extension Service to help calculate available nutrients and application rates.

Scheduling of Manure Application Manure nutrients should be applied as near to the period of plant uptake as possible. Nutrients that are readily available, such as in lagoon liquid, are more efficiently utilized by the crop in several small applications throughout the growing season. Nutrients should only be applied to crops during their normal growing season. For example, bermudagrass normally thrives from May to September and should not receive manure at other times of year except when overseeded with a cool season grass such as rye. Cool season crops are necessary to allow application to proceed during the cool season, or enough storage is necessary to avoid having to spread. Land application of manure nutrients on fallow soil or onto dormant crops will only lead to nitrate leaching downward toward ground water.

Manure Application Equipment Most manures will either be hauled with farm liquid manure spreaders, spread with irrigation systems, or applied by a custom applicator. Costs and time required for hauling, additional acreages required for concentrated slurries, soil compaction, odor considerations, and availability of custom applicators need to be considered for slurry management. It is not cost effective to haul wastewater. Most farms with lagoons will use simple farm irrigation systems, use portable company irrigation equipment, or hire custom irrigators. Those farms with field crops or tree stands will probably find portable systems such as travellers or center pivots most advantageous. Also, if portability to several different fields or large acreages are to be irrigated, travellers will be

selected. On the other hand, if small acreages of grass are to be irrigated and equipment portability is not necessary, small-nozzle, moderate-pressure, permanent irrigation systems provide low-labor and mo re uniform distribution of lagoon liquids. All manure equipment should be calibrated periodically for application rate and uniformity. Appropriate equipment or contractual arrangements must be available whenever manure or lagoon liquid needs to be land applied.

Crop Management Utilization It is important to remember that regardless of what crops are grown on land application sites, they all must be regularly harvested and removed from the site. Otherwise, nutrients will simply recycle back into the soil system and eventually become pollutants. For most field crops, readily established markets are available for the products. For grass crops, markets for hay may not be readily available and may need to be developed. Consideration should be given to marketing a particular crop before selecting that crop for land application.

Labor Availability / Accessibility The availability of labor and the ability to use that labor in the most efficient manner for manure management and farming chores outside of the production facilities should be considered. An irrigation system, e.g., that requires sprinklers to be moved or changed every two hours might require a laborer to shower out/in of the production complex for biosecurity reasons each time attention is given to the system. Would different irrigation equipment or management plans allow the labor to be used more efficiently? The same applies to crop establishment, maintenance, and harvest.

ANIMAL MORTALITY MANAGEMENT

Dead animals are required to be properly disposed of within 24 hours. On-farm mortality management options have consisted of below ground disposal or incineration. Below ground burial or pit disposal of animal and bird mortality may contribute nutrients to ground water in areas with coarse textured soils or high water tables. Mortality management alternatives currently being explored are collection for rendering or on-site composting. These alternatives would reduce below-ground point-sources of nutrients and produce a safe and marketable end product.

CONSERVATION PLAN

Erosion Control Soil as well as manure nutrients should be kept on the field where they are applied. Some nutrients such as phosphorus adhere to soil particles and only move when the soil particles move. Fields where manure is to be applied should have sound conservation practices where appropriate such as terraces, strip cropping, and conservation tillage.

Runoff and Drainage Management It is difficult to avoid occasional applications of manure that are immediately followed by a rainfall event. When this happens, conservation practices such as field borders, grassed waterways, sediment basins, and vegetative filters help to minimize the transport of nutrients and organics off-site. Fields receiving manure that have artificial drainage systems should have a water management plan in action. Some nitrates that have formed in the upper soil layers will be collected in the tile drainage and will be delivered to the drainage ditches or canals. Management of the water levels in these ditches and canals by water control structures can accelerate the denitrification of these nitrates harmlessly.

Cover Crops Double cropping or cover crops after harvest can help hold soil in place and remove some of the unused nutrients left in the upper soil layers. Crop rotation also tends to use certain nutrients or elements that otherwise would remain in the soil or be lost.

Planning a group of buildings and their surroundings to present a wholesome image is as important as planning for productive efficiency. When the public sees a livestock or poultry farm, they see much more than buildings and grounds. They see an attitude -- an attitude of pride in the business or an attitude of indifference. They see an environmental protector or an environmental polluter. Farm operators who take pride in maintaining the farmstead are generally better managers than those who practice poor housekeeping. Employees take more pride in their jobs and work output improves (Morris et al., 1973).

After weighing the important points of alternative manure management systems, a producer must decide which system appears best, then commit to providing the attention and management necessary to make the system function. No production or manure management system will take care of itself. An ounce of prevention is worth a pound of cure. The appearance of buildings and grounds on farms constantly generates images of the product, good or bad. A good farm image helps sell the product. Portraying an attitude of success is contagious -- to employees, to neighbors, to consumers and to the general public (Morris et al., 1973).

REFERENCE

Morris, T.B., W.C. Mills,Jr. and D.G. Harwood. 1973. Profit From Improving Your Image. PS&T Guide #17, N.C. Agricultural Extension Service, Raleigh, NC. 2 pp.

Prepared by

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Interim Criteria for Nutrient Management Planning
(Adapted from the Pennsylvania Bulletin, Vol. 24, No. 3, January 15, 1994, p 427-28)

Introduction

The Nutrient Management Act, Act 6 of 1993, requires the Pennsylvania State Conservation Commission to develop interim criteria for nutrient management planning as set forth in the Act. These criteria are not regulations, but give direction to the Department of Agriculture for the development of a nutrient management specialist certification program. In addition, the criteria provide the first statement of the basic elements of nutrient management plans to be developed by certified nutrient management specialists. The following interim criteria were prepared under Section 4(4) of the Act.

Interim Criteria

Nutrient management plans shall be developed to manage the use of plant nutrients for crop production and to protect the quality of surface and ground water. The plans shall include, but not be limited to, the following core components: nutrient application, manure management, excess manure utilization and/or disposal, stormwater runoff control and selection of other appropriate best management practices necessary to protect surface water and ground water quality. Plans developed under the Act shall address the following:

I. Nutrient Application - Formulation of an accurate nutrient application plan to assure appropriate plant utilization of nutrients and protection of surface and ground water. The basic components include:

(1) Determination of the cropping system and the crop acreage of specific lands suitable to receive nutrients. The land must be capable of receiving nutrients at the times and rates for proper application and utilization.

(2) Determination of all sources of nutrients available to the soil on the farm. Nitrogen is the nutrient of primary concern, but phosphorus, potassium and other nutrients would be reviewed. This determination would include amounts of nutrient materials available at specific times, determining nutrient content of materials intended to be used as plant fertilizer and determining nutrient availability for plant growth of nutrient residuals in the soil and in materials applied. The determination of nutrients produced would be based on an inventory of the annual animal equivalent units for each animal group on the farm, and/or available manure production data. Nutrient material testing and soil testing for suitable crop acreage will assist with development of assessment data.

(3) Determination of what additional nutrients would be required for crop growth to be applied only in the amounts necessary to achieve realistic expected crop yields. Nitrogen would receive primary consideration. Other nutrients will not be used as a limiting factor, unless appropriate to do so under specific criteria established by the Commission. As appropriate, additional testing of soil and nutrient materials would be scheduled.

(4) Determination and documentation of proper rates, amounts, application dates and methods for all nutrient source applications by field or crop group. Also, the adequacy of nutrient spreading methods and equipment would be determined.

II. Manure Management - The plan would evaluate the adequacy of the existing manure management system for the protection of surface and ground water and for proper nutrient utilization. The evaluation would consider the handling, collection, storage and spreading of manure. Manure storage facilities would not be required unless they are needed for the protection of surface and ground water as part of an integrated nutrient management system. The plan would identify appropriate practices, although engineering design work would not be included.

III. Excess Manure - The plan would determine the amount and type of any animal manure which exceeds the nutrient needs of projected crops. It would also select environmentally sound methods for the use or disposal of excess manure.

IV. Stormwater Runoff Control - The adequacy of existing stormwater runoff control practices to minimize erosion and sedimentation, and nutrient loss from cropland, pastures and animal concentration areas would be evaluated. Additional controls would be required if they are necessary for the protection of surface and ground water. Ordinarily, the existence of a current, implemented Conservation Plan would be adequate to address erosion and sedimentation control. However, conflicting plan components would be resolved, such as utilization of both manure incorporation and conservation tillage. The plan would identify appropriate practices, although engineering design work would not be included.

V. Laws, Regulations, Ordinances - Nutrient Management Plans developed under the Act shall comply with all relevant Federal and State laws, regulations and standards relating to water quality and the management of nutrients.

Input Needed

As noted in the introduction above, these interim criteria for nutrient management are the first public statement by the State Conservation Commission of the basic elements of nutrient management plans to be developed under this act. Thus, while these are not the regulations, it is likely that the regulations will be developed around these criteria. This provides an important opportunity for everyone to react to this preliminary statement of the criterial for nutrient management plans and provide input to the nutrient management advisory board which is drafting the final regulations. Input can be provided to any member of the nutrient management advisory board. The board members are listed below.

Livestock Producer
Irk A. McConnell
Washington County (1 yr.)
RR 1 Box 141
Cecil, PA 15321
412-745-8906

Swine Producer
Dennis Zimmerman
Snyder County (2 yr.)
RR 1 Box 163
Beaver Springs, PA 17812
717-658-4641

Fertilizer Industry Representative
William Brubaker
Lancaster County (2 yr.)
1408 Mission Road
Lancaster, PA 17601-5238
717-392-7577

Agriculture Lender Official
Bobby R. Jones
Union County (3 yr.)
PO Box 49
Lewisburg, PA 17837
717-523-1201

Meat Poultry Producer
Donald L. Bollinger
Lebanon County (3 yr.)
RR 1 Box 166
Millbach Road
Newmanstown, PA 17073
717-949-3866

Hydrologist
Jerrald R. Hollowell
Susquehanna River Basin Comm (2 yr)
Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102
717-238-0422

Egg Poultry Producer
Ronald L. Meck
Lancaster County (1 yr.)
275 Creamery Road
Denver, PA 17517
717-336-2631

Nonfarmer
Mary Lehman
Cumberland County (3 yr.)
8 Matthew Court
PO Box 312
Carlisle, PA 17013
717-532-1502

Dairy Producer
Joel Rotz
Franklin County (2 yr.)
3272 Guilford Springs Road
Chambersburg, PA 17201
717-375-2861

Nonfarmer
William Ebel
Lancaster County (1 yr.)
1894 Eden Road
Lancaster, PA 17601
717-393-5179

Veterinary Nutrition Specialist
Charles F. Ramberg, Jr.
University of Pennsylvania
School of Veterinary Medicine
(3 yr.)
378 West Street Road
Kennett Square, PA 19348
215-444-5800 Ext. 2317

Representative of Local Government
Eugene Billhime
Montour County (3 yr.)
161 Billhime Road
Danville, PA 17821
717-437-2742 or 717-271-3000

Feed Industry Official
George Robinson
Snyder County (1 yr.)
Kreamer Feed Store, Inc.
Route 522, PO Box 38
Kreamer, PA 17833
717-374-8148

Academic, Either an Agronomist or a
Plant Scientist from the School of
Agriculture of Penn College or
University
Lawrence D. Hepner, Jr.
Delaware Valley College (1 yr.)
100 Teal Drive
New Britain, PA 18901
215-345-4550

Environmentalist
Lamonte Garber
Lancaster County (2 yr.)
311 N. Lime Street
Lancaster, PA 17602
717-234-5550

Agronomy Facts # 40 RNutrient Management Legislation in PennsylvaniaS which describes the nutrient management law is available from all Penn State Cooperative Extension offices.

Dr. Douglas Beegle, Assoc. Prof. Agronomy
Dr. Les Lanyon, Assoc. Prof. Soil Fertility
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Agriculture & Natural Resources
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Worksheet

Poultry Waste As A Fertilizer

To calculate the amount of poultry waste (manure or litter) to use on a crop, you need to know the percentages of total N, organic N, and ammonium N in the waste on a wet-weight basis. If you have your litter or manure analyzed by a commercial laboratory, you can find these percetages on the lab report. Ammonium N may be referred to as mineral N or readily available N. Organic N is total N minus ammonium N.

Commercial laboratories usually report results on a dry-weight (oven dried) basis. Therefore, you will need to multiply lab results by the percentage of dry matter (DM) reported. For example, if 3.9% ammonium N and 20% moisture (80% DM) is on the lab report, 3.9% × 0.8 = 3.1% ammonium N in the fresh sample.

If you do not have a laboratory analysis done, you can use the following estimates for nitrogen on a wet-weight basis:

Total N = 3.1%
Ammonium N = 0.9%
Organic N = 2.2%

Step 1. Determine the amount of N available from poultry waste the first year of application.

1. Multiply the percentage of ammonium N in your waste sample by pounds per ton.

EXAMPLE:
0.009 ammonium N × 2,000 lb./ton = 18 lb. ammonium N in 1 ton of poultry waste.

YOUR ANALYSIS:
____ ammonium N × 2,000 lb./ton = ____ lb./ton.

2. Calculate the amount of ammonium N remaining after gaseous losses due to spreading. This is based on your method of application. Use the following factors to calculate the loss:

Factor	Method Of Application
0.75	Broadcast with no incorporation or incorporated after 7 days
0.80	Incorporated within 7 days
0.90	Incorporated within 4 days
0.95	Incorporated within 2 days

EXAMPLE (using broadcast with no incorporation):
18 lb./ton × 0.75 = 13.5 lb. ammonium N available per ton of waste applied.

YOUR FACTOR:
____ lb./ton × ____ (your factor) = ____ lb./ton.

3. Calculate the amount of organic N available the first year. Since only half of the organic N becomes available during the year of application, multiply the percentage of organic N in your waste sample by pounds per ton and by 0.5 (one-half).

EXAMPLE:
0.022 organic N × 2,000 lb./ton × 0.5 = 22 lb. organic N in 1 ton of poultry waste available the first year.

YOUR ANALYSIS:
____ organic N × 2,000 lb./ton × 0.5 = ____ lb./ton.

4. Add the factored amount of ammonium N available to the amount of organic N available the first year. This gives you the total amount of N available to your crop from poultry waste the first year you apply it.

EXAMPLE:
13.5 lb./ton ammonium N + 22 lb./ton organic N = 35.5 lb. total N in 1 ton of poultry waste available the first year it is applied.

YOUR TOTAL:
____ lb./ton ammonium N + ____ lb./ton organic N = ____ lb./ton.

If you have not applied poultry manure to your fields before this crop year, move to Step 3. If you have applied poultry manure the preceding year, complete Step 2.

Step 2. Determine the amount of N available from the previous years of application.

Only 50 percent of the organic N in poultry waste is available for use the first year. The remainder becomes tied up in the soil organic matter. However, another 12 percent becomes available as residual N the second year, and 5 percent becomes available two years after application. Calculate the amounts of residual N available in your fields from previous poultry waste applications.

1. Multiply the percentage of organic N in your waste sample by pounds per ton.

EXAMPLE:
0.022 organic N × 2,000 lb./ton = 44 lb. organic N in 1 ton of poultry waste.

YOUR ANALYSIS:
____ organic N × 2,000 lb./ton = ____ lb./ton.

2. Multiply the tons per acre of poultry waste applied to your field during the previous year by the pounds per acre organic N by 12 percent to find how much residual

Poultry By-Product Management
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Managing Broiler Litter and Fertilizers

Charles C. Mitchell, *Extension Agronomist*
James O. Donald, *Extension Agricultural Engineer*

Much has been said and written about the tremendous quantities of broiler wastes produced in Alabama and the potential problems and opportunities created by this agricultural resource. The use of broiler litter as a feed source for beef cattle has given cattlemen an abundant, inexpensive source of protein and minerals. However, the greatest opportunities exist in the proper use of broiler litter as an alternative source of plant nutrients on cropland, hayfields and pastures. This is where most of it has been applied in the past. However, excessive application of broiler litter on some soils overlying shallow aquifers or near streams has led to suspected water quality problems. High levels of nitrates and bacteria have been found in some wells, springs and surface waters in northern Alabama. Nutrient enrichment of surface waters with phosphorus can also occur where excessive phosphates have been applied in broiler litter and the land is not protected from erosion.

Figure 1 emphasizes the fact that broiler litter production has increased dramatically since the mid-70s. Broiler production is expected to experience even more growth within the next few years in Alabama. At the same time, fertilizer consumption has decreased to the lowest level in more than 20 years as cropland acreage drops.

Nitrogen Needs and Use

Nitrogen (N) is the primary nutrient of environmental concern in poultry waste. Nitrogen applied in excess of crop uptake is ultimately susceptible to leaching into ground water or runoff into streams. Nitrogen is also the most expensive fertilizer nutrient growers must apply and the nutrient needed in largest quantities by non-legume crops. We know where poultry production is concentrated (Figure 2). This happens to be in some counties where little cropland exists for disposal. Table 1 shows that of the 12 leading broiler producing counties in Alabama, 6 produce more than twice as much nitrogen in broiler litter as the total crop needs in that county.

The 12 leading poultry producing counties except Covington and Lawrence produce more nitrogen in broiler litter than is used annually in all the fertilizers applied in that county. For the entire state, 37 percent as much nitrogen is produced in broiler wastes as in all the commercial fertilizers used. For the state as a whole, we are not using enough nitrogen fertilizers to meet the demand for the major row crops and hay crops. This nitrogen deficit would be magnified considerably if pastures and non-farm uses were considered. However, the crop nitrogen needs in Table 1 do not take into consideration pastureland and non-farm uses of fertilizer nitrogen because statistics are not available for these demands. Nevertheless, when nitrogen in broiler litter is added to nitrogen used as fertilizer, there is a surplus of almost 28 thousand tons of nitrogen in Alabama. This figure grows much larger when other animal wastes from poultry layers and breeders, swine, dairies, and cattle feedlots are added.

Phosphate and Potash Needs and Uses

A similar story is revealed for fertilizer phosphate, potash, and broiler litter (Table 2). Again, all major broiler producing counties except Covington and Lawrence produce more phosphate (P_2O_5) in broiler litter than is used in commercial fertilizers. Soil samples from these broiler producing counties indicate a high per-

Table 2. Fertilizer Phosphate and Potash Used in Alabama Compared to that in Broiler Litter.

Leading broiler producing counties	Phosphate (P_2O_5) Fertilizer	Phosphate (P_2O_5) Broiler litter	Potash (K_2O) Fertilizer	Potash (K_2O) Broiler litter
	tons		tons	
1. Cullman	1000	8220	1173	5480
2. Dekalb	814	4500	1099	3000
3. Marshall	568	3060	752	2040
4. Blount	923	2700	1088	1800
5. Coffee	2169	2640	2784	1760
6. Pickens	1003	1920	832	1280
7. Winston	12	1740	13	1160
8. Crenshaw	601	1500	703	1000
9. Morgan	750	1440	962	960
10. Franklin	427	1380	567	920
11. Covington	1369	1260	1972	840
12. Lawrence	1453	1140	1168	760
Other counties	46,602	10,680	59,945	7120
STATE TOTAL	57,691	42,180	73,058	28,120

Table 3. Soil Samples Testing "Very High" and "Extremely High" from Major Broiler Producing Counties in Alabama in 1989.

Leading broiler producing counties	Soil samples testing "VH" or "EH" Phosphorus	Soil samples testing "VH" or "EH" Potassium
	% of all samples	
1. Cullman	28.0	10.8
2. Dekalb	28.8	12.2
3. Marshall	27.9	11.9
4. Blount	14.5	7.1
5. Coffee	13.2	3.8
6. Pickens	6.9	3.1
7. Winston	26.7	4.3
8. Crenshaw	29.9	5.0
9. Morgan	17.0	5.7
10. Franklin	14.7	12.2
11. Covington	28.3	0.6
12. Lawrence	3.0	5.5
STATE AVERAGE	15.2	6.7

Poultry By-Product Management
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Broiler Litter on Small Grains

C. C. Mitchell, *Extension Agronomist*
C. W. Wood, *Assistant Professor, Department of Agronomy and Soils*

Fertilizing wheat and other small grains with broiler litter provides an opportunity to utilize this abundant resource during the fall and late winter. However, excessive application of litter to crops grown for grain only increases risks of yield losses to diseases, lodging, and winter kill. This is not a primary concern where small grains are grown for forage only. In either case, too much litter combined with normal winter rains increases the potential for nitrate leaching into groundwater or nitrate and phosphate runoff into streams.

Broiler Litter Variability

Most growers who use broiler litter as a fertilizer source don't have it tested to determine the exact amount of plant nutrients they are applying. Even if tested, without proper storage it could change from the time the sample was taken until it was spread. Weather conditions and soil incorporation can have a large effect on nitrogen loss after litter has been spread. Spreader calibration (or lack of it) results in most application errors. Operators should take care to calibrate spreader trucks and manure spreaders using the "drop cloth" technique described in "Calibrating Spreaders for the Application of Animal and Poultry Manure" (circular 006 in this series).

Extension circular ANR-244 (also reproduced in this series) reports an average nutrient content of Alabama broiler litter equivalent to a 3-3-2 grade fertilizer (percent N-P_2O_5-K_2O). This would provide a total of 60-60-40 pounds per ton of N-P_2O_5-K_2O. But only about 25% of the nitrogen (15 pounds per ton) is readily available. The rest is organic nitrogen and depends on the soil's natural biological/chemical environment to mineralize it to a form plants can use. Around 70 to 80 percent of the phosphate and potash will be available to a crop this year. However, because of the potential water quality problems associated with excessive nitrogen applications, poultry litter should be applied primarily on the basis of its nitrogen content.

Nutrient Recommendations for Small Grains

Soil test recommendations are based on readily available inorganic nitrogen sources such as ammonium nitrate, urea, UAN-solutions, ammonium sulfate, or ammonium phosphates. Standard recommendations for small grains in Alabama on a soil testing MEDIUM in both P and K would be:

	Fall applied	Spring applied
	------ lb/a N–P_2O_5–K_2O ------	
Grain Only	20-60-60	60-0-0
Grazing	100-60-60	60-0-0

If adequate nitrogen is applied as broiler litter, excessive P and adequate K will usually be available for soils testing MEDIUM or HIGH.

How Much to Use–Theoretical

Fall applied: Assuming that 25 percent of the nitrogen is readily available, then a ton of litter at planting would yield 15 pounds of readily available nitrogen–just a little short of the 20 pounds per acre recommended. Certainly, no more than 2 tons per acre should be applied in the fall if wheat or other grain is planted for grain only. If it is heavily grazed, then 3 to 4 tons may be appropriate.

CAUTION–Excessive fall N could lead to greater risk of cold damage.

Spring applied: If 2 tons per acre is applied in the fall, a total of around 120 pounds of nitrogen per acre is in the soil-plant system. This may be enough for wheat grain. On the other hand, poultry producers often need to clean out houses in late winter and may have excess litter. An additional 2 tons per acre in February or early March would add another

Poultry By-Product Management
AGRICULTURAL ENGINEERING
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Calibrating Spreaders for the Application of Animal and Poultry Manure

Charles B. Ogburn, *Extension Agricultural Engineer*
James O. Donald, *Extension Agricultural Engineer*

Animal and poultry manure cannot be utilized effectively if you do not know how much you are applying to a given area. Calibrating your spreader is a simple and effective way for you to improve the utilization of the nutrients in the manure. Only by knowing the application rate of your spreader can you correctly apply manure to correspond to crop needs.

Calibration of Solid Manure Spreaders

In order to calibrate a spreader for solid (20% or more solids) manure, the following materials are needed:

1. Bucket
2. Plastic sheet, tarp, or old bedsheet (an even size, 8 ft. x 8 ft., 10 ft. x 10 ft., 10 ft. x 12 ft., etc., will make calculation easier)
3. Scales

To calibrate your spreader:

1. Locate a large and reasonably smooth, flat area where manure can be applied.
2. Spread the plastic sheet, tarp, or bedsheet smoothly and evenly on the surface of the test field.
3. Start driving the spreader at the normal application speed toward the sheet spread on the ground, allowing the manure to begin leaving the spreader at an even, normal rate.
4. Drive over the sheet at the normal application speed while continuing to apply manure.
5. Collect all manure spread on the sheet and pour it into the bucket.
6. Weigh bucket with manure, then subtract empty-bucket weight. This will give you the pounds of manure applied to the sheet.
7. Repeat the procedure three times to get a reliable average.
8. Determine average weight of the three manure applications.
9. Refer to the chart in Table 1 for size of the sheet and pounds of manure applied to the sheet. Then read "Tons of Manure Applied Per Acre."

If the size of your sheet is not listed, the following equation may be used to determine litter application per acre.

$$\frac{\text{Lbs. of manure collected over sheet X } 21.78}{\text{Area of sheet, sq. ft.}} = \text{Tons/acre}$$

This procedure is particularly suitable for dry waste such as broiler and turkey litter. Wet litter or manure is more difficult, but the basic procedure can still be used. A plastic sheet works well, with the main difference in procedure being that the sheet and the litter can be placed in the bucket together, and the dry weight of both bucket and sheet subtracted as in Step 6. The remaining steps are the same.

Calibration of Liquid Manure

The application rate for a liquid waste spreader can be determined by knowing: 1) the capacity of the tank in gallons; 2) the distance the spreader travels to empty the tank; and 3) the path width over which the waste is being spread. The path width can be paced off or measured with a tape. Determining the travel distance can be more difficult. One method is to measure and count the number of wheel rotations. Measure the tire from one side to the other. This is the tire's diameter. Multiply the diameter by 3.14 to determine the distance the spreader will travel in one tire rotation. Tie a piece of rope at the top of the tire, and as the spreader moves through the field count the number of times the rope comes to the top of the tire until the tank is empty.

Poultry By-Product Management
HORTICULTURE
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Horticultural Uses Of Composted Broiler Litter

Bridget K. Behe, *Extension Horticulturist*

Composted broiler litter is very useful in the home lawn and garden. It has nutritional value to the plant and improves the soil structure in gardens. When it is composted properly, the litter has no unpleasant odor, so it can be used indoors in a soilless potting medium. The lack of an unpleasant odor, in addition to the plant nutrient value of the composted broiler litter, makes it very useful for indoor and outdoor gardens. It adds organic material which improves soil structure and drainage.

Soil Amendment

One use for composted broiler in the home garden is as a soil amendment. Soils are amended with a variety of organic materials to improve their structure, improve drainage, and enhance the fertility of the soil. Many garden soils, especially soils in newer gardens, would benefit substantially from the addition of composted organic material. The soil structure often has too much sand or too much clay for proper growth of flowers and vegetables.

Composted broiler litter adds organic material to the soil, improving drainage in clay soils and improving the water-holding capacity of sandy soils. To use composted broiler litter as a soil amendment, first loosen the soil in the garden area with a shovel to the depth of about 1 foot. Next, spread 3 to 6 inches of composted broiler litter on the top of the soil. Two inches are recommended as a minimum amount. For especially poor soils, you may want to incorporate a maximum of 6 inches of composted broiler litter to the garden soil. Next, turn the garden soil over again, this time incorporating the composted organic material.

Flowering and Vegetable Transplants

Soil amended with composted broiler litter is in good condition for planting most kinds of garden plants, including annual and perennial flowers and vegetable transplants. Use your trowel to dig a small hole for the transplant. When you remove the plant from its container, be sure to tear the bottom of the root-ball prior to planting it. Otherwise, the roots can continue to grow in circles as though they were still in the container. Simply put your finger in the bottom of the transplant about a half-inch and tear some of the roots from the bottom. Fill in the hole with amended soil, and water thoroughly. Mulching the plants will help retain moisture and reduce the amount of water required.

Transplanting Trees and Shrubs

Composted broiler litter can be used as a soil amendment when planting or transplanting small trees and shrubs. First, determine the size of the container in which the tree or shrub is growing. Dig a hole at least twice the size of the plant's container. Work 3 to 6 inches of composted broiler litter into the soil removed from the hole. This backfill is now amended and ready to be used for planting. Add 6 inches of backfill soil to the hole, and place the tree or shrub in the hole. Be sure that you have removed the container, especially if it is plastic, but keep as much soil around the root-ball as possible. Check to see that the soil line on the plant is level with your garden. A shovel handle works well to see if the plant is resting where it should be. Use the remainder of the amended backfill to fill in the transplant hole. Be sure to water the shrub very thoroughly to remove any pockets of air which may have been trapped when the backfill was added.

Potting Mix for Indoor Plants

Flowering and foliage plants grown in the home during the fall and winter months can be potted in a soilless potting medium amended with composted broiler litter. To make your own potting medium, mix

Poultry By-Product Management

AGRONOMY

ALABAMA COOPERATIVE EXTENSION SERVICE, AUBURN UNIVERSITY, ALABAMA 36849-5633

The Value And Use Of Poultry Waste As Fertilizer

Charles C. Mitchell, Jr., *Extension Agronomist*
James O. Donald, *Extension Agricultural Engineer*
John Martin, *Consulting Agronomist*

The Alabama poultry industry (broilers and layers) produces more than 735 million birds a year. These birds produce about 1.7 million tons of manure and litter.

The nutrients in this manure could adequately fertilize every acre of corn, cotton, wheat, and sorghum produced in Alabama or 800,000 acres of bermuda or fescue pasture.* In fact, the nitrogen (N), phosphate (P_2O_5), and potash (K_2O) in poultry manure represent about 40 percent of the N, 90 percent of the P_2O_5, and 40 percent of the K_2O spread each year in commercial fertilizers in Alabama.

Poultry manure, if properly handled, is the most valuable of all manures produced by livestock. It has historically been used as a source of plant nutrients and soil amendment. However, in areas of intense poultry production, excess manure represents a waste problem for producers.

In some areas, over-fertilizing pastureland with poultry manure has resulted in groundwater and surface water problems. These problems developed as excess nutrients washed off the land or leached into groundwater supplies.

To obtain the maximum economic value of the plant nutrients in poultry manure and to protect the water supply from excessive nutrient run-off or leaching, apply poultry manure to match the nutrient needs of the crop.

Nutrient Analysis

Two basic types of poultry wastes are produced in Alabama—broiler litter and caged layer manure (Table 1). Broiler litter, for fertilizing purposes, includes all floor-type birds such as broilers, pullets, and floor layers. Some type of bedding or litter material is used on the floor of these houses.

Caged layer manure is free from litter material and generally has a higher moisture content than manure from broiler houses. Both types of waste will contain feathers and some wasted food.

The chemical analysis of either type of manure is highly variable due to several factors. These include moisture, temperature, amount and kind of litter, amount of soil picked up in cleaning a house, the number of batches of broilers fed on the litter, and the conditions under which the manure was stored and handled before spreading.

*Based on total nitrogen (N), phosphate (P_2O_5), and potash (K_2O) in manure and a fertilizer recommendation for a soil testing *medium* in P and K.

Table 1. Estimation Of Poultry Manure Production.

Type Of Poultry	Percent Moisture	Grow-Out Time Interval	Tons Produced Per 1,000 Birds
Broilers*	20	6 to 7 weeks	2
Caged layers	75	1 year	35 to 44

*Based on six grow-out cycles per year on pine shavings or peanut hull bedding.

Table 2 shows both the average and range of nutrient composition of broiler litter sampled in Alabama from 1977 through 1987. During this 11-year period, the litter from 147 broiler houses had an average moisture content of 19.7 percent and an average fertilizer content on a dry-weight basis of 3.9 percent N, 3.7 percent P_2O_5, and 2.5 percent K_2O.

Table 2. Nutrient Composition Of Litter (Dry-Weight Basis) From 147 Broiler Houses Sampled In Alabama, 1977-1987.

	Average Analysis (percent)	Range (percent)
Moisture	19.7	15.0 to 39.0
Nitrogen (N)	3.9	2.1 to 6.0
Phosphate (P_2O_5)	3.7	1.4 to 8.9
Potash (K_2O)	2.5	0.8 to 6.2
Calcium (Ca)	2.2	0.8 to 6.1
Magnesium (Mg)	0.5	0.2 to 2.1
Sulfur (S)	0.4	0.01 to 0.8

In 1981, litter from two slat-breeder houses and one pullet house and manure from two high-rise caged layer houses were analyzed for moisture and nitrogen. Results are given in Table 3.

The nitrogen content of litter from the pullet house was only about one-third the nitrogen content of broiler litter (Table 2). The nitrogen content of litter from the slat-breeder house was about half that of broiler litter.

When litter analyses are run by a laboratory, the readily available N is reported as ammonium N or NH_4^+–N. Fertilizer urea and manure urea are likely to convert to ammonia gas (NH_3) and then to evaporate.

When manure has a strong ammonia odor or is spread on the surface and not incorporated into the soil, significant nitrogen will be lost. As much as 75 percent of the ammonium N (22 percent of total N) could be lost within seven days after spreading if the weather is hot and dry and the manure is not soil-incorporated.

Of course, incorporation is not practical or even desirable in situations such as pastureland or hay fields, and ammonium N loss should be included in the total amount to be applied.

The organic N fraction gradually becomes available for crop uptake as the manure decomposes. Scientists in Virginia estimated that for broiler litter, about 50 percent of the organic N is released during the first year following application, 12 percent within the second, 5 percent during the third, and 2 percent during the fourth.

The percentages would be similar for North Alabama, but decomposition will be somewhat faster when manure is incorporated into the sandy soils of South Alabama. Therefore, the total amount of N available from manure applications is the sum of that available from applications being made at a given time plus that available from previous applications (residual N).

The P and K fractions are considered to be about 75 percent as effective as commercial fertilizers during the year of application. However, manure applications should be based on the N requirement of the crop because excess nitrogen can leach into groundwater or run off into streams, creating environmental concerns. If litter is applied at rates that will supply the N needed by the crop, adequate P and K are generally available.

Under frequent manure applications, P will build up in Alabama soils to very high levels. Potash may leach in sandy soils and some fertilizer K applications may be necessary to meet the needs of certain crops, particularly hay crops.

Land Application

When applying poultry manure to cropland, pastureland, and hay fields, consider the following.

1) Determine the nutrients in the manure or litter prior to spreading. An analysis by a commercial laboratory would determine exactly how much moisture, ammonia N, organic N, and other plant nutrients are in the sample. This will allow you to calculate the value of the manure and how much to spread. If a chemical analysis is not made, a good estimate of the fertilizer content of litter is as follows: *A ton of broiler litter with 20-percent moisture contains 60 pounds of nitrogen, 60 pounds of phosphate, and 40 pounds of potash.* However, keep in mind that stored litter can change over time unless it is protected, and an analysis may take as long as two weeks.

2) Determine the nutrients needed by the crop to be grown. Soil testing provides the best estimate of residual P and K in the soil and other soil amendments (e.g., lime) that should be applied for optimum yields and nutrient-use efficiency. Recommended N rates are given for each crop on the soil test report. *Exceeding the recommended rates by more than 30 percent could result in excessive N leaching in some soils or the potential for surface run-off into streams.*

3) Estimate the availability of N in the manure. Then calculate a rate of application that is consistent with the requirements from the soil test report (see Circular ANR-244a, "Worksheet For Calculating Poultry Waste").

Other Recommendations

Reducing ammonium odors. To conserve N in poultry manure and to reduce the ammonia odor and associated N loss, apply superphosphate at the rate of 100 pounds per ton of manure in the house. The phosphate will trap the ammonia as ammonium phosphate, and it will increase the fertilizer value of the final litter. Fermentation losses in broiler litter may be reduced by using litter materials which rapidly dry the manure. The most effective means of reducing N losses is to dry the manure in the poultry house.

Adding hydrated lime. Hydrated lime (calcium hydroxide) will help maintain good litter condition and reduce fly problems. However, it will also increase ammonia volatilization and N loss. Do not use it when the ammonia level in the house is high. Use lime at the rate of 50 pounds per 1,000 square feet of floor space.

Outside storage problems. Manure stored outside and exposed to the weather will decompose rapidly. An ashy gray appearance indicates a loss of nutrient value. The N and organic matter will be greatly reduced and K may be lost due to leaching. You get maximum fertilizer value when manure or litter is protected from the weather.

N-use efficiency. Where excess quantities of manure must be disposed of on the land, choose a system to maximize N uptake by a crop. Row crops are poor users of soil N because of limited root systems. Corn or cotton may take up only 50 to 60 percent of the N applied. Grasses, such as hybrid bermudagrasses, produce large amounts of dry matter and are efficient N users. As much as 90 percent of the applied N could be recovered by a good bermudagrass sod.

Cool-season grasses are not quite as efficient because most of their growth is in the early spring. The mineral N in manure applied in the summer and winter to cool-season crops such as tall fescue may be lost through leaching. Apply manure to crops to maximize N uptake and N-use efficiency. Harvest excess forage frequently to remove the N from the land. These practices will minimize potential surface and groundwater contamination from excess N applied in manure.

Poultry By-Product Management
ANIMAL SCIENCE
ALABAMA COOPERATIVE EXTENSION SERVICE, AUBURN UNIVERSITY, ALABAMA 36849-5625

Feeding Broiler Litter To Beef Cattle

B. G. Ruffin, *Extension Animal Scientist*
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Cattle and other ruminants have a unique digestive system that allows them to use waste and other types of by-products as sources of dietary nutrients. The cattle-feeding industry has been built largely on the use of by-products and other materials that can be digested only by ruminants. One by-product which can be used as a cattle feed is broiler litter.

The broiler chicken industry has long considered broiler litter a problem by-product. It has been used mainly as a fertilizer, but this use has lately been a cause for concern. Where broiler chickens are intensively produced and the litter is distributed over too small an area, broiler litter can contaminate the groundwater with excess nutrients. This problem will only intensify in the future as the poultry industry continues to grow.

Moreover, fertilizer does not make the most efficient use of broiler litter. In terms of the cost of replacing the nutrients it provides with nutrients from other sources, broiler litter is worth four times more as a cattle feed ingredient than as fertilizer. Litter is a good source of protein, energy, and minerals, especially for brood cows and stocker cattle, which are the backbone of the cattle industry in the state. In addition to offering an economic advantage, using broiler litter in feed also helps to conserve plant nutrients. These nutrients, nitrogen, phosphorus, potassium, and other mineral elements, are distributed on pasture land as manure by the cattle consuming the litter. Under present conditions, broiler litter offers so many advantages that even long-distance transportation does not reduce its economic value. Alabama beef cattle producers can make use of this plentiful resource to substantially reduce their production costs.

Beef producers can use large amounts of broiler litter, provided that it is of reasonably good quality and suitable for feeding. Two million tons of broiler litter are produced each year in Alabama, but only about 35 percent is good enough to be fed to cattle. With improved litter management practices, Alabama could produce 1.0 million tons of litter for cattle feed.

Most beef producers take into account the public perception of beef when they are considering using waste materials as feed. There is an apparent reluctance on the part of the public, as well as of some beef producers, to accept broiler litter as a cattle feed. However, the public readily accepts organically grown vegetables grown on composted broiler litter. The process by which a plant assimilates food into its tissues is much less complicated than the process by which a cow does the same thing; a cow's food is broken down and processed much more completely. And, in fact, a cow must be off broiler litter for 15 days before it can be slaughtered for beef, while a mushroom can go directly from its bed of manure to the grocery store.

It is important that the beef industry avoid a controversy over the healthfulness of beef. Broiler litter has been used as feed for over 35 years in all areas of the country without any recorded harmful effects on humans who have consumed the products of these animals. In addition, in Alabama, litter is most commonly fed to brood cows and stocker cattle which are not usually marketed as slaughter beef. Very little if any litter is in the diets of finished cattle fed for slaughter (although, allowing a 15-day withdrawal period from feeding litter before slaughter, such a diet would be considered safe). So the

Table 1. Nutrient Content of Broiler Litter in Alabama

Components, Dry basis	Average	Range
Moisture, %	19.5	4.70 - 39
Dry matter, %	80.5	61 - 95
*TDN,%	50.0	36 - 64
Crude Protein, %	24.9	15 - 38
Bound Nitrogen, %	15.0	5 - 64
Crude Fiber, %	23.6	11 - 52
Minerals		
Calcium, %	2.3	0.81 - 6.13
Phosphorus, %	1.6	0.56 - 3.92
Potassium, %	2.3	0.73 - 5.17
Magnesium, %	0.52	0.19 - 0.88
Sulfur, %	0.50	0.22 - 0.83
Copper, ppm	473	25 - 1,003
Iron, ppm	2377	529 - 12,604
Manganese, ppm	348	125 - 667
Zinc, ppm	315	106 - 669
Ash (Minerals), %	24.7	9 - 54

106 Samples *TDN = Total Digestible Nutrients

between fresh litter and litter stacked for 6 months.

Though moisture content is not an important measure of nutrient value, it will determine the physical quality of the feed. If the moisture content is 25 percent or more, a feed mix will not flow easily through an auger. However, if the broiler litter is 12 percent moisture or less, the ration may be dusty and less palatable to the cows. Some beef producers see an increase in feed consumption when water is added to extremely dry mixtures of litter and grain just prior to feeding.

TDN. The Total Digestible Nutrients (TDN) figure is calculated from crude protein and crude fiber values. The energy value of broiler litter is fairly low in comparison to grain. However, litter that has a calculated value of 50 percent TDN is comparable to good-quality hay. Litter could be a valuable source of energy for both stocker cattle and brood cows.

Crude Protein. The average crude protein level of the samples analyzed was 24.9 percent. Over 40 percent of the crude protein in litter can be in the form of non-protein nitrogen. The non-protein nitrogen is mostly uric acid which is excreted by poultry. Young ruminants do not utilize non-protein nitrogen as readily as more mature beef cattle. So, for best performance, feed broiler litter to beef cattle weighing over 450 pounds.

Bound Nitrogen. When feed ingredients overheat, the nitrogen becomes insoluble (bound), and cattle can digest it less easily. The bound nitrogen in the litter samples analyzed in this study averaged 15 percent of the total nitrogen. In litter that showed signs of overheating, more than 50 percent of the total nitrogen was bound nitrogen.

Studies have shown that as the amount of bound nitrogen increases, the dry-matter digestibility decreases. Thus, overheating significantly reduces the feeding value of the litter. Methods for managing the temperature of stored litter are discussed in the section on processing and storing broiler litter.

Crude Fiber. Crude fiber composed an average of 23.6 percent of the samples analyzed. The fiber comes mainly from chicken bedding materials such as wood shaving, sawdust, and peanut hulls. Bedding usually consists of finely ground, short fiber materials.

The fiber in litter cannot effectively meet the ruminant's need for fiber, because cattle also need stacked for at least 20 days. Studies have demonstrated that pathogenic bacteria (intentionally added to litter at levels higher than encountered in infected litter) were killed when litter was deep-stacked for 5 days. Longer stacking times are recommended to ensure a good margin of safety from pathogens.

In addition to the heat generated in stacked litter, ammonia resulting from the degradation of uric acid and urea, which are common nitrogen compounds in litter, also kills pathogenic organisms. At 140° F, bacteria such as *Salmonella*, tubercule bacilli (associated with avian and bovine tuberculosis), and pathogens excreted with feces are killed within an hour. There is essentially no risk involved with transmitting diseases through the feeding of litter **if the litter has been deep stacked for a period of 20 days or more, and the stack has reached an internal temperature of 130° F or more.**

Antibiotics fed to broiler chickens are not a problem when the litter is fed to beef cattle. Many of the antibiotics are degraded by microorganisms present in the litter as it is processed. Furthermore, essentially all the antibiotics approved for chickens are also approved for cattle.

Mycotoxins such as aflatoxin are not a cause for concern when feeding litter to cattle. Molds that produce mycotoxins do not grow well in litter because it is alkaline, because it releases ammonia which is toxic to molds, and because the growth of molds is limited to surfaces exposed to air. Deep-stack processing of litter helps to curtail mold growth.

Broiler litter is usually handled in bulk and transported in fairly large amounts. Thus, some beef producers store litter in 100- to 300-ton stacks. With proper storage there is very little loss in quality, even when litter is stored for more than 5 years. However, some precautions must be taken to ensure a good-quality litter at feeding time.

Heat is the one thing that reduces the quality of broiler litter in the stack. Excessive heating reduces the digestibility of the dry matter in the litter. Fresh stacked litter develops heat spontaneously. Trials have been conducted using a number of chemical additives such as urea or acid, as well as other procedures, to limit the heating of stacked litter.

Excessive heating (more than 140° F) can be controlled by limiting the moisture content of the litter to less than 25 percent and by limiting the litter's exposure to air. Some producers use farm tractors to exclude oxygen when packing broiler litter. This process will reduce overheating, but it is also expensive. Storing broiler litter in an upright silo has been shown to be an excellent storage procedure. However, litter is abrasive on silage handling equipment.

Sealing the broiler litter stack with 6 mil polyethylene to exclude oxygen is the least expensive method of heat control. Polyethylene should be used if the stack is under a barn or if it is outside. Figure 1 shows the temperature profile of two stacks of litter 12 feet deep, one uncovered and the other covered with polyethylene. To destroy pathogens in the litter, the temperature should reach 130° F. If the temperature is 160° F or more, the protein becomes bound and digestibility decreases. In both stacks of litter, the temperature was in excess of 130° F for 21 days. The litter covered with polyethylene achieved a temperature high enough to eliminate pathogens but did not overheat and decrease nitrogen digestibility. The litter stack that was not covered reached a temperature 27° F higher than the covered stack.

Suggested Rations

Because the nutrient levels in broiler litter are variable, the suggested rations in Table 2 should be used only as a guide. A supplement of vitamin A should be added to all broiler litter rations because litter is almost totally devoid of this nutrient. Adding Bovatec or Rumensin will decrease the incident of bloat when feeding stockers.

In Table 2, Ration 1 is calculated for use as the major ration for dry beef cows until 3 to 4 weeks before calving. Hay or some other roughage should be provided to maintain normal rumen function. At least 2 pounds daily of long hay should be adequate. A 1,000 pound dry cow will require 20 to 24 pounds of Ration 1 during the winter months for maintenance. Corn that is mixed with broiler litter should be cracked or ground. Cattle that are fed mixtures of litter and whole grain corn or other grains tend to waste more feed than when fed ground grain mixtures.

Ration 2 is formulated for the lactating brood cow. Fed at about 25 pounds daily, this ration will furnish adequate nutrients during the winter months. Some long hay or other roughage will be needed for both the lactating brood cow and the

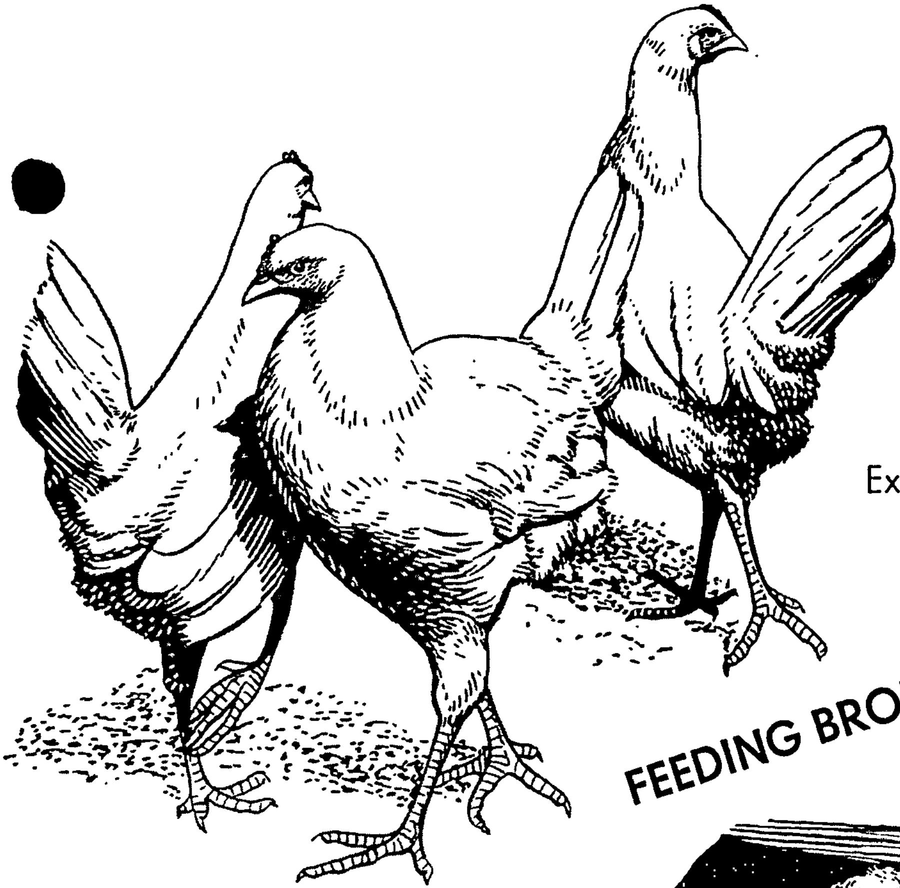
Table 2. Suggested Rations

Ration Number	1[a] Dry Brood Cow	2[a] Lactating Cow	3[a,b] Stockers
Ingredients	Pounds		
Broiler Litter	800	650	500
Cracked Corn	200	350	500
Total Pounds	1,000	1,000	1,000
	Nutritional Content %		
Dry Matter	80.5	82.2	83.8
TDN	62.6	68.3	70.3
Crude Protein	18.1	16.4	14.7
Crude Fiber	21.2	17.2	13.6
Calcium	1.6	1.27	0.96
Phosphorus	1.3	1.11	0.93

[a] Add vitamin A at 1,500 I.U. per pound of feed.

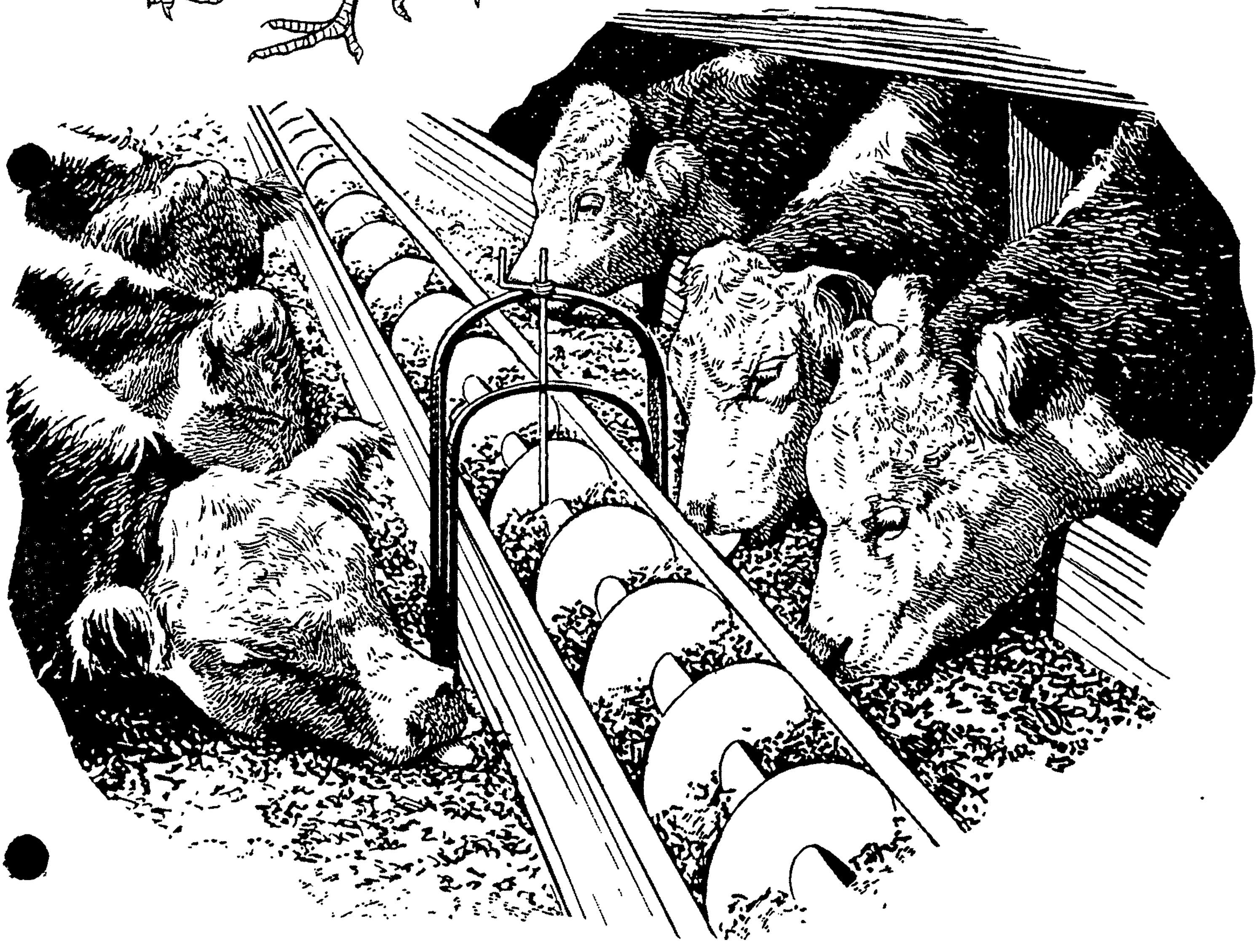
[b] Rumensin or Bovatec can be added to feed at 150 mg per day for animals weighing less than 700 pounds and 200 mg per day for animals weighing more than 700 pounds.

CIRCULAR ANR-280



The Alabama Cooperative Extension Service
Auburn University

FEEDING BROILER LITTER TO BEEF CATTLE



FEEDING BROILER LITTER TO BEEF CATTLE

BROILER LITTER has been used as a feed ingredient for cattle for almost 30 years. It has become a common feedstuff for cattle in many areas where broilers are produced. It has been used effectively to maintain the brood herd as well as in growing and finishing rations.

Alabama's broiler industry produces an estimated 1.5 million tons of litter each year. With proper supplementation this litter could provide most of the feed required for our 834,000 brood cows during the winter.

The Food & Drug Administration (FDA) has not sanctioned the feeding of animal waste. However, the FDA's current position is that regulatory action will not be taken unless animal waste intended for use as animal feed is found to be adulterated and is shipped in violation of their regulations. In the past several years, ten states have initiated specific administrative regulations or started registering animal wastes as feed ingredients under their existing feed laws, without adopting new regulations. In practice, FDA regulation of animal feed has typically involved a cooperative state-federal effort and such a program in the case of recycled animal waste would appear to be logical. Thus, the burden of setting rules and regulations for distribution and use of animal waste as feedstuff will be mainly left to the individual states.

The livestock producer, regardless of regulations and the feedstuff used, has the responsibility of selling a wholesome product that is free from drugs and toxic substances. Even with proper storage and processing, *broiler litter contains residues of drugs; therefore, Alabama regulations require that broiler litter feeding should be discontinued* 15 *days before slaughter.*

COMPOSITION

Broiler litter is a mixture of broiler manure, bedding material, waste feed and feathers. Wood shavings, sawdust and peanut hulls are the main bedding materials used in broiler houses in Alabama. The kind of bedding used apparently does not affect the quality of litter removed from a broiler house. However, broiler litter from different houses and management systems is variable in nutrient content.

The Alabama Cooperative Extension Service and the Tennessee Valley Authority have collected and analyzed broiler litter samples from north Alabama. The nutrient content found is given in Table 1.

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JOHN MARTIN, *Agronomist, Tennessee Valley Authority*

Table 1. NUTRIENT CONTENT OF BROILER LITTER[1]

Composition	*Average*	*Range*
	%	%
Dry Matter	78.3	69-84
Composition of Dry Matter		
TDN (calculated)	55.0	26-64
Crude Protein	23.9	13-31
Crude Fiber	26.9	14-46
N-P-N (Protein Equivalent)	5.7	10-11
Ash	21.5	10-47
Calcium	2.1	1.0-3.5
Phosphorus	1.6	1.1-1.9
Potassium	1.7	1.3-2.1
Magnesium	0.44	0.3-2.1
Sulfur	0.21	0.01-0.41
Copper	0.036	0.0011-0.060
Arsenic	0.0036	0.0018-0.0062

[1]Found in 31 samples collected from north and central Alabama.

The average crude protein content of litter samples was 23.5 percent, which is not as high as quoted by other states. This could be due to greater loss of non-protein nitrogen (NPN) due to higher humidity and heat. NPN protein equivalent was 5.7 percent on a dry weight basis. Thus, the NPN makes up only 24 percent of the total crude protein. Some states report 40 to 50 percent of the total crude protein occurring as NPN. Generally, the lower the NPN value, the higher the quality of the crude protein. More bedding will tend to reduce the more important nutrients and increase the crude fiber content.

High levels of ash indicate that soil is mixed with the litter and this will also reduce the level of the important nutrients. Broiler litter with over 22 percent ash has soil contamination that lowers its feeding value.

Chemical analysis of the samples showed that mineral content increased as more batches of broilers were grown out on litter. Litter is a rich source of calcium and phosphorus. Trace minerals are also present in more than adequate amounts for cattle when broiler litter is fed properly. When litter makes up more than 30 percent of a ration there is no need for additional supplemental minerals.

The Total Digestible Nutrients (TDN) found in broiler litter indicates a relatively low-energy feed. Calculated TDN values range from 26 to 64 percent. Even dry brood cows need additional energy such as grain (corn, wheat, etc.) when wintered on broiler litter. The average TDN level of litter is similar to average quality hay grown here in Alabama.

PROCESSING BROILER LITTER

Select only good quality litter for processing. The only sure way to determine the quality is chemical analysis. The litter should be analyzed for moisture, crude protein, crude fiber and ash. Avoid litter that is high in moisture. Litter directly out of the house will usually have 20 to 25 percent moisture, which is adequate for the ensiling process and storage.

Select litter that is free of rocks, glass, metal and other foreign objects. Figure 1 shows only a few of the items that may be found in broiler litter. Precautions should be taken to keep these

materials out of the litter. They can be harmful and even fatal when eaten by cattle. Metal can be removed by locating magnets at the proper place in handling equipment.

It is important to process broiler litter in such a manner that harmful agents like salmonella and coliform bacteria are destroyed. Processing litter will also increase its acceptability to cattle. Deep stacking under a shed or outside is the method most often used to process litter. It should be stacked at least 6 to 8 feet deep for proper heat development.

Allow 4 to 6 weeks for ensiling before feeding. After ensiling, the litter should have a "chocolatey" smell. Properly stored litter will lose its typical manure smell and will be much more acceptable to the cattle.

Litter can be stacked outside, but the loss will be much greater. Covering the litter with heavy duty polyethylene will prevent water penetration, eliminate loss and reduce mold development. All wet surface areas should be discarded before feeding. Broiler litter can also be processed in a pit or bunk silo.

When deep-stacking litter, it is important to pack the litter with a tractor, if possible. This will eliminate caramelization or dark heated areas in the litter stack. If overheating takes place it could tie up the protein as well as produce spontaneous combustion. Eliminate all boards or wood protruding into a stack.

Broiler litter stored in an upright silo also produces a palatable feedstuff for cattle. If additional moisture is needed, apply water as the litter comes out the blow pipe at the top of the silo. Broiler litter with added water has poor handling qualities. Litter with 35 to 40 percent moisture is almost impossible to blow into a silo with conventional blower machinery and other handling equipment.

Broiler litter can be ensiled with feedstuffs such as grain or silage. Adding corn at the rate of 10 to 20 percent by weight has been shown to be beneficial in the ensiling process. This is also a procedure to increase the energy value of the litter with no mixing before feeding. Twenty percent broiler litter and 80 percent silage is generally an adequate mixture for ensiling. For best results, however, an analysis to determine the dry matter of the silage and broiler litter is necessary.

Chemicals such as formaldehyde can be used to destroy pathogens in fresh broiler litter. Chemical treatment reduces storage time as well as the amount of space needed for storage. Short chain fatty acid is used by some producers to reduce spoilage and mold development.

SUGGESTED RATIONS

Because the nutrient levels in broiler litter are variable, the suggested rations in Table 2 should be used only as a guide. Ration number 1 is calculated for use as the major ration for dry beef cows. Hay or some other roughage should be provided to maintain normal rumen function. Three pounds of long hay fed every two or three days will be adequate. A 1,000 pound dry brood cow will need about 20 to 24 pounds of ration number 1 for maintenance during winter months. Corn mixed with broiler litter should be cracked or ground. Cattle fed mixtures of litter and whole corn tend to waste more feed than when fed ground corn mixtures.

The number 2 ration is formulated for the lactating brood cow. Fed at about 25 pounds daily it will furnish adequate nutrients during the winter months. Some long hay, as with the dry cow, will be needed for normal function of the rumen.

The number 3 ration is formulated for growing stocker cattle. Stocker cattle weighing 500 pounds will consume about 14 pounds of this ration. Healthy stockers that have been wormed, vaccinated, implanted and otherwise managed as recommended by the Extension Service Stocker 700 program should gain two pounds or more daily consuming this ration.

The number 4 ration can be fed to cattle weighing 750 pounds or more. Consumption should be 25 to 28 pounds daily for maximum gain. Long hay or a small amount of oat or wheat straw will maintain normal rumen function for cattle consuming finely ground rations such as the number 4 mixture.

Calculated analysis of the suggested rations, based on the broiler litter analysis given in Table 1, is given in Table 3.

Table 2. SUGGESTED RATIONS

Ration number	1	2	3	4
Ingredients	– – – – –	pounds	– – – – –	
Broiler litter	800	650	500	345
Cracked yellow corn	200	350	500	650
Ground limestone	....	....	....	5
	1,000	1,000	1,000	1,000

Add vitamin A at 1,500 I.U. per pound of feed, and Rumensin at the rate of 150 mg per day for animals weighing less than 700 pounds and 200 mg per day for animals weighing more than 700 pounds. Provide plain salt free choice.

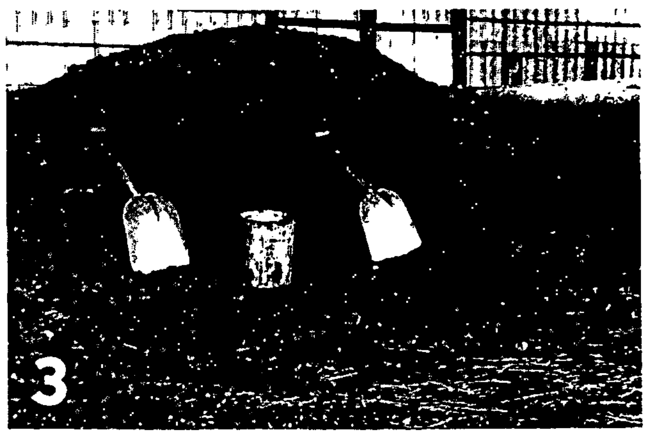
Table 3. CALCULATED ANALYSIS OF SUGGESTED RATIONS (DRY BASIS)

Ration number	1	2	3	4
	– – – – – – –	%	– – – – – – –	
Dry matter	80.5	82.2	83.8	85.4
TDN	62.6	68.3	73.8	78.9
Crude protein	18.1	16.4	14.7	13.1
Crude fiber	21.2	17.2	13.6	9.9
Calcium	1.60	1.27	0.96	0.78
Phosphorus	1.30	1.11	0.93	0.74

BROILER LITTER FEEDING IN ALABAMA

Most of the income from beef cattle in Alabama is from our brood cow herds. However, more cattlemen are now growing weaned calves to heavier weights in various stockering programs as well as finishing cattle for slaughter. Beef producers and farmers traditionally adapt to a variety of production practices to remain competitive, and many systems are being used in the state to process and feed broiler litter. The ones presented here show only a few of the many ways to feed broiler litter.

Most beef herds in Alabama have only 25 to 30 brood cows. It is not economical for such small producers to invest in costly machinery to provide feed for the 120- to 130-day winter feeding period. Low cost systems for wintering a small herd include deep-stacked litter covered with polyethylene as shown in Figure 2, or litter stored under a shed as shown in Figure 3. The



outside stack covered with polyethylene is used by a part-time farmer in Franklin County. Old discarded truck or tractor tires are used as feed troughs (Figure 4). The litter is placed in the tire and 20 percent ground corn mixed in with a hoe or shovel (Figure 5).

A beef producer in Colbert County feeds a herd of 60 brood cows sorghum silage and broiler litter. A trench silo (Figure 6) is filled with sorghum silage. After packing and settling take place, broiler litter is added on top to make up about 20 percent by weight. The silo is then covered with polyethylene. Removing the silage and litter with a front-end loader and placing in troughs provides adequate mixing.

A Marion County beef producer takes advantage of the availability of 300- to 500-pound calves, and feeds an economical litter ration to grow

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stockers to heavier weights. A mixture of 50 percent litter, 35 percent ground corn, and 15 percent whole cottonseed makes a good growing ration for stockers. A portable grinder and mixer is used to blend the ration and auger the mix into a covered trough (Figure 7).

A stocker producer in Colbert County feeds stocker cattle corn silage, broiler litter and whole cottonseed. This mixture is layered in a truck as shown in Figure 8. Shoveling the material from the truck into the trough blends the feedstuffs. Equipment used in this program is used in row crop production and in general farm operations during the year.

Only a small number of our total cattle are finished to slaughter weight in Alabama. However, with high feed cost and other changes taking place we could begin producing more of the beef we consume, which is now being finished in distant states. The use of an economical feedstuff such as broiler litter could initiate more feed-

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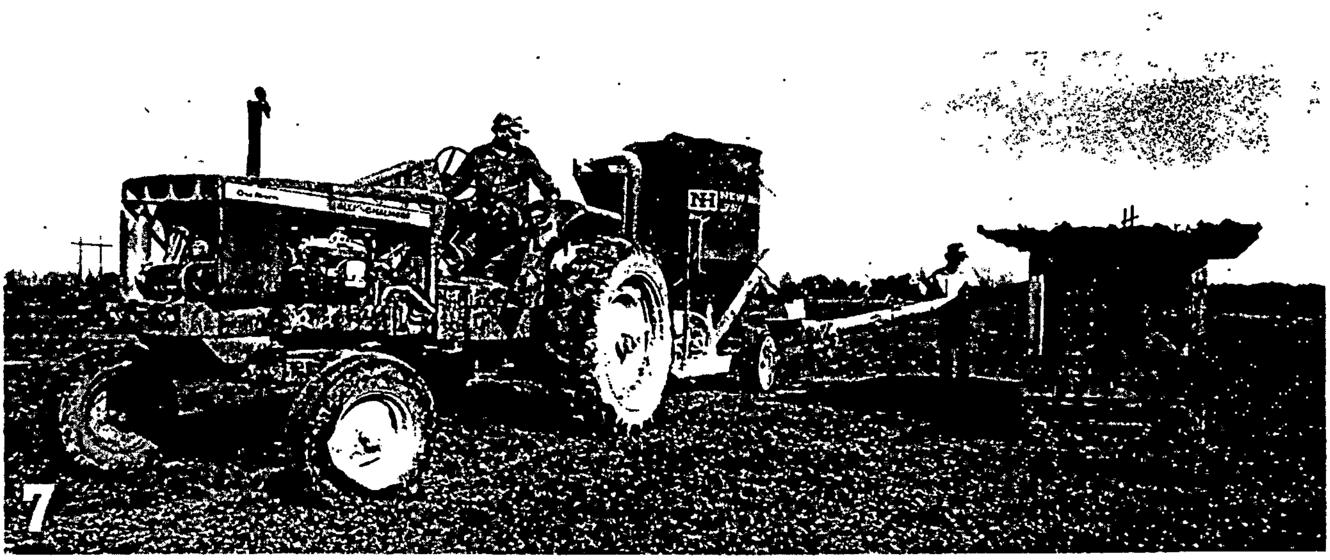
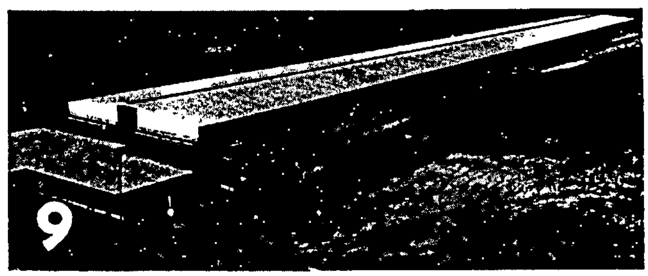


ing. Figure 9 shows a recently constructed 5,000-head capacity confinement feedlot. Broiler litter furnishes a high proportion of the most expensive nutrients in the feed lot ration. The litter is cleaned of foreign matter by a screening mechanism, formaldehyde is added to destroy pathogens, and the litter is then stored in concrete bays (Figures 10 and 11). Least cost rations using ground corn, molasses, citrus pulp or other energy feeds are mixed with litter in the feeding facility and fed to cattle in the confinement lots (Figure 12). Liquid manure from the flush system of the feedlot will be incorporated into irrigation water to fertilize nearby cropland.

An integrated broiler producer has recently constructed a 1,500 head fully automated feedlot in Pickens County. Broiler houses with concrete floors are adjacent to the feedlot to furnish litter for feeding cattle (Figure 13). Broiler litter is processed in airtight, upright silos. Mixing of the litter with high moisture corn molasses and other feed ingredients is controlled and the mixture conveyed to the trough automatically by a computer (Figure 14).

These are only a few of the systems used in processing and feeding broiler litter to cattle in Alabama. It's obvious that broiler litter can be processed by using a simple program for handling and feeding; or one that is completely automated.

Numerous research and farm trials with broiler litter over the years have demonstrated the nutritive value of broiler litter. Current knowledge indicates that there are no harmful effects to cattle fed litter. If good processing practices are observed, and litter is withdrawn from cattle to be slaughtered, broiler litter is as safe as other feedstuffs.



Funds for printing this publication were provided by the Tennessee Valley Authority.

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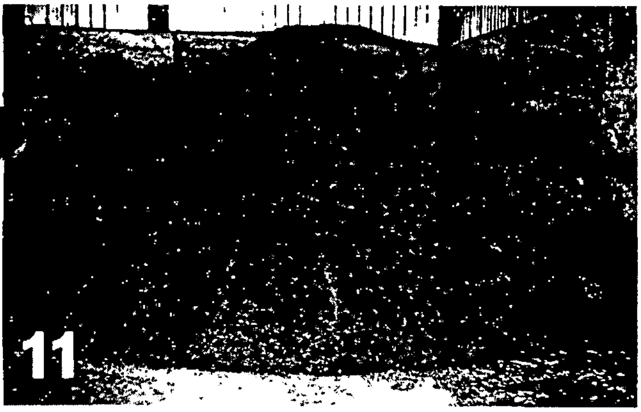
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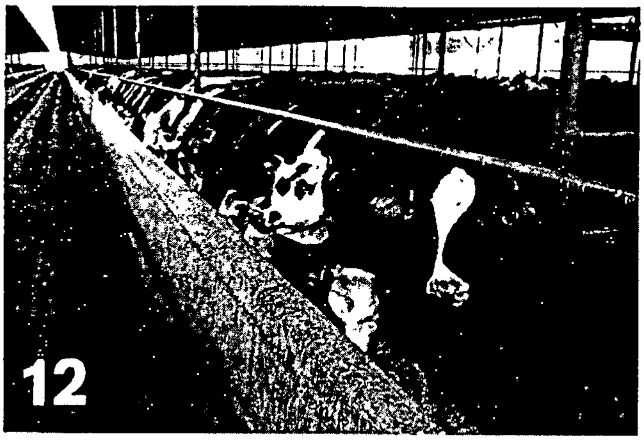
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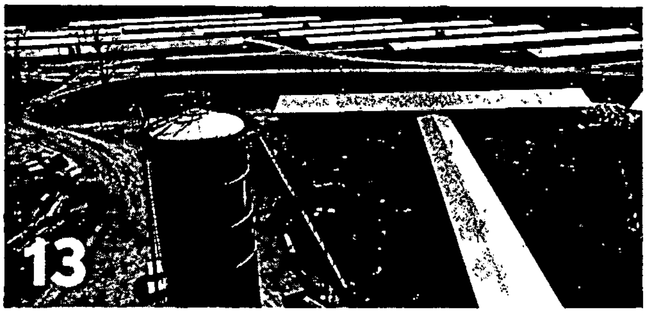
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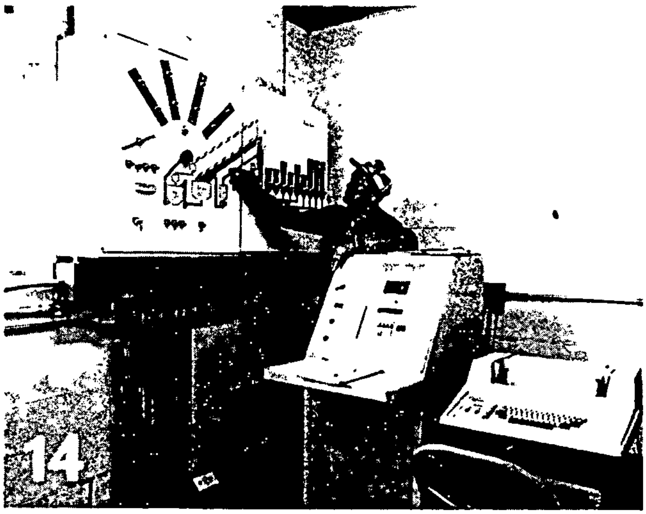
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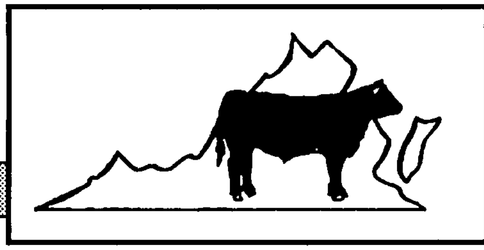

Beef
PUBLICATION 400-754

Feeding Broiler Litter to Beef Cattle and Sheep

H. John Gerken, Jr., Extension Specialist, Animal Science

Cattle and sheep producers searching for ways to reduce feed costs and/or stretch feed supplies should consider broiler litter as a possible source of protein, energy, and minerals for wintering, growing, and finishing rations.

Litter from a broiler house consists of bedding material such as wood shavings, peanut hulls or corncobs, and poultry excreta. It may also contain wasted feed and feathers. Cage layer waste, another poultry waste with potential livestock feeding value, is not discussed in this publication. The Virginia Department of Agriculture and Commerce approved the use of dried poultry waste (DPW), including broiler litter, in commercial manufactured cattle feeds in 1976. The purpose of this publication is to inform livestock producers on the correct use of broiler litter in rations prepared on the farm.

Broiler litter is available in the poultry-producing areas of Virginia where it has been mainly used as fertilizer in the past. When properly included in nutritionally balanced rations, it is more valuable as livestock feed than as fertilizer. Broiler litter contains significant amounts of crude protein, total digestible nutrients (TDN), calcium, phosphorus, and trace minerals. The nutrient composition of litter resembles that of alfalfa hay. Table 1 provides a comparison of the approximate nutrient content of broiler litter with alfalfa. When shelled corn is valued at $2.50 per bushel and soybean meal at $210 per ton, broiler litter can have a replacement value, on a dry-matter basis, in excess of $80 per ton in cattle and sheep rations.

Table 1. Approximate Composition of Broiler Litter Compared With Alfalfa Hay

		Percent Composition (Dry Basis)				
	Average Dry Matter	Crude Protein	Crude Fiber	TDN	Calcium	Phosphorus
Alfalfa Hay (Early Bloom)	90	18.4	29.8	57	1.25	0.23
Broiler Litter	65-90	28.0	14.9	60	2.3	2.0

Safety and Precautions

Extensive testing at VPI&SU and elsewhere, and several years of practical feeding experience on farms, has demonstrated the nutritional value of broiler litter in cattle and sheep rations. No deleterious effects have been observed in cattle. Copper toxicity is a potential problem producers must be aware of when

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reared before the house is cleaned. Because of this potential variability in composition and nutrient content, it is desirable to have an analysis made on each batch intended for livestock feeding to obtain accurate estimates of moisture, protein, fiber and ash content. Samples of litter can be sent to the VPI&SU Forage Testing Laboratory for analysis.

Handling and Processing Broiler Litter

Avoid litter that has a dry matter content of less than 65% as wet spots and mold can be troublesome. Extremely dry litter can be dampened by sprinkling lightly with water. This helps to reduce dust and may facilitate more rapid heat buildup during deep stacking. Litter should be free of nails and wire, glass, rocks, dirt, or other foreign material. Do not use litter from sources where careless management has permitted such contamination to occur.

Upon removal from the house, broiler litter should be processed for feeding by either deep stacking, ensiling alone, or by ensiling with corn forage. Deep stacking consists of piling the litter in a stack 6 or more feet deep and allowing the material to go through a heating process for a period of two weeks or more. Deep stacking should be done in an open shed or outside; it should not be done in an enclosed building as spontaneous combustion (fires) may result. Outside stacks need not be covered if the damp outer layer is discarded before use. Covering the stack tightly with plastic film is an alternate procedure that will reduce weather damage. After deep stacking, litter should contain 85-90% dry matter.

Litter can best be ensiled alone when it contains about 35-40% moisture. However, adding water to litter may result in material which is sticky and hard to handle. Thus, it may be best to ensile it without added water.

Litter can be ensiled with whole plant corn at harvest time. Litter should be added at the level of 30% of the total silage dry matter. To achieve this level of dry matter, it will usually be necessary to combine about 20% litter and 80% corn forage on a wet basis. This can vary depending on the moisture content of each and a moisture test will be helpful in determining the correct proportions to use. The example below can be applied when ensiling litter at harvest time or when mixing deep-stacked litter with silage prior to feeding.

How To Combine Broiler Litter With Corn Silage To Achieve A 70/30 Dry Matter Mix

1. Weigh or estimate weight of a wagon load of corn silage. The average weight of freshly chopped silage will be about 20 pounds per cubic foot.
2. Weigh a known volume of litter such as the amount in a level-full front end loader scoop.
3. Estimate as accurately as possible the moisture content of litter and silage.
4. Combine litter and silage in the correct proportions according to the procedure used in Table 2.

Table 2. Example of Proportions of Corn Silage and Broiler Litter to Mix to Achieve Proper Mixture of 30% of Dry Matter

	Desired Dry Matter, %		Dry Matter In Feed, %				Parts In Mixture	Percent of Mixture
Corn Silage	70%	divided by	35	X	100	=	200	83%
Broiler Litter	30%	divided by	75	X	100	=	40	17%
							240	100%

Table 3 gives the pounds of litter to mix with one ton (2000 lbs.) of corn silage to achieve the desired level of 30% of the dry matter in the silage-litter coming from litter. The examples cover the normal range of dry matter content for both silage and litter. For example, if silage contains 30% dry matter and litter

70%, the addition of 380 lbs. of litter to one ton of corn silage would result in a 2380 lb. batch of the correct proportions.

Table 3. Pounds of Broiler Litter to Add to One Ton (2000 lbs.) of Corn Silage to Supply 30% of The Dry Matter As Litter

Dry Matter Percent		Pounds of Litter
Silage	Litter	
30	70	380
	80	330
	90	250
35	70	440
	80	350
	90	280
40	70	500
	80	440
	90	320

Using Broiler Litter In Cattle Rations

Broiler litter ensiled with corn forage at harvest makes a satisfactory feed for all classes of beef cattle. It can be fed as the only feed for cows or supplemented with grain for young, growing cattle or fattening cattle. Use forage test results to determine the amount to feed and the level of supplemental grain and/or protein to add depending on the type of animal fed and the expected level of gain. In most cases, sufficient protein will be present in the litter silage to eliminate the need for any additional protein beyond that supplied by the corn or other grains included in the ration. Deep-stacked litter or litter ensiled alone can also be added to corn silage at feeding time in the proportions necessary to balance protein requirements. When silage is unavailable, deep-stacked broiler litter can be used in a variety of dry rations with hay or grain.

Beef-cow wintering rations are well suited to the use of broiler litter. Pregnant cows can be wintered on 35-40 lbs. of the litter-silage mixture described above. Cows nursing calves will require 40-50 lbs. per day. Cows may also be wintered on a mixture of 80% deep-stacked broiler litter and 20% ground corn or other palatable concentrate. The reason for mixing grain with the litter is to insure adequate consumption since litter alone will meet the protein and energy requirements of pregnant cows if they ate enough of it. Feed 14-15 lbs. of the litter corn mixture to pregnant cows daily and increase this to 18-20 lbs. per day after calving. A small amount (2-3 lbs.) of hay or other dry roughage should also be fed to provide additional fiber and bulk.

Calves may be successfully wintered on a ration of 50% broiler litter and 50% ground corn along with hay fed free-choice. Feed 7 pounds of the mixture per day to 400-500 pound calves being wintered to gain 1.0 to 1.1 pounds per day. The mixture could also be fed with as little as 5-10 lbs. of silage or 2-3 lbs. of hay per head daily.

Calves wintered on corn silage and intended for sale in the spring will make excellent gains on a ration of 20-25 pounds of silage and 4-5 pounds of broiler litter with no additional supplement. Calves that will go on pasture next spring can be wintered on 20 pounds of silage and 4 pounds of broiler litter daily to gain at the rate of 1.0 pound per day.

Up to 20-25% of the dry matter in beef-cattle finishing rations can be broiler litter. It can be fed either as litter ensiled with corn silage or by mixing deep-stacked litter with silage or other ration ingredients at feeding time. When [redacted] T.A. McCASKEY, A.H. STEPHENSON, and B.G. RUFFIN

GOOD MANAGEMENT NECESSARY TO CASH IN ON BROILER LITTER RESOURCE

ANIMAL WASTES derived from poultry, beef, and swine production contain nitrogen, phosphorus, and potassium (N-P-K) which can be used as a source of low-cost fertilizer nutrients, or as a source of crude protein, fiber, and minerals for ruminant animals. However, the same nutrients that make these agricultural by-products valuable also make them sources of environmental pollutants. Hence, animal wastes can be a resource or a liability, depending on how they are managed.

In Alabama, the major collectable animal waste is broiler chicken litter. Annual production of broiler litter in the State is estimated at 2 million tons (wet basis). Essentially all of the litter is collectable and is easily managed as a solid material. Much of the litter is treated as a waste for disposal, usually deposited directly on land. When application of litter exceeds 10-12 tons per acre per year, excessive nutrient loading of the soil can cause concern for surface and groundwater contamination.

Expanding the use of litter as a nutrient resource would be a prudent way to regain some of the fixed costs of handling litter, cut down on the use of more expensive nutrient sources, and alleviate some of the concerns about its impact on water quality. But litter nutrient content and quality have proven to be limiting factors in the use of litter as a resource. A recent Alabama Agricultural Experiment Station study investigated these issues by analyzing 106 samples of broiler litter collected at several locations in Alabama, some collected from broiler houses and some from stacks of litter held for various periods of time.

These litter samples showed great variations in nutrient content. The nitrogen content (dry basis) ranged from a low of 2.3% up to 6.0%, with an average of 4.0%, table 1. Crude protein (N x 6.25) ranged from 14.4 to 37.5% and averaged 24.9%. Ash content (total minerals) of the samples ranged from 8.9% to 54.4%. Dirt collected inadvertently from the broiler house floor when litter is removed will raise ash content. Litter that has 19.5% moisture (average) and 54.4% ash contains 73.9% of non-organic nutrients. Therefore, moisture and ash dilute litter's nutrient components such as crude protein.

If litter is being considered for use as a low-cost fertilizer or as an alternative crude protein source for ruminants, it is important to have the litter analyzed to determine its nutrient content. Based on the survey results, broiler litter of average composition has an estimated value as a fertilizer replacement of $27.59 per wet ton of litter, table 2. The value of litter in an 80% litter, 20% ground corn diet for beef cattle to replace a diet of corn, Coastal hay, and soybean meal is estimated at $104.95 per wet ton of litter, based on current feed prices.

Litter samples showed great variation in nutrient content.

Good quality litter purchased for use as a fertilizer should contain in excess of 3% nitrogen on a dry basis. If used as an alternative, low-cost crude protein source for ruminants, litter should have 3% or more nitrogen (18.8% crude protein). Less than 25% of the nitrogen should be insoluble, and the ash content should not exceed 30 percent.

Management of litter has a great impact on the by-product's nutrient value. If dirt is mixed with the litter when it is collected from the broiler house floor, ash content will be higher. Management of the litter after it is removed from broiler houses and stored, usually by stacking, can affect its value as a crude protein source for ruminants. Previous research has shown that if litter heats excessively in a stack, which is evident by its dark, crumbly appearance, much of the litter's crude protein will become insoluble and unavailable to ruminants.

TABLE 1. ANALYSIS OF BROILER LITTER COLLECTED IN ALABAMA[1]

Component	Minimum	Maximum	Mean
Dry matter, pct.	61.0	95.3	80.5
Pct. of dry matter			
Nitrogen (N)	2.3	6.0	4.0
Crude protein	14.4	37.5	24.9
Crude fiber	10.8	51.6	23.6
Acid detergent fiber	18.0	69.1	41.1
Bound nitrogen[2]	5.1	64.3	15.0
Ash (minerals)	8.9	54.4	24.7
Ca	.81	6.13	2.31
K	.73	5.17	2.32
Mg	.19	.88	.52
P	.56	3.92	1.56
S	.22	.83	.50
Cu (p.p.m.)	25	1,003	473

[1]Minimum, maximum, and mean of 106 samples.
[2]Percent of total nitrogen.

TABLE 2. REPLACEMENT VALUE OF AVERAGE QUALITY BROILER LITTER, 1989 PRICES[1]

Component replaced	Amount replaced per ton	Value per ton
	Lb.	*Dol.*
As fertilizer		
Nitrogen	64	15.36
P_2O_5	58	6.38
K_2O	45	5.85
Total		27.59
As feed[2]		
Corn	550	30.94
Soybean meal	273	36.31
Coastal hay	1,178	37.70
Total		104.95

[1]Based on regional prices of nitrogen ($0.24/lb.), P_2O_5 ($0.11/lb.), K_2O ($0.13/lb.), corn grain ($3.15/bu.), soybean meal ($266/ton), and Coastal bermudagrass hay ($64/ton).
[2]Based on a ration containing 80% broiler litter and 20% corn compared to a ration containing 41.5% corn, 47.6% Coastal hay, and 10.9% soybean meal.

The study illustrated the need for careful litter management practices to ensure that quality characteristics are preserved. By enhancing the economic value of this by-product, producers can help promote economy in plant and ruminant animal production and reduce the impact of this nutrient resource on the environment.

McCaskey is Professor and Stephenson is Graduate Student of Animal and Dairy Sciences and Ruffin is Extension Animal Scientist.

Reprinted from Highlights of Agricultural Research, Vol. 36, No. 3, Fall, 1989.
Published by Alabama Agricultural Experiment Station, Auburn University, Alabama 36849.

T.A. McCaskey, S.N. Britt, B.G. Ruffin, J.T. Eason, and R.C. Strickland

Feed Value of Broiler Litter for Stocker Cattle

Each year, Alabama's poultry industry produces about two million tons of broiler litter — the bedding, feed, feathers, and waste materials that collect on the floors of chicken houses. Improper disposal of this byproduct poses a threat to the environment, but with proper handling, litter can be a valuable resource.

Broiler litter has value as a fertilizer because it is a good source of nitrogen, potassium, and phosphorus; but an AAES project showed it is even more valuable when used as a feed for cattle. Auburn scientists, in cooperation with the Tennessee Valley Authority, found that beef producers can use litter in stocker cattle diets, dramatically cutting feed costs while maintaining acceptable weight gain and feed utilization.

Litter is a good source of crude protein, energy, and minerals, especially for overwintering brood cows and stocker calves. Because cattle have a specialized digestive system, they are able to digest such byproduct feeds that other animals cannot. However, not all broiler litter is suitable for use as feed. Only litter that contains less than 28% ash and more than 18% crude protein — with less than 25% of that protein in the insoluble or bound form — should be used as a feed ingredient.

To determine the feed value of broiler litter, stocker cattle were fed either a conventional diet containing corn, soybean meal, and cottonseed hulls, or a 50:50 mixture of corn and broiler litter (Table 1). The diets were formulated to provide approximately the same amounts of nutrients. Bovatec is routinely added to corn:litter diets to prevent bloat, and it was included in the conventional diet as well. The poultry litter was deep-stacked in a pole barn, covered with polyethylene sheeting, and stored 28 days before use. Diets provided 17% crude protein on a dry matter basis and 70% total digestible nutrients.

Thirty-six crossbred heifers, initially weighing 548 pounds, were purchased, vaccinated, dewormed, and implanted. Three groups were fed the conventional diet and three were fed the corn:litter diet. Cattle were housed in pens in an open-sided barn with a concrete floor, and manure was mechanically scraped from the barn twice daily. Water was available at all times during the 112-day trial, but the cattle were not fed any hay.

Consumption of the conventional and corn:litter diets was similar: 22.1 and 22.9 pounds per day, respectively (Table 2). Heifers consumed feed at 2.5-2.8% of body weight. Average daily gain was higher for heifers fed the conventional diet: 2.53 pounds per day, compared to 2.12. Thus, the feed:gain ratio for the conventional diet was 8.7:1 versus 10.8:1 for the experimental diet.

Researchers estimated feed costs at 7.6 cents per pound for the conventional diet and 4.2 cents per pound for the corn:litter diet. The cost for each pound gained by the cattle was higher for the conventional diet, 66 cents per pound, than for the corn:litter diet, 46 cents per pound.

These figures indicate that a beef producer could pay up to 6.1 cents a pound, or $123 per ton, for the corn:litter diet, and production costs would be similar to those incurred in feeding the conventional diet. But as the cost of the corn:litter diet increases above the $123 per ton, the economic advantage of feeding litter disappears, because it becomes more expensive than the conventional diet.

The economic advantage of feeding broiler litter becomes apparent when livestock producers are able to buy it at low cost and blend their own 50:50 diets. The difference between the break-even cost of $123 per ton and the cost required to prepare the corn:litter diet in-house represents the profit of feeding litter. However, producers must make sure they buy litter from a reliable source to ensure consistent nutritional quality of the poultry byproduct.

A major problem that prevents commercialization of pelleted litter feeds and similar products is the excessive market price demanded for such feeds. Most are in excess of the $123 per ton break-even cost.

Table 1. Composition of Diets

Ingredient	Conventional	Corn:Litter
	Lb./ton	*Lb./ton*
Cottonseed hulls	501.0	—
Soybean meal, 44%	160.0	—
Corn grain	1,218.0	1,000.0
Broiler litter	—	999.0
Urea	40.0	—
Minerals	80.0	—
Vitamin A-30	0.5	0.5
Bovatec	0.5	0.5

Table 2. Production Data for the 112-Day Study

Variable	Conventional	Corn:Litter
Initial weight (lb.)	550	546
Day 112 weight (lb.)	833	784
Gain (lb.)	283	238
Avg. daily gain (lb.)	2.53	2.12
Intake (lb.)	22.1	22.9
Feed:Gain	8.7:1	10.8:1
Feed cost/ton (dol.)	152	84
Feed cost/lb. (cents)	7.6	4.2
Cost/lb. gain (cents)	66	46

McCaskey is a Professor, Britt is a Research Associate, and Ruffin is a Professor of Animal and Dairy Sciences. Eason is Superintendent of the Sand Mountain Substation and Strickland is Project Manager of the TVA Biotechnical Research Department.

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June 27, 1995

Mr. Ed Schwille
TVA-CST 17D, 1101 Market St.
Chattanooga, TN 37402-2801

Dear Ed:

I enjoyed visiting with you on the phone when you called. I am pleased to send the enclosed materials regarding the use of broiler litter as cattle feed. In Virginia this practice is now recognized as a typical feeding program. Thousands of tons of litter leave the Harrisonburg area each winter for use as cattle feed in other parts of the state, sometimes more than 200 miles away. Cattle producers realize significant cost savings by using this as a feedstuff.

One of the enclosures is our Extension publication on the practice. Dr. John Gerken is a retired Extension Animal Scientist, and spent a major portion of his later career promoting the use of litter as cattle feed. He also produced a videotape highlighting several cattlemen who have built their feeding programs around broiler litter.

Also enclosed is a short list of references on the topic. A couple of years ago we had a graduate student give a seminar on this topic. This is her list of references. I enclose it to simply give some idea of the good research that stands behind the recommendation to use broiler litter as cattle feed.

I am happy to provide these materials to you. I hope that it is of some help in the situation you are currently addressing. Please do not hesitate to contact me at any time, should you desire.

Sincerely,

Mark L Wahlberg

Mark L. Wahlberg
Extension Animal Scientist, 4-H Livestock

MLW/BBF
Encl.:
cc: Julian Brake

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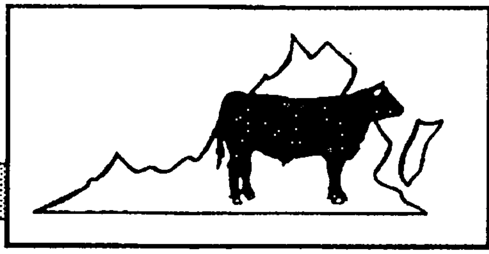

Beef
PUBLICATION 400-754

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Safety and Precautions

Extensive testing at VPI&SU and elsewhere, and several years of practical feeding experience on farms, has demonstrated the nutritional value of broiler litter in cattle and sheep rations. No deleterious effects have been observed in cattle. Copper toxicity is a potential problem producers must be aware of when

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broiler litter is fed to sheep. A logical concern is that of unknown potential hazards from medicinal drugs used in poultry rations, pesticides, residues, molds, heavy metals other than copper, or disease causing pathogens that might be present in litter. No guarantee of total freedom from such hazards is possible; but, based on current scientific knowledge, it has been demonstrated that when reasonable methods and safeguards are used broiler litter can be safely fed to livestock. Broiler litter should not be fed to milk-producing dairy animals and its use should be discontinued 15 days prior to slaughter of cattle or sheep.

It has been demonstrated that:

1. Pathogens such as E. Coli and others can be isolated from fresh broiler litter but can be reduced to safe levels or eliminated by mild heat treatment such as deep stacking or ensiling.

2. Molds are not a problem if litter is stored and handled properly.

3. No pesticide residue problem has been detected but caution should be exercised by broiler producers to avoid possible contamination of litter intended for livestock feeding. Livestock owners intending to feed litter should be aware of any pesticides used in the broiler growing operation and reject litter when residues could exist, or have tests run to assure safety before feeding.

4. Broiler litter may contain medicinal drug residues but no unapproved levels have been detected in the tissues of cattle or sheep fed such litter following a modest withdrawal period. Virginia regulations for DPW in manufactured feeds stipulate a 15-day withdrawal before litter-fed animals go to slaughter. It is recommended that producers follow this same precaution when using farm-prepared rations containing broiler litter.

5. No metal toxicity problems have been observed other than copper toxicity in sheep.

Producers intending to feed broiler litter to their livestock are cautioned that unforeseen problems in any of the above areas could become apparent in the future. As with any new technological development, not all risks can be evaluated or removed initially. Producers who feed litter accept responsibility for risks which, although considered minimal, are still possible.

Feeding Value Of Broiler Litter

Broiler litter is fairly high in crude protein, averaging 28% or higher on a dry basis. Protein nitrogen makes up 40-50% of the total nitrogen and non-protein nitrogen compounds such as uric acid; ammonia and urea are also present. Both the protein and non-protein forms of nitrogen in broiler litter are efficiently utilized by cattle and sheep. Broiler litter is not a satisfactory feed for non-ruminants such as horses, swine, or poultry since they are unable to utilize non-protein nitrogen compounds.

Litter containing either wood shavings or peanut hulls will analyze up to 60% TDN on a dry basis. When rations are formulated in terms of available energy, broiler litter has an approximate metabolizable energy value of 1.0 Mcal per pound on a dry basis. The energy in broiler litter is readily digested by ruminants and performance has been similar with all types of litter materials normally used in broiler growing operations.

Calcium and phosphorus are present in broiler litter at a level of 1.5 to 2.5% of each element. The calcium to phosphorus ratio is normally about 1:1. When broiler litter makes up 20% or more of the ration, litter will supply ample calcium and phosphorus to meet the animal's requirements for these minerals. Litter is lacking in vitamin A and a supplemental source will be needed unless other feeds in the ration supply an adequate amount. On the average, broiler litter will contain 75% dry matter and 25% moisture as it comes from the house. Dry matter percentage may vary from less than 65% to 90%. Also the proportion of litter material can vary depending on the amount used and the number of flocks of birds reared before the house is cleaned. Because of this potential variability in composition and nutrient content, it is desirable to have an analysis made on each batch intended for livestock feeding to obtain accurate estimates of moisture, protein, fiber and ash content. Samples of litter can be sent to the VPI&SU Forage Testing Laboratory for analysis.

Handling and Processing Broiler Litter

Avoid litter that has a dry matter content of less than 65% as wet spots and mold can be troublesome. Extremely dry litter can be dampened by sprinkling lightly with water. This helps to reduce dust and may facilitate more rapid heat buildup during deep stacking. Litter should be free of nails and wire, glass, rocks, dirt, or other foreign material. Do not use litter from sources where careless management has permitted such contamination to occur.

Upon removal from the house, broiler litter should be processed for feeding by either deep stacking, ensiling alone, or by ensiling with corn forage. Deep stacking consists of piling the litter in a stack 6 or more feet deep and allowing the material to go through a heating process for a period of two weeks or more. Deep stacking should be done in an open shed or outside; it should not be done in an enclosed building as spontaneous combustion (fires) may result. Outside stacks need not be covered if the damp outer layer is discarded before use. Covering the stack tightly with plastic film is an alternate procedure that will reduce weather damage. After deep stacking, litter should contain 85-90% dry matter.

Litter can best be ensiled alone when it contains about 35-40% moisture. However, adding water to litter may result in material which is sticky and hard to handle. Thus, it may be best to ensile it without added water.

Litter can be ensiled with whole plant corn at harvest time. Litter should be added at the level of 30% of the total silage dry matter. To achieve this level of dry matter, it will usually be necessary to combine about 20% litter and 80% corn forage on a wet basis. This can vary depending on the moisture content of each and a moisture test will be helpful in determining the correct proportions to use. The example below can be applied when ensiling litter at harvest time or when mixing deep-stacked litter with silage prior to feeding.

How To Combine Broiler Litter With Corn Silage To Achieve A 70/30 Dry Matter Mix

1. Weigh or estimate weight of a wagon load of corn silage. The average weight of freshly chopped silage will be about 20 pounds per cubic foot.
2. Weigh a known volume of litter such as the amount in a level-full front end loader scoop.
3. Estimate as accurately as possible the moisture content of litter and silage.
4. Combine litter and silage in the correct proportions according to the procedure used in Table 2.

Table 2. Example of Proportions of Corn Silage and Broiler Litter to Mix to Achieve Proper Mixture of 30% of Dry Matter

	Desired Dry Matter, %		Dry Matter In Feed, %				Parts In Mixture	Percent of Mixture
Corn Silage	70%	divided by	35	X	100	=	200	83%
Broiler Litter	30%	divided by	75	X	100	=	40	17%
							240	100%

Table 3 gives the pounds of litter to mix with one ton (2000 lbs.) of corn silage to achieve the desired level of 30% of the dry matter in the silage-litter coming from litter. The examples cover the normal range of dry matter content for both silage and litter. For example, if silage contains 30% dry matter and litter

70%, the addition of 380 lbs. of litter to one ton of corn silage would result in a 2380 lb. batch of the correct proportions.

Table 3. Pounds of Broiler Litter to Add to One Ton (2000 lbs.) of Corn Silage to Supply 30% of The Dry Matter As Litter

Dry Matter Percent Silage	Dry Matter Percent Litter	Pounds of Litter
30	70	380
	80	330
	90	250
35	70	440
	80	350
	90	280
40	70	500
	80	440
	90	320

Using Broiler Litter In Cattle Rations

Broiler litter ensiled with corn forage at harvest makes a satisfactory feed for all classes of beef cattle. It can be fed as the only feed for cows or supplemented with grain for young, growing cattle or fattening cattle. Use forage test results to determine the amount to feed and the level of supplemental grain and/or protein to add depending on the type of animal fed and the expected level of gain. In most cases, sufficient protein will be present in the litter silage to eliminate the need for any additional protein beyond that supplied by the corn or other grains included in the ration. Deep-stacked litter or litter ensiled alone can also be added to corn silage at feeding time in the proportions necessary to balance protein requirements. When silage is unavailable, deep-stacked broiler litter can be used in a variety of dry rations with hay or grain.

Beef-cow wintering rations are well suited to the use of broiler litter. Pregnant cows can be wintered on 35-40 lbs. of the litter-silage mixture described above. Cows nursing calves will require 40-50 lbs. per day. Cows may also be wintered on a mixture of 80% deep-stacked broiler litter and 20% ground corn or other palatable concentrate. The reason for mixing grain with the litter is to insure adequate consumption since litter alone will meet the protein and energy requirements of pregnant cows if they ate enough of it. Feed 14-15 lbs. of the litter corn mixture to pregnant cows daily and increase this to 18-20 lbs. per day after calving. A small amount (2-3 lbs.) of hay or other dry roughage should also be fed to provide additional fiber and bulk.

Calves may be successfully wintered on a ration of 50% broiler litter and 50% ground corn along with hay fed free-choice. Feed 7 pounds of the mixture per day to 400-500 pound calves being wintered to gain 1.0 to 1.1 pounds per day. The mixture could also be fed with as little as 5-10 lbs. of silage or 2-3 lbs. of hay per head daily.

Calves wintered on corn silage and intended for sale in the spring will make excellent gains on a ration of 20-25 pounds of silage and 4-5 pounds of broiler litter with no additional supplement. Calves that will go on pasture next spring can be wintered on 20 pounds of silage and 4 pounds of broiler litter daily to gain at the rate of 1.0 pound per day.

Up to 20-25% of the dry matter in beef-cattle finishing rations can be broiler litter. It can be fed either as litter ensiled with corn silage or by mixing deep-stacked litter with silage or other ration ingredients at feeding time. When fed with silage plus concentrates, such as ground corn at 1% of body weight, 20% broiler litter in the ration on an as-fed basis will provide all the protein needed to balance the ration. For example, yearling steers weighing 700-800 pounds and gaining at the rate of 2.9 pounds per day require about 1.95 pounds of crude protein and 15.5 pounds of TDN daily. A daily ration of 30-35 pounds of corn silage, 6-7 pounds of broiler litter, and 8 pounds of corn will supply the energy and protein required. Litter should be withdrawn from the ration 15 days before cattle are expected to go for slaughter.

Special Considerations Regarding The Feeding Of Broiler Litter To Sheep

Much of the research on the feeding of broiler litter has been done with sheep. Results have demonstrated that sheep can utilize the energy, protein, and other nutrients in broiler litter very efficiently. Broiler litter can be used in both feeder lamb and ewe rations if certain restrictions and precautions are observed. The limitations on feeding broiler litter to sheep comes about because sheep are sensitive to high levels of copper in their feed, and the fact that copper levels in broiler litter may be quite high because of the use of copper compounds in broiler production. Extended feeding of sheep with feeds having high levels of copper will result in toxicity and death. For this reason, sheep producers planning to use broiler litter in their feeding programs should:

1. Limit the feeding of broiler litter in all sheep rations to not more than 60 days.
2. Use broiler litter in feeder lamb rations at the lowest level required to balance protein needs.
3. Withdraw litter from feeder lamb rations 15 days before slaughter.
4. Feed broiler litter to ewes only as an emergency measure when other feeds are in short supply.
5. Limit the feeding of rations containing broiler litter to ewes to a period of not more than 60 days during a single winter feeding season.
6. If possible, have litter tested for copper and avoid using litter having in excess of 100 ppm copper in sheep rations. Litter containing about 200 ppm copper has caused copper toxicity in ewes fed rations containing 25% and 50% litter for long periods of time (more than 130 days).

Using Broiler Litter In Sheep Rations

Feeder lambs can be fed a ration of 25% ground hay, 25% broiler litter, and 50% ground corn. Include 10-20 pounds of ground limestone per ton and feed iodized salt (not trace-mineralized salt) free-choice.

Ewes can be self-fed a mixture of 50% ground hay, 25% corn, and 25% broiler litter. Limestone should be added as above. Free-choice feeding of iodized salt is also recommended.

A mixture of 50% litter and 50% ground corn can be fed to pregnant and nursing ewes. Feed 3/4 to 1 pound per head daily before lambing and 1 1/2 to 2 pounds per head after lambing. Feed the larger amount to ewes nursing twin lambs. In addition, ewes fed this ration will need hay or other roughage.

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all Minerals
Baseline for Litter

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University of Arkansas, United States Department of Agriculture, and County Governments Cooperating

September 26, 1994

Dr. Jim Ransom
Tennessee Valley Authority
P.O. Box 1010
Muscle Shoals, AL 35680

Dear Jim:

Enclosed you shall find our report on the TVA-supported stocker cattle demonstration. The overall management of the demonstration went very well which certainly is a tribute to Dr. George Davis, Mr. Leon Duncan (Carroll County Extension Agent) and Mr. Joe Hale (cattle producer). I think you will find the report very interesting. If you have any questions or concerns about the demonstration, I'll be happy to visit with you.

The Arkansas Cattlemen's Association has organized a "1994 Cattlemen's College" with a theme of "Ranching for Profit." Dr. Davis submitted the TVA stocker data to the Cattlemen's Association for this program. The topic was selected and Dr. Davis will present the data at this year's convention. Enclosed you shall find a copy of that program.

We also plan to write a news article about the TVA data. I want to complete this article by October 15, 1994. I'll send you a copy when it is completed.

Another thing that we would like to do with the data is to submit and present it at the Southern Section, American Society of Animal Science meeting. The Southern Section meeting will be in New Orleans, Louisiana from January 28 to February 1, 1995. This will allow us to expose the TVA stocker cattle information to our southern section colleagues. In order to do this, I would like to request that the stocker cattle TVA funds be carried over in order to cover the travel expenses to the meeting. Currently, the balance of the TVA stocker cattle funds is approximately $1800. We would like to request that this money be carried over into the next fiscal year (for meeting expenses).

Jim, congratulations on your retirement. I hope you find a way to stay around a little longer for I have enjoyed working with you and TVA. Please let me know about the carry over money. I'll forward any articles about the demonstration to you. Thank you and TVA for supporting this project. Support like this allows the Cooperative Extension Service to help beef cattle producers. I remain,

Sincerely yours,

Tom R. Troxel, Ph.D.
Extension Beef Cattle Specialist
Section Leader - Animal Science

TRT:ah
Enclosures
cc: Dr. Mike French
Dr. George Davis
Dr. Gary Burke
Mr. Leon Duncan
Mr. Joe Hale

Linking People to Research

Supplemental Corn and Broiler Litter for Stocker Cattle on Legume-Grass Pastures and Subsequent Feedlot Performance

G. V. Davis, T. R. Troxel,
G. L. Burke and R. L. Duncan
University of Arkansas Cooperative Extension Service

Summary

One hundred seventeen weaned calves were dewormed, weighed, ear tagged and randomly assigned to one of three stocker treatment groups. Treatment 1 (control) calves (5 steers and 5 heifers) were pastured together and received mineral supplementation only. Treatment 2 calves (27 steers and 26 heifers) were separated by sex, placed in different pastures of similar quality, and fed 2.81 lb. of corn/hd/day. A third treatment consisted of 27 steers and 27 heifers which were also assigned to different pastures and fed daily 2.81 lb. of corn and 3.39 lb. of broiler litter. Pastures consisting primarily of white clover and fescue were very high in quality throughout the 80-day stocker grazing period. The steers and heifers in the control pasture gained .75 and .84 lb./day, respectively. Treatment 2 steers and heifers gained 1.71 and 1.82 lb./day, respectively, while treatment 3 steers and heifers gained 2.16 and 1.57 lb./day, respectively. There were no differences between treatment 2 steers and heifers in the cost of additional gain over the control ($.21/lb. of gain). Treatment 3 steers and heifers had a cost of gain over controls of $.16 and $.31, respectively. Calves from treatments 2 and 3 had higher ($P < .005$) shrink losses when shipped to the feedlot. On the average, the treatment 2 and 3 calves entered the feedlot weighing 89 lb. and 93 lb. more than the control calves. During the feedlot phase, ADG was greater for control calves, as expected. Carcass characteristics were similar for all of the pasture treatments. Results showed that cost-effective gains were achieved by feeding supplements consisting of corn or corn and litter to stocker cattle grazing excellent quality legume-grass pastures. No detrimental effects in feedlot performance or carcass characteristics were observed due to the feeding of broiler litter to stockers on legume-grass pastures.

Introduction

Approximately 1.5 million tons of broiler litter are produced annually in Arkansas. In the past, most of the broiler litter has been used as pasture fertilizer. With increasing attention to environmental issues, other avenues such as feeding broiler litter to cattle need to be explored for disposal of the litter. When broiler litter is properly processed and stored, it can be fed to cattle. Feeding broiler litter to cattle can result in lower winter feed cost and cost-effective gains.

The stocker production phase is the growth phase beginning at weaning and continuing until the cattle are placed in a feedlot. Stocker cattle are grazed on pasture and fed small amounts of supplement to obtain inexpensive gains. There is the perception that stocker calves fed broiler litter during their growing phase perform poorly during the feedlot phase. This perception is not supported by research.

The objectives of this demonstration were to (1) evaluate broiler litter as a supplement during the stocker phase, (2) determine if feeding cattle broiler litter affects feedlot performance, and (3) determine subsequent carcass traits.

Materials and Methods

One hundred seventeen weaned calves (59 steers and 58 heifers) were ear tagged and randomly assigned to five pasture groups and one of three treatments (Table 1). Treatment 1 consisted of 5 steers and 5 heifers and served as controls. These calves grazed the same pasture and received no additional supplements other than salt and minerals. Treatment 2 calves (27 steers and 26 heifers) were divided by sex and placed on different but similar pastures. Calves assigned to treatment 2 received 3 lb. of corn per head per day plus salt and minerals. The remaining 27 steers and 27 heifers were assigned to treatment 3. Treatment 3 calves were also divided by sex and placed on different but similar pastures. Calves assigned to treatment 3 received a mixture composed of corn and broiler litter. Three pounds of corn per head was fed daily. The amount of litter fed daily/head was gradually increased from 1.5 pounds until it reached 4.5 lb./head on day 41 of the trial. Because of the high mineral content of broiler litter, additional mineral supplement was not necessary. Salt, however, was provided. All calves remained within their respective treatments for 80 days. Calves were individually weighed at the beginning and the end of the stocker phase.

Table 1. Treatment Summary for the Stocker Phase

	Treatment Groups					
	1[a]		2		3	
	Steers	Heifers	Steers	Heifers	Steers	Heifers
Number of calves	5	5	27	26	27	27
Corn (lb./hd/day)	0	0	3	3	3	3
Litter (lb./hd/day)	0	0	0	0	1.5-4.5[b]	1.5-4.5[b]
Minerals and salt	yes	yes	yes	yes	no	no

[a] The steers and heifers in treatment 1 grazed the same pasture while the steers and heifers in treatments 2 and 3 grazed different pastures.
[b] Increased gradually from 1.5 lb./hd/day to 4.5 lb./hd/day by day 41 of the trial.

Feedstuffs were tested to monitor changes in the nutritive value of the pasture, broiler litter and corn. Each pasture was sampled biweekly. The pastures consisted of tall fescue and white clover. Corn was received in three deliveries. Each delivery was sampled and analyzed. The broiler litter was sampled three times – at the beginning, middle, and end of the feeding period. All samples were analyzed for moisture, crude protein, acid-detergent fiber, nitrate and major and minor minerals.

Calves were weighed at the beginning of the stocker phase, prior to loading on trucks for shipment to the feedlot, upon arrival at the feedlot and prior to slaughter. Average daily gains and shrunk weights were determined. After processing, calves were placed in pens for the feedlot phase.

During the feedlot phase, calves were adapted to a high energy ration. Cattle were fed in two feedlot pens, one for heifers and the other for steers. They were removed from the feedlot pens and sent to slaughter based on their degree of finish or optimum slaughter potential. Cattle were individually weighed at the feedlot prior to shipping to the slaughter plant. Final weights were adjusted to a 4 percent shrink. Carcass data were taken on all carcasses at the slaughter plant.

Results and Discussion

Stocker Phase

The pastures were predominantly a fescue grass and white clover mixture (Table 2). The within-pasture quality did not change over time nor did the quality change across pastures within the same time period. However, crude protein and TDN content of pasture forages tended to increase as the trial progressed (Table 3). For all pastures, the mean ± standard deviation for percent crude protein, TDN, calcium, phosphorus, and sodium (dry matter basis) was 18.7% ± 3.16, 65.3% ± 5.44, .64% ± .12, .33% ± .07, and .02% ± .01, respectively. Calcium:phosphorus ratios averaged 1.94:1 which is an excellent ratio for growing cattle. The sodium level was very low which supports the management practice of providing salt. Forage quantity remained high for all pastures except for one. Based upon visual appraisal, the pasture quantity for the heifers in treatment 3 became a limiting factor during the last two weeks of the grazing season.

Table 2. Average Composition of Legume-Grass Pastures During the 80-Day Stocker Phase as Related to Treatments

Component	Treatment[1]				
		Steers		Heifers	
	Control	Corn	Corn + Litter	Corn	Corn + Litter
Dry Matter, %	54.7	34.8	33.5	36.4	39.1
Crude Protein, %	15.8	19.9	19.4	19.7	18.1
Total Digestible Nutrients, %	63.2	67.7	67.7	67.4	63.8
Acid Detergent Fiber, %	28.2	25.6	25.2	25.9	29.4
Nitrate Nitrogen, %	486	645	673	616	685
Calcium, %	.63	.64	.69	.64	.54
Phosphorus, %	.34	.37	.36	.30	.29
Potassium, %	2.11	2.78	2.68	2.61	2.61
Magnesium, %	.27	.35	.37	.36	.34
Sulfur, %	.23	.28	.27	.28	.27
Sodium, %	.01	.01	.03	.01	.02
Iron, ppm	109	92	98	103	123
Manganese, ppm	101	79	84	94	101
Copper, ppm	8.6	9.5	9.7	9.6	9.8
Zinc, ppm	28.6	26.7	26.0	27.5	26.9

[1]Each value in the table is the average for 7 forage samples obtained biweekly throughout the stocker phase.

Table 3. Average Composition of Legume-Grass Pastures Throughout the Stocker Phase

Component	Stocker Phase		
	First Third	Middle Third	Last Third
Dry Matter, %	29.2	37.7	49.6
Crude Protein, %	17.3	19.2	20.0
Total Digestible Nutrients, %	61.8	67.3	70.7
Acid Detergent Fiber, %	31.6	25.5	21.4
Nitrate Nitrogen, %	532	678	702
Calcium, %	.65	.63	.60
Phosphorus, %	.28	.33	.38
Potassium, %	2.39	2.61	2.67
Magnesium, %	.36	.33	.30
Sulfur, %	.24	.29	.27
Sodium, %	.01	.01	.02
Iron, ppm	89	130	97
Manganese, ppm	87	93	96
Copper, ppm	9.8	9.6	8.9
Zinc, ppm	26.4	29.1	25.9

The corn and broiler litter nutrient analysis is reported in Table 4. There was no difference ($P > .10$) across sampling periods; therefore, the three sampling periods for both corn and broiler litter were averaged together. The composition of both the corn and broiler litter falls within normal ranges.

Table 4. Composition of Corn and Broiler Litter on a Dry-Matter Basis

Component	Corn	Broiler Litter
Dry Matter, %	87.7	79.1
Crude Protein, %	9.0	28.5
Acid Detergent Fiber, %	4.3	18.5
Nitrate Nitrogen, ppm	43	424
Calcium, %	.05	3.22
Phosphorus, %	.25	1.78
Potassium, %	.38	3.08
Magnesium, %	.13	.65
Sulfur, %	.11	.71
Sodium, %	.01	.96
Iron, ppm	55	330
Manganese, ppm	15	969
Copper, ppm	6	491
Zinc, ppm	32	852

The average daily consumption of corn for both treatments 2 (corn only) and 3 (corn plus broiler litter) was 2.81 pounds. The calves in the corn and litter group received an average 3.39 pounds of broiler litter. This resulted in a corn:broiler litter ratio of 45:55 for the 80-day pasture phase. Calves in treatment 1 did not receive corn or broiler litter.

Minerals and salt consumed by calves are reported in Table 5. The average daily consumption of minerals was 28.7 and 41.5 g/hd for calves in treatments 1 and 2, respectively. Calves in all three groups consumed salt. The litter-fed group, however, consumed the least amount. Overall, the calves (both steers and heifers) in treatment 2 consumed more mineral and salt than the calves in treatments 1 and 3. Monitoring salt and mineral intake and cost was important when comparing cost of gain across treatment groups. The high mineral content in the broiler litter resulted in those calves consuming salt at only .40 oz/head/day.

Table 5. Average Daily Consumption of Minerals and Salt

Treatment Group	Minerals* (g/hd/day)	Salt (g/hd/day)	Minerals and Salt (oz/hd/day)
Control (1)	28.7	14.8	1.53
Corn (2)			
Steers	37.5	23.6	2.16
Heifers	45.5	18.3	2.25
Average	41.5	21.0	2.21
Corn and Litter (3)			
Steers	—	12.8	.45
Heifers	—	9.8	.35
Average	—	11.3	.40

* Guaranteed analysis: 18.5% calcium; 10% phosphorus; 10% salt; 0.02% sulfur; 0.1% magnesium; 0.07% manganese; 0.2% zinc; 0.03% iodine; 0.4% iron; 0.02% copper; 0.01% cobalt; 0.002% selenium; vitamin A, 300,000 IU/lb.; vitamin D_3, 50,000 IU/lb.; and vitamin E, 65 IU/lb.

The initial calf weights and average daily gains during the stocker phase are shown in Table 6. Initial weight of steers was heavier (P < .005) than heifers. There were no differences (P < .10) between initial weight across treatment groups, nor was there a treatment × sex of calf interaction. Calves in the control group grazing pasture only gained an average of .80 lb. (.75 lb. for steers and .84 lb. for heifers). ADG increased by .97 lb. by the addition of 2.81 pounds of corn (treatment 2). The steer and heifer calves in treatment 2 had an 128% and 117%, respectively, increase in ADG over the control. Calves (both steers and heifers) in the corn and litter group (treatment 3) had the highest increased gain over controls. That increase in gain, however, was quite variable. The steer calves in treatment 3 gained 35 percent more than the heifer calves. During the last 2 weeks of the grazing period, the forage quantity available for treatment 3 heifers became a limiting factor. This conclusion was based upon visual appraisal of the pastures. Therefore, it could be suggested that if the treatment 3 heifers had adequate forage quantity their ADG would have improved.

Table 6. The Average Daily Gains of Steers and Heifer Calves During the Pasture Phase by Treatment Groups

Treatment Group[1]	Initial Weight (lb.)	Final Weight (lb.)	ADG (lb.)	Improvement Over Control	
				ADG (lb.)	Percent
Control (1)					
Steers	633	692	.75	—	—
Heifers	580	646	.84	—	—
Average	607	669	.80	—	—
Corn (2)					
Steers	658	794	1.71	.96	128
Heifers	577	721	1.82	.98	117
Average	618	758	1.77	.97	121
Corn and Litter (3)					
Steers	647	818	2.16	1.41	188
Heifers	579	705	1.59	.75	89
Average	613	762	1.88	1.08	135

[1] Steer calves were heavier (P < .005) than heifer calves (654 vs. 578 lb.).

In treatment 2, 2.94 pounds of supplemental feed (corn and minerals) were required for each pound of additional gain over the control (Table 7). In treatment 3, 5.67 pounds of supplement (corn, litter, salt) were required per pound of additional gain. In treatment 2, cost of additional gain over the control calves was the same for steers and heifers. Treatment 3 steers had an additional cost of gain of $.16 while the heifers within the same treatment recorded a cost of gain of $.31. This higher cost of gain reflects the lower ADG by these heifers when compared to the steers of the same treatment. The net value of additional gain by stockers fed corn or corn plus litter is shown in Table 8. These supplements added a net increase in the value of calves from $17.58 per head for heifers fed corn and litter to $49.18 per head for steers fed corn plus litter.

Table 7. Supplemental Feed Cost and Feed Efficiency

Treatment Group	Supplement/Lb. Additional Gain, Lb.				Supplement Cost/Lb. Additional Gain, Cents[1]			
	Corn	Litter	Minerals	Total	Corn	Litter	Minerals	Total
Control (1)	—	—	—	—	—	—	—	—
Corn (2)								
Steers	2.93	—	.04	2.97	20.5	—	0.4	20.9
Heifers	2.87	—	.04	2.91	20.1	—	0.7	20.8
Average	2.90	—	.04	2.94	20.3	—	0.5	20.8
Corn and Litter (3)								
Steers	1.99	2.40	-.07	4.32	14.0	2.4	—	16.4
Heifers	3.74	4.52	-.07	8.19	26.2	4.5	—	30.7
Average	2.60	3.14	-.07	5.67	18.2	3.1	—	21.3

[1] Supplement cost per pound of additional gain above the control group. Cost of feed per hundredweight was as follows: corn, $7; litter, $1; 10 percent phosphorus mineral, $17; and salt, $3.70.

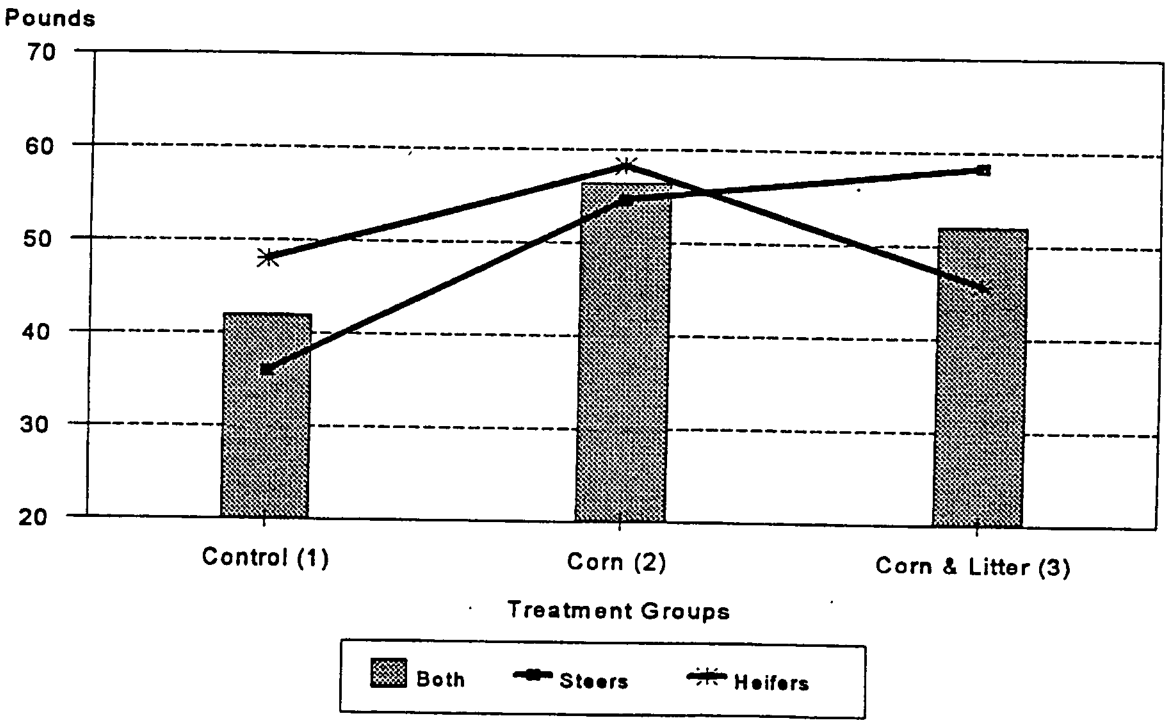
Table 8. Value of Additional Gain Obtained From Corn or Corn Plus Broiler Litter During the 80-Day Stocker Phase

Item	Value of Additional Gain Per Head, $[1]	Cost of Supplements Per Head Above Control, $[2]	Net Value of Additional Gain Per Head, $[3]
Corn			
Steers	46.08	16.05	30.03
Heifers	47.04	16.31	30.73
Average	46.56	16.18	30.38
Corn and Litter			
Steers	67.68	18.50	49.18
Heifers	36.00	18.42	17.58
Average	51.84	18.46	33.38

[1] Value based on $60 per cwt. for weight gain above control calves.
[2] Based on supplement cost per pound of additional gain (Table 7).
[3] Value of added gain minus cost of supplements.

There was a difference in shrink from the time the calves were weighed on the farm prior to loading into the truck and the next day after arriving at the feedlot. There was a treatment effect on shrink and a sex of calf by treatment interaction ($P < .005$, respectively; Figure 1). The control calves lost 42 pounds whereas the corn and corn:litter fed calves lost 56 pounds and 52 pounds, respectively. A treatment by sex of calf interaction was also detected. This interaction occurred because the shrink in the treatment 3 heifers was lower than the shrink in the treatment 2 heifers, while the shrink of the treatment 3 steers was higher than the shrink of the treatment 2 steers. This shrink data supports the theory that treatment 3 heifers had lower pasture quantity during the last 2 weeks of the trial. Lower pasture quantity reflected lower fill and therefore less shrink.

Figure 1. The Average Shrink by Treatment



Treatment Effect - P<.005; Treatment X Sex Interaction - P<.005

Results show that ADG was enhanced 121% when 2.8 lb. of corn was fed daily to stocker calves. The addition of broiler litter increased the steers' ADG by 26% over the corn-fed steers. The heifers fed corn and broiler litter had a reduced ADG as compared to the corn-fed heifers. This, however, was likely due to short pasture condition with the heifers fed corn and broiler litter. This demonstration indicates that an improved rate of gain can be expected by stocker steers grazing fall pastures of tall fescue and white clover when litter is added to a corn supplement. Cost-efficient gains were achieved by feeding corn or corn and broiler litter to stocker cattle grazing excellent quality forage.

Feedlot Phase

The feedlot phase began on November 16, 1993, only one day following the conclusion of the pasture phase. As cattle reached their optimum slaughter potential, they were removed from the feedlot and slaughtered on April 4, May 10, and June 7, 1994, which was 139, 175, and 203 days after the start of the feedlot phase, respectively.

On the first slaughter date, 72 percent of the steers and 46 percent of the heifers were slaughtered. This trend continued, so overall the heifers were fed an average of 23 days longer (170 vs. 147) in the feedlot. Due to the longer feedlot period for heifers, they tended to have carcasses with greater dressing percentage, internal fat, backfat thickness, and percent choice (Table 9).

Table 9. Performance of Cattle During the Feedlot Phase, November 16, 1993, to June 7, 1994[1]

Item	Steers			Heifers		
	Control	Corn	Corn + Litter	Control	Corn	Corn + Litter
Initial wt., lb.	692	794	818	646	721	705
Final wt., lb.	1146	1147	1181	1088	1052	1084
Total gain, lb.	454	353	363	442	331	379
Avg. daily gain, lb.	3.11	2.80	2.88	2.62	2.41	2.42
Avg. days on feed	158	144	147	187	161	176
Dressing percentage, %	61.7	62.1	61.7	63.7	63.9	63.6
Internal fat, %	2.10	1.93	2.05	2.88	2.56	2.75
Backfat thickness, in.	0.37	0.38	0.37	0.54	0.49	0.49
Ribeye area, sq. in.	12.36	11.64	11.57	13.70	12.31	12.73
Ribeye area/cwt., sq. in.	1.75	1.63	1.59	1.97	1.83	1.85
Yield grade	2.56	2.83	2.91	2.54	2.82	2.82
Percent choice	0	33.3	30.8	50.0	62.5	45.8

[1]Treatments shown relate to the 80-day pasture phase.

When feedlot and carcass data were averaged for steers and heifers, rate of feedlot gain was greater for control animals (Table 10). Controls were sent to the feedlot after 80 days of rather low ADG on pasture; therefore, compensatory gain occurred during the feedlot phase. Control steers were fed in the feedlot for 13 days longer than the other steers while control heifers were fed 19 days longer than the other heifers.

Table 10. Means for Feedlot Performance and Carcass Characteristics

Item	Treatment[1]		
	Control	Corn	Corn Plus Litter
Initial wt., lb.	669	758	762
Final wt., lb.	1117	1100	1133
Total gain, lb.	448	342	371
Avg. daily gain, lb.	2.87	2.61	2.65
Avg. days on feed	173	153	162
Dressing percentage, %	62.7	63.0	62.6
Internal fat, %	2.49	2.25	2.40
Backfat thickness, in.	.46	.44	.43
Ribeye area, sq. in.	13.03	11.98	12.15
Ribeye area/cwt., sq. in.	1.86	1.73	1.72
Yield grade	2.55	2.83	2.87
Percent choice	25.0	47.9	38.3

[1]Treatments during the 80-day pasture phase.

Average cost of gain (feed, medication, feedlot charges) for all steers and heifers fed in the feedlot was $49 per hundredweight or $1.29 per head per day. Because all treatments were included in each pen of cattle, cost of gain for each treatment during the stocker phase could not be calculated.

Table 10 shows no detrimental effect on feedlot performance or carcass characteristics of stocker steers and heifers that were fed broiler litter during the stocker phase. Carcass characteristics were similar among treatments.

Results of the stocker and feedlot phases indicate that supplemental broiler litter plus corn or corn alone produced efficient, economical gains by steers and heifer calves pastured on excellent quality legume-grass pastures. Broiler litter supplementation during the pasture phase did not adversely influence feedlot performance or carcass characteristics of the animals.

The University of Arkansas Cooperative Extension Service acknowledges Mr. Joe Hale for his assistance with this demonstration. Appreciation is expressed to the Tennessee Valley Authority for funding the project.

UTILIZATION OF POULTRY WASTE BY FEEDING CATTLE

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Poultry waste has been used as cattle feed in Virginia for more than 25 years. Beef producers in Virginia are not alone in this regard as poultry waste, particularly broiler litter, is being increasingly utilized as a source of nutrients for cattle wherever commercial broiler production is practiced.

For example, I have recently received requests from Iowa Extension Specialists on our litter feeding experience. This was prompted by an expansion of broiler production in Iowa and their awareness that the feeding of broiler litter could be of economic benefit to their cattle industry.

Virginia beef producers can claim to be innovators and early adopters of the practice because of the pioneering work of Dr. J. P. Fontenot, distinguished Animal Scientist and Ruminant Nutritionist at VPI&SU, who continues his work in this area today. He is recognized as one of the world's foremost authorities on the utilization of animal wastes as feed for ruminants. His scope of work now includes such things as rumen contents collected at slaughter and seafood processing wastes from crab, clam, shrimp, and fin fish, but he continues to work on refining our understanding of opportunities to use poultry waste materials effectively, safely, and profitably.

For the purpose of this discussion, I would like to limit my remarks to coverage of broiler and turkey litter or manure collected from housed, floor-reared birds. There are other wastes to be sure, such as cage layer manure. These wastes have feeding value and can be utilized if they can be properly processed before feeding. Generally, the energy costs of drying cage layer waste and other considerations have limited the practical application of proven technology to preserve and utilize the nutritional value of cage layer manure. This is the current situation in Virginia but elsewhere in the world and with different energy and other input costs, cage layer waste can and is being used as feed for cattle and even for recycling to poultry as a source of calcium and phosphorus. This winter I made a trip to India as a consultant on a Winrock International project on recycling of biodegradable animal wastes. I became aware of innovations that Indian poultry industry firms are applying supplement limited supplies of hay fed to beef cows. This type of feeding requires more equipment and labor than a hay diet alone. It is generally found that mixing some corn grain or other palatable concentrate is needed to stimulate litter consumption. Also, troughs of some type are needed when litter or a litter-concentrate mixture is fed. These additional requirements are a hindrance to sustained use of litter for beef cows. Hence, litter feeding to cows tends to rise or fall depending on forage supplies. When hay is abundant, less litter is used by cow/calf herd operators.

Stocker-backgrounding programs have proven to be a different situation. The need for supplemental protein is greater, corn silage is often used in backgrounding diets, and larger numbers of animals with similar nutritional needs are usually fed together. Litter usage suits backgrounders very well. Appropriate feed bunks and other facilities which provide a mechanized situation for handling, mixing and feeding are often available. This limits the need for additional capital expenditures. Use of litter in backgrounding programs has increased dramatically in recent years. An extension publication on litter feeding has been widely distributed and has been a source of useful information to stocker operators. In most cases, a backgrounding operator who starts to use litter continues the practice. Operators realize that this resource contributes significantly to the opportunity for profit. Levels of usage range from only enough litter needed to supply the supplemental protein needed to balance a hay or silage-based ration to up to 40% or more of diet dry matter. Generally, smaller cattle respond more favorably to lower levels of litter while larger cattle can consume large amounts of litter with resulting major impact on lowered ration costs, reduced costs of gain, and ultimately increased profit. In general, levels of litter fed to 300-400 lb cattle will approximate 10-20% of diet dry matter. For 300-400 lb cattle, the level may range from 20% to 30% and may reach as high as 40% for 500-600 lb stockers where levels of gain of 1.5 to 2.0 lbs per day are desired.

There is limited feeding of slaughter cattle in Virginia and consequently, limited use of poultry litter in cattle finishing diets. The suggested use of litter is at levels needed to provide supplemental protein since energy levels in litter are comparable to hay and too low to result in maximum daily gain. Therefore, levels of litter fed to finishing cattle are limited to 2 to 3 lbs per head per day. At these levels, the reduction in total ration energy is minimized and gains are acceptable. Research at our Shenandoah Valley Research Station conducted by Dr. Fontenot demonstrated that litter could supply all the supplemental protein needed in finishing diets for beef cattle. We recommend a 15-day removal of litter from diets of slaughter

Table 2. Results of Experiments Comparing Broiler or Turkey Litter Diets Fed to beef Cattle

Year	Type of Litter	Average Daily Gain	Dry Matter/ lb of Gain
		lb	lb
1985-'86			
Expt. 1	Turkey	2.1	7.9
	Broiler	2.5	7.0
Expt. 2	Turkey	3.2	4.8
	Broiler	3.1	4.7
1986-'87			
	Turkey	2.4	6.1
	Broiler	2.6	5.5
1987-'88			
	Turkey	3.3	9.6
	Broiler	3.5	10.8
1988-'89			
	Turkey	2.6	7.1
	Broiler	2.5	7.0

Adapted from Va. Tech Livestock Research Reports.

While the results differed from year to year, performance was similar indicating that selected turkey litter or broiler litter can be successfully fed to finishing cattle at 30% of the dry matter. These studies also showed that the litter could be ensiled with the corn forage or added at feeding time with similar results. We have several turkey producers who are successfully using turkey litter as a feed for stocker cattle. Typically, they select dry litter which is then stored in a manure storage structure. This protects the litter from rain and resulting run-off until it can be fed or used as fertilizer. That used as feed is moved to the feeding area where it is generally incorporated with corn silage and other ration ingredients at feeding time. These methods are identical to those used by producers who routinely use broiler litter in their stocker background programs.

Extension Demonstrations Promote Litter Feeding

A variety of methods have been used in recent years to acquaint Virginia beef producers with litter feeding. In addition to the Extension bulletin previously mentioned, information has been presented in news articles and at county and area producer meetings. Interested producers have been given individual advice. This is important for those who are trying litter feeding for the first time. Analysis of forages and feeds available, consideration of the size and type of cattle to be fed and facilities

Table 3. Demonstrations on Farms Where Broiler Litter Was Fed in Virginia, 1989-'90

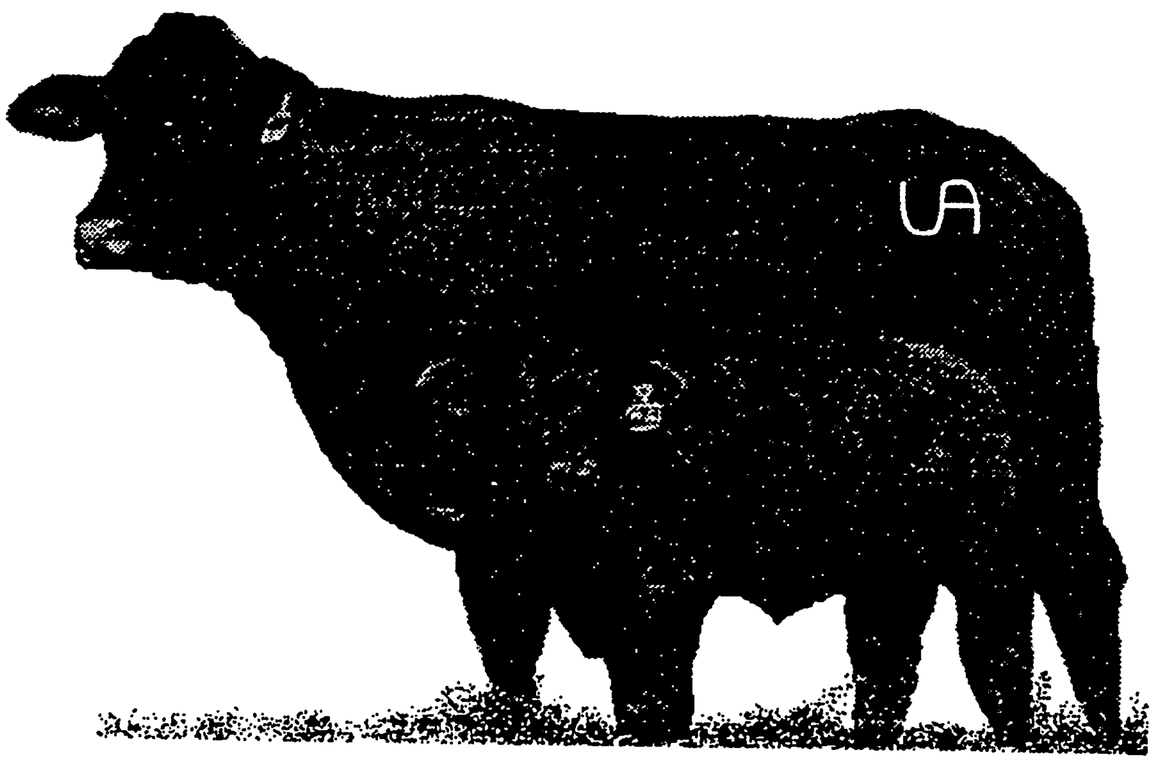
County	No. of Cattle	Type of Ration	Avg. Daily Gain	Feed Cost/ lb of Gain
			lb	$
Clarke				
Litter	40	Litter, corn, silage	3.5	0.31
No Litter	39	Haylage, corn, silage	2.4	0.51
Frederick				
	25	Litter, sh. corn	1.8	0.35
Tazewell				
600 lb heifers	28	Litter, hay, corn screenings	1.3	0.40
300 lb heifers	50	Litter, hay, corn screenings	0.9	0.30
Bland				
	40	Litter, corn, silage	1.7	0.37
Russell				
Litter	96	Corn, litter, hay	1.2	0.29
No Litter	87	Corn, hay	0.8	0.41

Adapted from summary of producer demonstrations.

A lesson learned in all of these demonstrations that bears emphasis is the need to introduce a new and somewhat unpalatable feed into the ration gradually. When this was done carefully by producers, no problems of adjusting cattle to the litter rations was encountered. When producers tried a more abrupt approach, there was feed refusal, reduced intake and producer concern. However, these producers found that acceptance was obtained within one to two weeks and thereafter no problems with feed intake or other difficulties were experienced. In all cases shown, producers and their county agricultural extension agents were satisfied that litter could be fed successfully and economically in their operations. All are first time users of broiler litter and those located in Tazewell, Russell, and Bland counties are located about 200 miles from a major broiler growing region. Therefore, the cost of litter used in the ration cost calculations was in excess of $30.00 per ton of which more than two-thirds was trucking cost. The availability of a low-cost source of protein and minerals was accepted enthusiastically by producers who gained firsthand knowledge of litter feeding and these producers have proceeded to develop links with poultry industry sources.

Arkansas Beef Improvement Program

BROILER LITTER PELLET COMPARED TO CONVENTIONAL FEEDSTUFFS FOR GROWING REPLACEMENT HEIFERS AND MAINTENANCE OF COWS



COOPERATIVE EXTENSION SERVICE, University of Arkansas,
U.S. Department of Agriculture, and County Governments, Cooperating

Acknowledgment

This project was funded by the Tennessee Valley Authority. Without their concern and commitment, it would have not been conducted.

Special appreciation is given to Sam Sharp and Kenneth Knoll for providing their farms and cattle for this demonstration.

County Agents Gerald Alexander, Mike Burns, and Charles Albritton provided support to the program by devoting their time and expertise.

Technical assistance and advice was provided by Tom Troxel, Bobby Simpson, and George Davis. Their advice and support helped to overcome serious problems.

These herds are two of the demonstration herds involved in the Arkansas Beef Improvement Program. This program is supported by the Extension Service, U.S. Department of Agriculture, and the Cooperative Extension Service, University of Arkansas, under special project number 92-EXCA-2-0185.

Kelly Gage, Coordinator
Arkansas Beef Improvement Program

BROILER LITTER PELLET COMPARED TO CONVENTIONAL FEEDSTUFFS FOR GROWING REPLACEMENT HEIFERS AND MAINTENANCE OF COWS

Kelly Gage
Extension Specialist - Livestock

Feeding trials were initiated in December of 1992 on two Arkansas Beef Improvement Program demonstration farms. The purpose of the feeding trials was to evaluate a commercially-prepared chicken litter feed which consisted of 43 percent chicken litter, 40 percent corn, 10 percent cottonseed meal, 5 percent alfalfa meal, and 2 percent soybean oil. This product was to be mixed thoroughly and then pelted into a 1/4" pellet.

Previous experience with feeding chicken litter has indicated that there is a certain percentage of cattle which do not like it and will not consume it. This feedstuff was prepared with these ingredients to eliminate the rejection potential of cattle to chicken litter. A pretrial was conducted in June 1992 to determine the palatability of different feed ingredients and their effect on the consumption of broiler litter. The trial involving 100 steers indicated that the addition of cottonseed meal and corn definitely increased palatability. (Study reported on page 9.)

The chicken litter product was compared to two other feedstuffs, a 20 percent, all-natural range cube and whole cottonseed.

The two herds participating in this trial were: 1) the Sam Sharp herd in Columbia County and 2) the Kenneth Knoll herd in Hempstead County. The Sam Sharp herd consisted of 195 replacement heifers. These Brangus heifers were purchased in Tennessee and delivered to the Sharp farm weighing approximately 500 pounds each. The heifers were divided into three equal groups and were fed the three feedstuffs. They were randomly sorted and weighed to eliminate as much variation as possible.

The Kenneth Knoll herd consisted of 85 mature mother cows. These cows were also divided into three groups.

The feedstuffs were delivered to the farms by the fifth day of December. After observing the broiler litter pellet, it was determined that there must have been some mistake in the feed formulation. There appeared to be very little corn present, and the visual appearance of the pellet appeared to be primarily chicken litter. Therefore, complete analyses were run.

One sample was sent to the University of Arkansas at Fayetteville for a complete chemical analysis. Another sample was sent to Woodson-Tenent Laboratories in Little Rock to determine the composition of the various ingredients. The results from Woodson-Tenent indicated that there was less than 5 percent corn and very small amounts of cottonseed meal. The chemical analysis indicated that the protein content was around 30 percent, and the anticipated protein level based on various calculations indicated it should not be in excess of 21 percent. Therefore, it was determined that a mistake was made.

The trials were initiated on the Sam Sharp farm on December 7 and on the Kenneth Knoll farm on December 14. During the process of producing a new chicken litter pellet, corn was added to the first pellet to make it equal to the anticipated product.

The new product was delivered to the farms on January 12. All cattle were then switched over to the new product, which appeared to be formulated correctly. Visual observation of the cattle had been made on both farms up to this point, and by the middle of January, it appeared that the cattle on the natural protein feed were consuming more hay and were in better condition than the cattle in the other two treatments (chicken litter and whole cottonseed).

The heifers in the chicken litter group appeared to increase weight after the correct litter feedstuff was being fed. The feed was consumed in a matter of minutes, and all calves appeared to be eating the feed.

The heifers receiving the whole cottonseed did not consume their projected intake of 3 pounds per head per day. It was extremely difficult to get them to consume more than two pounds per head per day. Therefore, ground corn was added to the cottonseed to provide about one pound of ground corn per head per day and about two pounds of whole cottonseed. The addition of ground corn increased the consumption of the whole cottonseed to the desired intake.

The results of the trial on the Kenneth Knoll farm involving the mature cows indicated that the cows eating the natural cube consumed the product readily, aggressively sought it as it was fed, and appeared to have the better body condition for the first thirty days.

The cows consuming the broiler litter pellet were, however, in good flesh. There were four cows out of 30 that completely rejected the broiler litter. They would not come to the trough when it was fed. There were cows in this group, however, that aggressively consumed the chicken litter. When corn was added to this product, there were certain cows that had such a preference to the broiler litter that they would seek it out and leave the corn in the trough. However, the four cows that did not eat the chicken litter pellet at first continued to reject it as the corn was added.

When the new chicken litter pellet was fed to the cows, the four cows which would not consume the first broiler litter pellet were given range cubes to observe their consumption. They immediately ate the range cubes. The new broiler litter product was spread on the ground in the same manner the range cubes had been fed. The all natural protein cube was put on top of the broiler litter pellets to see if the cows would consume the cubes and then eat the broiler litter pellets. Three of the cows consumed the cubes and left the pellets, and one cow would not even eat the cubes. She completely rejected both products and would not have anything to do with anything in close proximity of the broiler litter.

The cows receiving the delinted cottonseed on the Kenneth Knoll farm did not consume this material, either. The product would be eaten by the end of the day, but there were three to four cows in this group that would not eat the delinted seed. The seed had a bitter taste and a strong odor. Most mature cattle will readily consume whole cottonseed. Since intake was a problem, the feed was changed to whole, linted cottonseed. This substitution took place on February 2.

Observations on February 19 revealed the cattle on linted seed were eating it well. Four cows on the broiler pellet were still not eating the feed. They were cows 56, 65, 87, and 58. These cows did not eat a supplement all fall.

Chemical Analysis of Feedstuffs

Table I. Delinted Cottonseed

Chemical Composition	As Fed Basis		Dry Matter Basis	
Moisture	9.4	%		
Dry Matter	90.6	%		
Crude Protein	19.4	%	21.4	%
Acid Detergent Fiber	34.1	%	37.7	%
Nitrate Nitrogen			344	ppm
Phosphorus	0.22	%	0.24	%
Potassium	0.83	%	0.92	%
Calcium	0.40	%	0.44	%
Magnesium	0.22	%	0.24	%
Iron	187	ppm	206	ppm
Manganese	11	ppm	12	ppm
Copper	9.42	ppm	10.4	ppm
Zinc	45.4	ppm	50.1	ppm

Table II. Whole Linted Cottonseed

Chemical Composition	As Fed Basis		Dry Matter Basis	
Moisture	10.9	%		
Dry Matter	89.1	%		
Crude Protein	25.4	%	28.5	%
Acid Detergent Fiber	51.1	%	57.3	%
Nitrate Nitrogen			140	ppm
Phosphorus	0.11	%	0.12	%
Potassium	0.58	%	0.65	%
Calcium	0.30	%	0.34	%
Magnesium	0.19	%	0.21	%
Iron	72	ppm	81	ppm
Manganese	8	ppm	9	ppm
Copper	10.6	ppm	11.9	ppm
Zinc	22.1	ppm	24.8	ppm

Table III. Range Cube

Chemical Composition	As Fed Basis		Dry Matter Basis	
Moisture	11.1	%		
Dry Matter	88.9	%		
Crude Protein	19.7	%	22.2	%
Acid Detergent Fiber	17.7	%	19.9	%
Nitrate Nitrogen			200	ppm
Phosphorus	0.21	%	0.24	%
Potassium	0.84	%	0.94	%
Calcium	1.55	%	1.74	%
Magnesium	0.38	%	0.43	%
Iron	250	ppm	281	ppm
Manganese	181	ppm	204	ppm
Copper	19.1	ppm	21.5	ppm
Zinc	135	ppm	152.3	ppm

Table IV. Broiler Litter Pellet

Chemical Composition	As Fed Basis		Dry Matter Basis	
Moisture	14.3	%		
Dry Matter	85.7	%		
Crude Protein	18.8	%	21.9	%
Acid Detergent Fiber	12.8	%	14.9	%
Nitrate Nitrogen			394	ppm
Phosphorus	0.39	%	0.45	%
Potassium	0.94	%	1.10	%
Calcium	0.94	%	1.10	%
Magnesium	0.27	%	0.32	%
Iron	179	ppm	209	ppm
Manganese	135	ppm	157	ppm
Copper	173	ppm	201.7	ppm
Zinc	126	ppm	147.3	ppm

Table V. Chemical Composition of Hay Fed to Mature Cows

	As Fed
Moisture	13.3%
Crude protein	8.6%
Acid detergent fiber	31.4%
Neutral detergent fiber	57.6%
Nitrate nitrogen	< 400 ppm
Phosphorus	.36%
Potassium	1.36%
Calcium	.43%
Magnesium	.28%
Sulphur	.16%
Copper	9.89 ppm
Sodium	.05%

Table VI. Chemical Composition of Hay Fed to Replacement Heifers

	As Fed
Moisture	9.4%
Crude protein	9.8%
Acid detergent fiber	33.2%
Neutral detergent fiber	52.6%
Nitrate nitrogen	< 400 ppm
Phosphorus	.35%
Potassium	2.63%
Calcium	.53%
Magnesium	.2%
Sulphur	.2%
Copper	11.0 ppm
Sodium	.04%

Results and Discussion

The Brangus heifer trial was concluded on March 18, 1993. Ryegrass pastures were making fast growth and, to eliminate the response from forages, the trial was stopped.

On April 19 and 28, 1993, blood samples were collected on all heifers to determine progesterone concentrations which would indicate if they were experiencing estrus cycles. The exact age of the calves was unknown. Based on their weight at the beginning of the trial, it was assumed they were between 12 and 16 months old on May 1.

Table VII. Performance of Weaned Heifers on Different Supplements

	Range Cube	Whole Cottonseed	Litter Pellet
Number of animals	65	66	64
12-8-92 weight	535	523	526
3-18-93 weight	633	617	627
ADG	.98	.94	1.01
4-28-93 weight	658	640	657
Percent cycling	40.7	36.4	29.7
Average weight cycling	659.8	662.5	677.6
Average weight not cycling	655.1	626.8	647.7
Lbs. fed/day	3.85 lbs.	3.24 C.S./1.06 corn	3.94 litter/.453 corn
Cost of supplement/ton	$170	$140 C.S./$120 corn	$110 litter/$120 corn
Cost of supplement/head/day	$.327	$.285	$.240
Lbs. of hay fed[1]	15	15	15
Cost of hay/ton	$42	$42	$42
Cost of hay/head/day	$.312	$.312	$.312
Feed cost/heifer	$63.90	$59.70	$55.20
Total cost/day	$.639	$.597	$.552
Cost/lb. of gain	$.65	$.635	$.547

[1]Hay consumption and wastage was included in amount fed.

All mature cows were weighed on December 14, 1992, and were in good body condition. The cattle were fed hay free choice and supplemented daily with the different supplements. The trial was concluded on April 23, 1993, when forage supplies were adequate (130 days of feeding).

Table VI. Mature Cow Performance on Different Supplements

	Range Cube	Whole Cottonseed	Litter Pellet
Number of animals	29	30	26
12-14-92 weight	1184	1125	1166
Body condition score	5.9	5.1	5.7
4-23-93 weight	1,040	1,045	1,105
Body condition score	4.9	4.7	5.1
Weigh difference	-141 lbs.	-72 lbs.	-61 lbs.
Body condition score difference	-1.0	-0.3	-0.6
Total initial cow weights	34,340 lbs.	33,755 lbs.	30,315 lbs.
Final cow weights	29,110 lbs.	31,365 lbs.	28,735 lbs.
No. of calves born at weighing	24	15	17
Total calf gains (lbs.)	4,005	2,490	3,060
Cow and calf weight difference	-1,225 lbs.	+100 lbs.	+1,480 lbs.
Average weight difference for cows including calf wts.	-42 lbs.	+3.3 lbs.	+57 lbs.
Lbs. of supplement fed/day	3 lbs. each from Dec. 14 - March 1 and 4 lbs. to 4-23		
Cost of supplement fed/day[1]	$.29	$.23	$.1878
Lbs. of hay fed/day	16	15.79	16.9
Cost of hay head/day[2]	.36	.36	.38
Total cost/head/day	.65	.58	.57
Feed cost/cow	$84.50	$75.40	$74.10

[1]Range cube priced at $170/ton, cottonseed at $140/ton, litter pellet $110/ton.

[2]Hay cost based on $25/roll that weighs 1,100 lbs. or $45/ton. Hay feeding didn't take place until 12/17/92. Costs are based on the number of rolls fed for 130 days. Hay stored outside with less than 10% spoilage. Number of rolls fed/group. Rolls fed - range cube 55, cottonseed 56, litter pellet 52.

Chicken Litter Pellet Consumption Study

Five treatments were used to compare different ingredient combinations with broiler litter on palatability to stocker calves. Each treatment contained approximately ten pounds of feed. The five treatments were as follows:

Ration Composition	Time Required to Consume Feed
1) 50% litter 35% corn 10% cottonseed meal 5% alfalfa	1 hour 100% consumed
2) 50% litter 50% corn	1 hour 75% consumed
3) 50% litter 40% corn 10% cottonseed meal	1 hour 100% consumed
4) 50% litter 40% corn 10% soybean meal	1 hour 25% consumed
5) Commercial creed feed pellets	< 5 minutes 100% consumed

All five treatments were pelleted into a 3/8" diameter pellet. The treatments were fed in five different troughs that were ten feet long and one hundred stocker calves were allowed to consume these products at will.

The results were as follows:

— All the commercial pellets for treatment 5 were consumed in less than 5 minutes.

— Cattle were still consuming treatments 1 and 4 after 8 minutes.

— No cattle were eating from treatments 2 and 3.

— A few cattle were eating treatment 1 after 12 minutes. Treatment 1 was nearly all consumed.

— All other cattle had gone back to grazing.

— After one hour, some of the cattle returned to the feed trough. Treatments 1 and 3 were consumed.

— Treatment 2 – 75% consumed.

— Treatment 4 – 25% consumed.

The trial was repeated the next day and the cattle were adjusting to the litter and all treatments were consumed in about 30 minutes. However, about one-half of the calves would not consume the litter pellets.

A comparison was made between a litter alfalfa and litter corn pellet the third day. About 75 percent of the cattle were consuming the feed well with cattle having a slight preference for the litter corn.

From these observations, it appears that cottonseed meal was the preferred ingredient for increasing the acceptance of broiler litter. Cottonseed meal appeared to be followed by corn, alfalfa, and soybean meal.

Summary

There were no significant differences among the three treatments for either trial (heifers or cows). Broiler litter can make up a large portion of a winter feed supplement without adversely affecting average daily gain.

The average gain slightly favored those cattle receiving the broiler litter supplement on both the replacement heifers and the mature cows. There were more heifers cycling in the range cube group than either the cottonseed or broiler litter pellet group. The percent cycling was 41, 36, and 30 for the respective groups. No significant difference was measured.

There was an $8.70 difference in the heifer wintering cost among the different feeds (the range cube, which was the highest, and the litter pellet, which was the lowest). There was a 10¢/lb. difference in cost per pound of gain favoring the litter pellet. The cows on the litter pellet also lost less weight than the other two groups during the winter. The litter group lost an average of 61 pounds per cow where the range cube group lost 141 pounds and the cottonseed group lost 72 pounds. It also cost $10 per cow less for cows receiving the broiler litter than the range cube. The cost and performance of the cottonseed and broiler litter was very similar. The convenience of feeding must also be weighed by a producer in his supplemental feed program.

The performance and cost of feeding broiler litter in commercial feed or on-the-farm mix offers potential to reduce cost and maintain production. Before it can be used commercially, the rejection problem by certain cows must be eliminated. If the four cows that would not eat the broiler litter pellet had been started on the feed that was formulated correctly, they might have eaten it. The four cows which did not eat any supplement lost an average 143 pounds versus a 61-pound loss for the group. Three of these cows had calved and averaged a 187-pound body weight loss. The fourth cow (dry) only lost 10 pounds during the winter.

Limited amounts of broiler litter can provide minerals and protein that will be beneficial at economic prices.

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February 7, 1994

Dr. Richard C. Strickland
Biotechnical Research Department
Tennessee Valley Authority
Muscle Shoals, AL 35660

Dear Richard:

Enclosed is a project report for TVA contract TV-85337V entitled "Marketing Potential of Pelleted Broiler Litter as an Alternative Crude Protein Supplement for Beef Cattle." This is the final report on the litter feeding trial conducted at the Sand Mountain Substation.

This report is being sent to Dr. Ransom to cover reporting of this work under the companion AUTRC project.

If you have questions regarding any of the data, please call me at 205/844-1518.

Sincerely,

Tom

Thomas A. McCaskey

Progress Report 11

for

Project: TVA-TV-85337-ADS

entitled

Marketing Potential of Pelleted Broiler Litter as an Alternative Crude Protein Supplement for Beef Cattle

COMPLETION REPORT FOR LITTER FEEDING TRIAL

Submitted to

Tennessee Valley Authority

through

Richard C. Strickland
Biotechnical Research Department
Tennessee Valley Authority
Muscle Shoals, AL 35660

Submitted by

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Department of Animal & Dairy Sciences
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William E. Hardy, Jr.
Department of Agricultural Economics and Rural Sociology
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February 7, 1993

Introduction

This completion report contains data from the litter feeding trial conducted at the Sand Mountain Substation from June, 1993 through October, 1993. Three preliminary reports on the feeding trial were submitted. The objectives of the study were: 1) to compare growth and intake of stocker cattle fed a conventional diet, a 50:50 mixture of corn and broiler poultry litter, and a pelleted mixture of corn and broiler poultry litter; and 2) to determine diet digestibility and fertilizer value (N-P-K) of manure from cattle fed the diets.

Materials & Methods

Fifty-four crossbred beef heifers (initial wt 544 lbs) were purchased, vaccinated, dewormed and implanted. Cattle were allowed an adjustment period of 28 d, during which a litter-based ration was fed, then were weighed and sorted into 9 groups. Three groups were fed a conventional corn/soybean meal ration (conventional), three were fed a 50:50 corn:broiler litter ration (corn:litter) and three were fed a pelleted broiler litter ration (pellets) in a 112-d feeding trial (Table 1). Rations were formulated to provide approximately equal amounts of nutrients. All rations contained 0.5 lb/ton of Bovatec and 0.5 lb/ton Vitamin A-30. Pelleted litter feed containing approximately 50% corn and 50% poultry litter was purchased from a commercial processor. The conventional and corn:litter diets were mixed at the research station from ingredients purchased from commercial sources. Litter for the corn:litter diet was deep-stacked in a pole barn, covered with 6 mil polyethelyne sheeting and stored at least 28 d before being used. Thermocouple wires were inserted into the litter stack and temperature was monitored for 84 d. Heifers were housed in an open-sided barn on concrete, to facilitate feces collection. Water was available at all times, but the cattle were not fed any hay. Hay was not fed because it would decrease consumption of the diets, thereby making it more difficult to assess the feed value of the test diets. Every 28 d the cattle were weighed, and feed and feces samples were collected. Proximate analysis was conducted by AOAC procedures (AOAC, 1984). Total N in feces was determined by kjeldahl digestion of wet samples. Mineral analysis was performed using inductively coupled argon plasma spectroscopy, according to procedures outlined by Hue and Evans (1986). Apparent dry matter and N digestibility were calculated using acid-insoluble ash (AIA) as an internal marker. Acid-insoluble ash was determined using the 2 N HCl procedure described by Van Keulen and Young (1977).

Results and Discussion

Proximate analysis of the litter used to manufacture the diets is shown in Table 2. Litter used in the corn:litter diet and the litter used to manufacture the pelleted corn:litter diet were high quality, with low ash concentrations, 17.9% and 18.8%, respectively, and high crude protein, 24.5% and 25.9%, respectively. Bound N as a percent of total N was less than 12% for each litter. The temperature of the deep-stacked litter did not exceed 135°F during storage (Figure 1); therefore, little heat damage and loss of nutritive value occurred. Generally, broiler poultry litter can be used as a feedstuff if it contains less than 28% ash, greater than 18% crude protein, and less than 25% of total N is bound (ADIN). Calcium, phosphorus, magnesium and potassium content of the poultry litters were similar, but litter used for pellets was higher in iron, aluminum and silicon (Table 3).

Proximate analysis of the feed samples showed that the conventional and corn:litter diets were very similar, with the corn:litter slightly higher in ash (9.9 vs. 6.9%) and bound N content (9.6 vs. 7.1%; Table 4). This would be expected due to the relatively low ash and bound N content of most conventional feeds. Although the pelleted feed was formulated to contain the same proportions of corn and poultry litter as the 50:50 mixture, the proximate analysis revealed that the pellets were much higher in ash (16.9 vs. 9.9%) and bound N (12.5 vs. 9.6%) than the corn:litter feed (Table 4). This was unexpected, since the proximate analysis of the litter used for each diet was very similar. Mineral concentration of the litter-based feeds generally was higher than the conventional feed, due to the higher ash content of poultry litter (Table 5). However, the concentrations of calcium, iron, aluminum and silicon were much higher in the pelleted feed, more so than would be expected for a 50:50 corn:litter mixture using the mineral analysis of the litter shown in Table 3. This may have been due to use of a pellet binder in the feed manufacturing process or the use of a lower quality litter as an ingredient in the pelleted feed. Mineral and nutrient concentrations in all diets were adequate to meet recommendations for growing heifers (NRC, 1984).

Data from Periods 1 to 3, which represent cattle weighing periods of 28, 56 and 84 d, respectively, are shown in Tables 6 to 8. Generally, intake of the pelleted feed was lower than intake of the other diets, which were similar. This was reflected in the low average daily gain (ADG) by heifers consuming the pelleted diet. The conventional and corn:litter rations exhibited similar ADG and feed:gain ratios through Period 2, after which the conventional ration provided greater ADG and lower feed:gain. Data from Period 4 (112 d) indicated that daily intake of the conventional and litter:corn rations was similar, 22.2 and 23.5 lbs/d, respectively (Table 9). Consumption of pelleted feed averaged 19.7 lbs/d over the 4-week period. Intake of pelleted feed was increasing slightly during this time, while intake of the conventional and litter:corn rations was decreasing, as illustrated in Figure 2. However, the increase in pelleted feed intake was not reflected by an increase in ADG. By week 16 (d 112) average feed consumption by all groups was similar, 20.5 lbs/d (Figure 2). Average daily gain during Period 4 was highest for cattle fed the conventional diet, 2.14 lbs/d, followed by the pelleted ration and corn:litter ration, 1.53 and 1.46 lbs/d, respectively.

Data for the 112-d trial demonstrated that cattle fed the corn:litter diet performed similarly to cattle fed a conventional ration (Table 10). Cattle consuming pellets did not perform as well as the others. Although all groups were similar in weight at the start of the trial (544 lbs), cattle fed pellets finished the trial at 700 lbs, while cattle consuming the conventional and corn:litter diets finished at 833 and 784 lbs, respectively. Average daily gains for cattle fed corn:litter were similar to those of the conventional ration for the first 56 days, but declined to that of the pelleted ration for the latter half of the trial (Figure 3). Cattle fed the pelleted diet finished the study at 700 lbs, which was the 56 d weight of cattle fed the conventional or corn:litter diets.

Differences in digestibility among the diets also explained the poor performance of cattle fed pellets. Apparent dry matter digestibility of the conventional, corn:litter and pellets was 71.4, 56.1 and 38.0%, respectively, while apparent N digestibility was 67.7, 51.9 and 14.0%, respectively (Table 11). The actual digestibility values may be higher or lower; however, the trend (conventional>corn:litter>pellets) is likely correct. This analysis illustrated the disparity of calculated TDN values, which were about 70% for all diets (Table 4), and digestibility determined by feeding trials. It is difficult to establish a TDN value for litter, due to its heterogenous nature. Variations in management have a marked effect on poultry litter composition and nutritive value.

Concentrations of N-P-K were highest in manure from cattle fed pellets, followed by manure from the corn:litter and conventional diets (Table 12). Litter-based diets were higher in mineral concentrations than the conventional diet (Table 5);

therefore, fertilizer value of the manure would be higher, assuming mineral digestibility was equal to or less than that of the conventional diet. Also, manure output from cattle fed litter-based diets would be 1.5 to 2.2 times higher, since apparent dry matter digestibility of the litter-based diets was less than that of the conventional diet (Table 11).

Considering only feed costs (Table 13), the corn:litter diet outperformed the conventional diet and the pelleted diet. Although ADG of cattle fed corn:litter was not always as high as that of cattle fed the conventional diet, cost/cwt gain was very favorable to the corn:litter diet. Using the overall feed:gain ratios of 8.7, 10.8 and 12.0 and cost/ton of $121, $54 and $135 for conventional, corn:litter and pellets, respectively, the cost:gain was lowest for the corn:litter, $29.16/cwt, followed by the conventional, $52.64/cwt and the pellets, $81/cwt (Table 14). The breakeven cost for the corn:litter diet when compared to the conventional diet was $97/ton, which means that a beef producer could pay up to $97/ton for the corn:litter diet and spend less money in comparison to feeding the conventional diet. In this study, there was no economic incentive to feed the pelleted corn:litter feed, based on its high cost ($135/ton) and high feed:gain ratio.

In summary, beef producers using broiler litter in rations for stocker cattle may dramatically cut feed costs while maintaining acceptable daily gain and feed utilization.

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Table 1. Composition of conventional and litter-based feeds.

Ingredient	Conventional	Corn:Litter	Pellets
	- - - - - - - lbs/ton	- - - - - -	
Cottonseed hulls	501.0		
Soybean meal	160.0		
Corn grain	1218.0	1000.0	X
Broiler litter		999.0	X
Urea	40.0		
Dicalcium phosphate	40.0		
Limestone	8.0		
Trace mineral salt	10.0		
Dynamate	22.0		
Vitamin A-30	0.5	0.5	X
Bovatec	0.5	0.5	X

Table 2. Proximate analysis of litter used to manufacture corn/litter ration and pellets.

	Mixture Litter[a]	Pellet Litter[a]
Dry matter, %	81.78	82.81
	- - % of	DM - -
Ash	17.86	18.75
Nitrogen (N)	3.89	4.15
Crude protein	24.47	25.92
Acid detergent fiber	35.82	33.55
Ether extract	3.76	<1
Crude fiber	29.11	21.90
Bound N, % of total N	10.75	11.57
TDN, %[b]	47.8	49.2

[a]Mean of 5 samples for mixture litter, 1 sample for pellet litter.
[b]Calculated using acid detergent fiber.

Table 3. Mineral analysis of litter used to manufacture corn/litter mixture ration and pellets.

Mineral	Mixture Litter	Pellet Litter
	- - - % of DM - - -	
Calcium	2.88	2.89
Phosphorus	2.00	2.04
Magnesium	0.64	0.57
Potassium	2.52	2.89
	- - ppm of DM - -	
Iron	1600	2822
Aluminum	1107	3865
Silicon	1541	2134

Table 4. Proximate analysis of feed samples.

	Conventional[a]	Corn:Litter[a]	Pellets[a]
Dry matter, %	89.11	83.86	88.37
	- - - - - - - - % of DM - - - - - - - - -		
Ash	6.87	9.90	16.86
Nitrogen (N)	2.87	2.67	2.54
Crude protein	17.94	16.66	15.89
Acid detergent fiber	18.19	18.72	21.80
Ether extract	1.64	1.30	1.04
Crude fiber	11.70	11.63	12.67
Bound N, % of total N	7.12	9.61	12.50
TDN, %[b]	71.3	69.7[b]	70.1[b]

[a]Data are means from analysis of six feed samples.
[b]Calculated using acid detergent fiber.

Table 5. Concentrations of selected minerals in feeds.

Mineral	Conventional	Corn:Litter	Pellets
		% of DM	
Calcium	0.68	1.14	2.44
Phosphorus	0.66	0.95	1.15
Magnesium	0.31	0.30	0.37
Potassium	0.98	1.35	1.61
		ppm of DM	
Iron	285	719	2204
Aluminum	195	456	2980
Silicon	156	707	2666

Table 6. Daily intake and feed conversion during Period 1 (d 0 to d 28).

	Conventional	Corn:Litter	Pellets
Initial wt., lbs	550	546	536
d 28 wt., lbs	613	622	566
Gain, lbs	63	76	30
ADG, lb/d	2.25	2.71	1.07
Daily intake, lbs	20.2	20.0	14.4
Feed/Gain	9.0:1	7.4:1	13.4:1

Table 7. Daily intake and feed conversion during Period 2 (d 28 to d 56).

	Conventional	Corn:Litter	Pellets
d 28 Wt., lbs	613	622	566
d 56 Wt., lbs	695	694	616
Gain, lbs	82	72	50
ADG, lb/d	2.93	2.57	1.79
Daily intake, lbs	22.9	23.7	17.4
Feed/Gain	7.8:1	9.2:1	9.7:1

Table 8. Daily intake and feed conversion during Period 3 (d 56 to d 84).

	Conventional	Corn:Litter	Pellets
d 56 Wt., lbs	695	694	616
d 84 Wt., lbs	773	743	657
Gain, lbs	78	49	41
ADG, lb/d	2.78	1.75	1.46
Daily intake, lbs	23.0	24.5	18.4
Feed/Gain	8.3:1	14:1	12.6:1

Table 9. Daily intake and feed conversion during Period 4 (d 84 to d 112).

	Conventional	Corn:Litter	Pellets
d 84 Wt., lbs	773	743	657
d 112 Wt., lbs	833	784	700
Gain, lbs	60	41	43
ADG, lb/d	2.14	1.46	1.53
Daily intake, lbs	22.2	23.5	19.7
Feed/Gain	10.4:1	16.0:1	12.9:1

Table 10. Daily intake and feed conversion for the 112-d feeding trial (d 0 to d 112).

Item	Conventional	Corn:Litter	Pellets
Initial Wt., lbs	550	546	536
Final Wt., lbs	833	784	700
Gain, lbs	283	238	164
ADG, lbs/d	2.53	2.12	1.46
Intake, lbs/d	22.1	22.9	17.5
Feed/Gain	8.7:1	10.8:1	12.0:1

Table 11. Apparent dry matter and nitrogen digestibility of diets during 112-d trial.

	Conventional	Corn:Litter	Pellets
	---------- % ----------		
Dry matter	71.4	56.1	38.0
Nitrogen	67.7	51.9	14.0

Data are means of 4 observations/pen (3 pens/diet).

Table 12. Concentrations and amounts of fertilizer nutrients (N-P-K) in manure from animals fed 3 diets.

	Conventional		Corn:Litter		Pellets	
Nutrient	%	lbs/ton	%	lbs/ton	%	lbs/ton
	---------- wet basis ----------					
N	3.06	61.2	3.53	70.6	3.62	72.4
P_2O_5	0.96	19.2	1.17	23.4	1.34	26.9
K_2O	0.37	7.4	0.52	10.4	0.56	11.3

Data are means of 4 observations/pen (3 pens/diet).

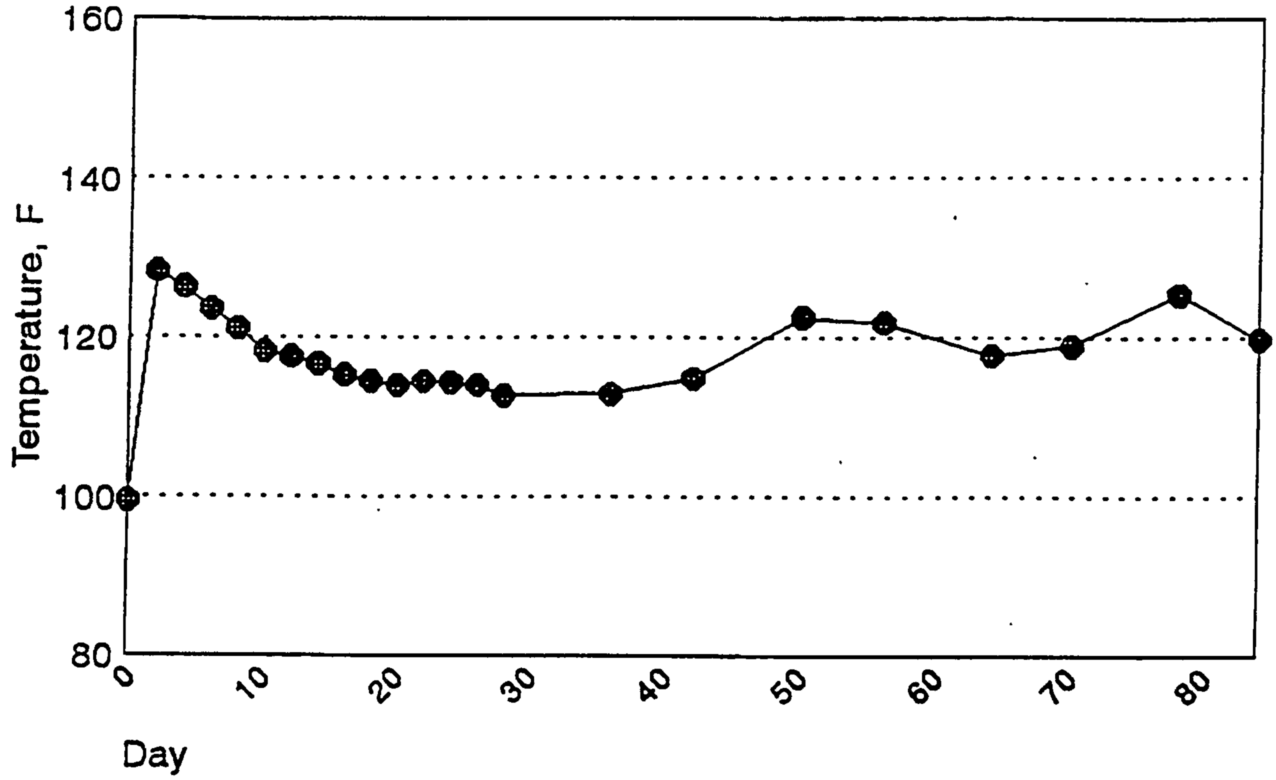
Table 13. Dollar value of feed ingredients used to calculate cost of diets mixed at research station.

Ingredient	$/lb
Corn grain	0.047
Broiler litter	0.005
Cottonseed hulls	0.057
Urea	0.112
Soybean meal	0.114
Limestone	0.029
Dynamate	0.096
Trace mineral salt	0.068
Bovatec	4.470
Vitamin A-30	0.760
Dicalcium phosphate	0.170
Ration	
Conventional	0.060
Corn:litter	0.027

Table 14. Cost of production for 112-d trial.

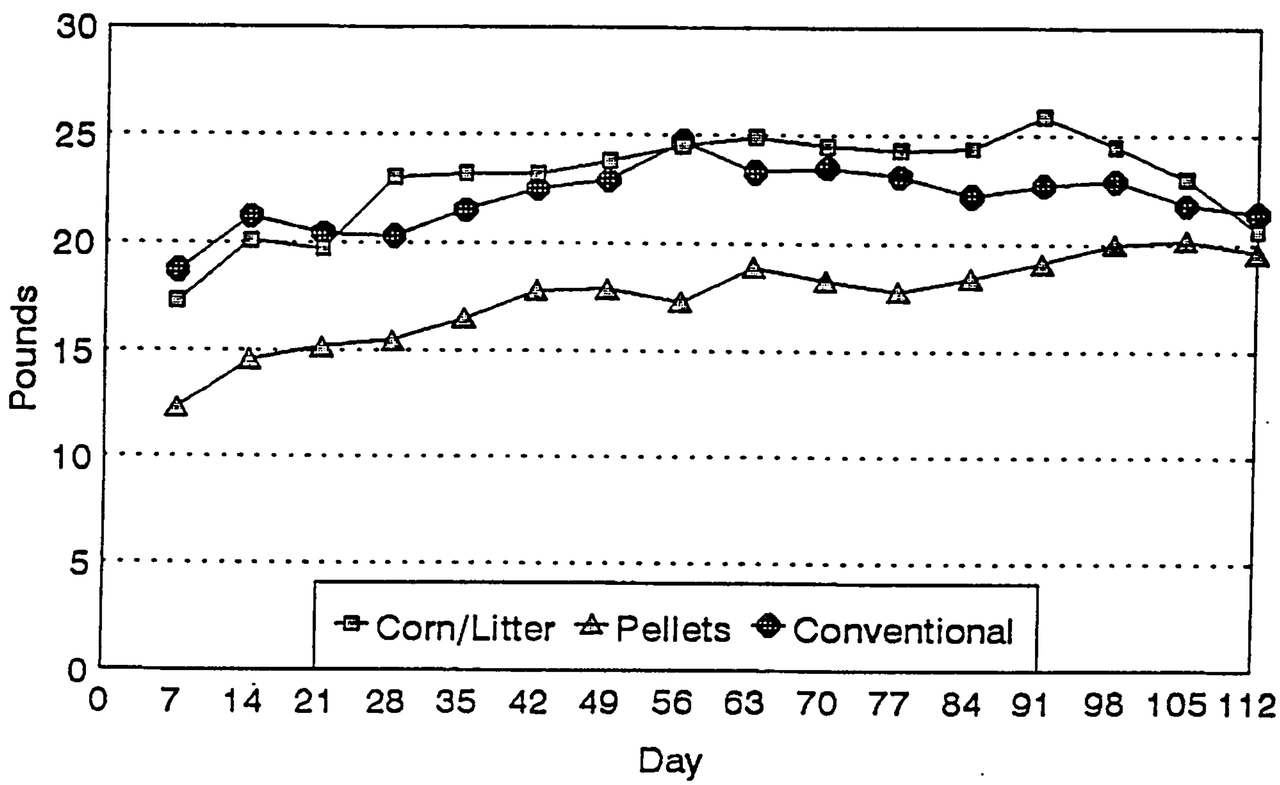
Item	Conventional	Corn:Litter	Pellets
ADG, lbs/d	2.53	2.12	1.46
Feed/Gain	8.7:1	10.8:1	12.0:1
Feed cost/ton	$121	$54	$135
Cost/cwt gain	$52.64	$29.16	$81.00

Figure 1. Temperature of deep-stacked broiler litter.



S Litter Feeding Trial, 1993

Figure 2. Average daily feed intake of stocker cattle.



SAFETY ASPECTS OF FEEDING ANIMAL WASTES[1]

T. A. McCaskey* A. L. Sutton* E. P. Lincoln*

D. C. Dobson* J. P. Fontenot*

Animal wastes contain nutrients that can serve as dietary components for animals, especially ruminants. Reports on nutrients contained in animal wastes and their potential value as feed ingredients date back to the early 1940's. New concepts for using animal wastes as feed ingredients gained impetus in the mid to late 1950's, and current interest continues since animal wastes may become an economically feasible alternative to more costly conventional feedstuffs.

As interest in refeeding animal wastes became more wide-spread and some operations used this technology, the United States Food and Drug Administration (FDA) issued a policy statement (Kirk 1967) which indicated that the FDA did not sanction the use of poultry litter, or other animal wastes, as a component of feed for animals. This policy statement followed a review by a committee formed by the U. S. Department of Agriculture with an advisor from the FDA. The committee recommended the need for research to develop methods of processing poultry litter and other animal wastes to improve its safety status as a feed ingredient. An organized effort was initiated in 1976 by researchers from several state Agricultural Experimental Stations (AES) and the federal Agricultural Research Service to investigate potential health risks associated with feeding animal wastes.

In 1978, an AES regional project entitled, Animal Health and Food Safety Aspects of Feeding Animal Waste was developed and initiated to address three major potential health areas of waste refeeding: 1) pathogenic microorganisms, microbial toxins and internal parasites 2) minerals and heavy metals, and 3) pesticide and drug residues. During the six-year project, 38 researchers from 13 states participated in the project. A majority of the project participants were in the Southern U.S.; therefore, the AES project was given a southern designation of S-139. The following is a report by committee representatives of the S-139 project on significant research findings.

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[1]This manuscript was published in the Proceedings of the 5th International Symposium on Agricultural Wastes held December 16-17, 1985, Chicago, Illinois as Publication ASAE SP 13-85:275-285, 1985.

MICROBIAL SAFETY

Animal wastes blended with feed ingredients, such as ground shelled corn, corn silage and ground hay, undergo a fermentation process similar to ensiled chopped whole corn plant. Under laboratory conditions bovine manure-feed mixtures ensiled (incubated) at 25 C achieved pH 4.5 in 5 days or less. In addition to preservation, the ensiling process has been demonstrated to be an effective method of eliminating coliforms (Knight et al. 1977) salmonellae (McCaskey and Anthony, 1975), mycobacteria (McCaskey and Shehane 1980; McCaskey and Wang 1985), Brucella abortus (McCaskey1985) and for reducing viability of bovine coccidia (Farquhar et al. 1979), and clostridia from animal wastes (McCaskey and Anthony 1978). Spores of Clostridium sporogenes inoculated at levels of 2000 to 6800 viable spores/g of a feed mixture, formulated with steer manure, ground shelled corn and corn silage, were decreased to 70 to 200 viable organisms/g of feed mixture after fermentation for 60 days at 25 C (McCaskey and Anthony 1978). The organism, which has characteristics similar to C. botulinum, also survived 60 days in ensiled chopped whole corn plant forage. Conditions in both ensiled feeds were not favorable for growth of C. sporogenes. Thus, the potential health risk due to C. botulinum would appear to be diminished by fermentation of forages and rations formulated with animal manures due to pH's below 4.7. Acid foods with pH's of 4.7 or less are generally considered to be safe from this organism.

Aines et al. (1982) ensiled mixtures of cattle waste and ground rye straw treated with 4% NaOH for 42 days. Mixtures not treated with NaOH attained pH 4.2, whereas mixtures ensiled with manure from cattle fed a high concentrate diet and treated with 4% NaOH attained pH 5.1. Mixtures ensiled with manure from cattle fed high roughage diets treated with NaOH only attained pH 7.6. Coliforms and Proteus organisms were eliminated in all manure-straw mixtures except those treated with NaOH. Shorter et al. (1981) reported that NaOH treatment of a 60:40 mixture of cattle manure and ground corn stover suppressed acid production in the mixture ensiled 45 days. Treatment of animal waste and straw or corn stover mixtures with NaOH at the time of ensiling prevented the mixtures from attaining pH values low enough to eliminate enteric bacteria indigenous to cattle manure. However, when ensiled mixtures of cattle manure and straw reach pH 4.6, coliforms, salmonellae, shigellae and Proteus bacteria were eliminated (Cornman et al. 1981).

A continuous, two-stage lactic acid fermentation process for beef cattle feedlot waste (FLW) coated on cracked corn (5 parts FLW to 8 parts corn) was developed and tested at the USDA Northern Regional Research Center. The fermentation process improved the nutrient content of corn and effectively eliminated potentially pathogenic microorganisms (Hrubant 1985). The fermented product had about 45 % moisture and a pH of 4.0 to 4.2. Fecal coliforms indigenous to the FLW were killed by the fermentation process in 9 hr. Mycobacterium paratuberculosis inoculated at the rate of 1 g cells/20 grams of feed mixture also was killed in 9 hr. The process has been demonstrated to kill viruses. At inoculation rates of 0.1 to 10 billion viruses / gram of FLW-corn mixture, the time required to achieve 90 % destruction of five model bacterial viruses ranged from less than 5 min. to 18.1 hr. The process killed 5 million indigenous coliform bacteria / gram of mixture when pH 4.2 was achieved in 48 hr (Hrubant and Detroy 1980). A similar process was evaluated for the fermentation of a swine waste slurry and cracked corn (1:2) mixture (Weiner 1977a). The mixture, adjusted to 40% moisture, was fermented at 28 C in flasks tumbled at 0.6 rpm. The pH decreased from 6.5 to 4.5 in about 24 hr. Coliform bacteria indigenous to the slurry, and present in the waste-feed mixture at 100 thousand/g of mixture, were destroyed in 36 hr. A scaled-up study conducted under similar conditions showed that when the initial pH of the feed mixture was 7.3, the pH decreased to 5.1 after 36 hr of fermentation. Under these conditions coliforms were not destroyed (Weiner 1977b). However, when the pH decreased to 4.5, coliforms were destroyed. A mixture of swine waste and corn inoculated with fecal coliforms, Salmonella derby and Treponema hyodysenteriae and fermented at 30 C for 1 day achieved pH 4.1 (Weiner 1984). Salmonella derby was killed after 8 hr, T. hyodysenteriae in 1 day and the fecal coliforms were destroyed after 2 days.

Swine waste ensiled with corn grain achieved lower pH values than swine waste ensiled with ground orchard grass hay (Berger et al. 1981). Total and fecal coliforms indigenous to the mixtures were killed in all waste-corn mixtures after ensiling for 42 days. Fecal coliforms were destroyed in the waste-hay mixtures but coliforms persisted. Sutton et al. (1980) also evaluated the ensiling process to ensure the elimination of potential bacterial pathogens in a swine manure-chopped whole corn plant forage mixture (26:74 blend, dry basis). The mixture had 68% moisture, and after ensiling achieved pH 4.4. Indigenous total and fecal coliforms were not viable after 4 days, and salmonellae and fecal streptococci were not detected after 1 wk. In a similar study swine manure and chopped whole corn plant ensiled in a 6-ton bunker silo achieved pH 4.4. Total coliforms, fecal coliforms, salmonellae, and fecal streptococci were not viable after the mixture fermented 6 days.

Broiler chicken litter has been used more extensively as a feed ingredient than other types of animal wastes. Litter has higher levels of N, P and Ca than cattle waste (Fontenot et al. 1983). A survey of 31 samples of litter collected in north and central Alabama showed the following average analysis (dry basis): C.P. 23.9 %, Ca 2.1 % and P 1.6 % (Ruffin and Martin 1981). Due to the high pH and high acid buffering capacity of broiler litter, silages with litter do not achieve low pH values as do cattle and swine manure silages. Broiler litter has a pH of about 8.0 to 8.5, and after litter-feed mixtures are ensiled the pH decreases to about 5.0 to 5.5. Caged layer waste feed mixtures have similar ensiling characteristics (Grotheer et al. 1981). However, fecal coliforms and salmonellae are killed in broiler litter feed mixtures following ensiling (Caswell et al. 1978; McCaskey and Wang 1985). Mycobacteria are more tolerant of acidic conditions than enteric bacteria. Mycobacteria, inoculated into a broiler litter feed mixture, were not killed after the mixture fermented 15 days (McCaskey and Wang 1985). In ensiled chopped whole corn plant forage and in an ensiled cattle manure feed mixture mycobacteria were killed in 5 days. Because mycobacteria are more tolerant of acidic conditions than fecal coliforms and salmonellae, more research is needed to ensure the destruction of these bacteria in broiler litter silages if fermentation treatment of litter is advocated.

Deep stacking is a method commonly used to destroy potential pathogens in broiler litter. Litter stacked in a pile undergoes spontaneous heating and temperatures over 60 C are achieved and maintained for several days. Enteric pathogens are killed within a few minutes at 60 C. Broiler litter inoculated with Escherichia coli and Salmonella typhimurium was rendered free of these bacteria by heating the litter to 60 C in a simulated feed pellet mill (McCaskey and Harris 1982). Treatment of broiler litter by deep stacking should destroy mycobacteria since these bacteria do not survive the mild heat process used to pasteurize milk (71.7 C for 15 sec. or 62.8 C for 30 min.). Composting caged layer manure, a heat generating process, also destroys salmonellae and other enteric bacteria (Dobson et al. 1984).

Animal manures also have been evaluated as a source of nutrient enrichment in fish ponds for the production of tilapia (Collis 1979; Nerrie 1979; Kartamulia 1983), and for production of silver carp and tilapia in co-culture (Behrends et al. 1980). The use of manure in aquaculture has been practiced for centuries in the far east and in parts of the world where fish constitute an important economical source of food protein.
Many of the potential health concerns associated with the feeding of animal manures to livestock are evident also in integrated animal waste fish farming practices. Salmonella typhimurium inoculated into pools of tilapia fertilized with swine manure survived in the pools and in the fish for 16 days but not 32 days (Baker et al. 1983).

Microalgae cultivated in dilute animal waste has potential as a high protein (50 % C.P., dry basis) feed for livestock. Effluent from an anaerobic swine manure lagoon has been evaluated as substrate for production of algal biomass in a shallow multi-channel system. The algal biomass, mainly species of Chlorella and Mondus, was harvested from the system by chemical flocculation and autoflocculation. The algal system reduced fecal coliforms in the lagoon effluent by 90 to 99 % (Lincoln, 1981). A more immediate health risk than potentially pathogenic enteric bacteria was the periodic dominance of a coccoid cyanobacterium, Synechocystis sp, in the algae production system. When Synechocystis was fed to broiler chicks as 10-20 % of their diet high mortality resulted. Whereas, a diet containing 16.5 % (by wt.) of the algae fed to swine showed no signs of toxicity. Injection of the toxic strain I. P. at 1000 mg/kg body weight into mice was lethal in all cases (Lincoln and Carmichael 1981).

MINERALS AND HEAVY METALS

Heavy metals and other minerals in waste from animals fed high dietary levels of minerals might cause elevated levels of these minerals in tissues and products of animals fed recycled wastes. Arsenicals (As) and copper (Cu) deserve special consideration because they are commonly found in broiler litter and other animal wastes at levels that might result in elevated levels in animals fed litter. Earlier studies dealing with this potential problem were reviewed by Fontenot and Webb (1975) and McCaskey and Anthony (1979).

Dehydrated poultry manure from caged laying hens fed at 17 % of the diet (dry basis) to lactating dairy cows for 210 days did not increase levels of Cu, Fe, Zn, Cd, and Ni in the milk (Calvert and Wheeler 1979). Arsenic (as arsanilic acid and 3-nitro-4-hydroxyphenylarsonic acid) fed in diets to sheep and lactating dairy cows increased As content in liver, kidney and blood of the sheep as the level of As in the diet increased from 25.9 to 274.1 g/kg dry matter (Calvert and Smith 1980). Arsenic in muscle tissue of sheep was unaffected, and levels in all tissues were depleted within 6 days after As was withdrawn from the sheep diets. High As levels were observed in milk of cows fed 3.2 or 4.8 mg As/kg body weight as arsanilic acid or 3-nitro-4-hydroxyphenlyarsonic acid. Arsenic fed continuously in the diet to cows for 28 days increased the As level in the milk during the first 14 days of the study, and then the level plateaued. The As level decreased to pre-experiment levels after a 5-day as withdrawal period.

A profile of 43 minerals in tissues of heifers fed diets containing 30 % broiler litter ensiled with 70 % corn for 201 days was reported by Westing et al. (1980). Litter used in the diets contained 593 ppm Cu and 76 ppm As. Liver, kidney and rib muscle samples collected from the heifers 24 hr after withdrawal from the litter-silage ration increased liver Cu 2.3 times, and the liver As level was lower for heifers fed litter compared to heifers fed a control diet of corn silage and supplemental protein. Kidney Cu was 1.6 times higher and the kidney As level was 3 times higher for heifers fed the litter silage than the control diet. Levels of Cu and as in rib muscle were similar for heifers on both diets. Steers fed a diet containing either 12.5 or 25% of dried cage layer manure had increased Ca in muscle, Ca in liver, and Mg and P in kidney, but decreased Fe in kidney (Vijchulata et al. 1980). Arsenic in kidney and muscle increased when caged layer manure was fed to the steers for 126 days. However, As, Pd, Cd and Hg did not accumulate to levels that might be harmful to ruminants.

Copper toxicity is a problem with sheep fed broiler litter because sheep cannot regulate dietary Cu and it accumulates to toxic levels in the liver (Fontenot and Webb 1975). Olson et al. (1984) evaluated the effects of supplemental feeding of molybdenum and sulfate to sheep on liver Cu levels of ewes fed broiler litter with a high Cu level. Liver Cu level continually increased during feeding of broiler litter, but liver Cu was decreased by supplementing the sheep diet with Mo and SO_4. Although there were no acutely toxic affects of feeding high Cu broiler litter to nongestating ewes, broiler litter or other wastes containing high levels of Cu is not recommended as a safe feed for sheep. Supplementing litter diets for ewes with Mo and SO_4 might prevent accumulation of dangerous levels of Cu, but more research is needed to determine optimal levels of these supplements. Copper toxicity is not a problem with beef brood cows fed broiler litter. Beef brood cows fed grain mixtures with 80 % broiler litter with and without added Cu in wintering diets for nine years showed no evidence of abnormalities (Webb and Fontenot 1975). Liver Cu levels increased in the spring due to broiler litter in the winter diets, but the Cu levels were depleted by the fall of the year.

Swine manure solids ensiled with corn forage at 14 % of the forage dry matter was fed to sheep in finishing diets (Sutton et al. 1981). Liver Fe and kidney Fe levels were increased in lambs fed the wastelage diet, but kidney Cu and Zn levels and liver Zn were lower in lambs fed wastelage compared to the control corn silage diet. Liver Cu levels tended to be elevated with the feeding of wastelage. In other research, swine manure solids ensiled with corn forage at 20 % and 27 % of the dry matter was fed to beef cattle in finishing diets (Sutton et al. 1983;1984). When Cu in the wastelage mixture was 59 or 275 ppm (dry matter basis), liver Cu in cattle was increased reflecting dietary Cu levels. Copper in muscle, fat and kidney were not affected by diet. Iron in liver and kidney were higher for the waste fed cattle compared to the controls. Other minerals analyzed in tissues (fat, kidney and muscle) were not affected by feeding swine manure solids.

Cattle manure from a commercial feedlot added to a diet at 0, 20, 40 and 60 % of the roughage was fed to cattle over 124 days (Richter et al. 1980). Mercury, Pb, Cd, Ni, Cu, and Fe levels were not increased in any of the diets or in the muscle, liver and kidney of the cattle fed the manure diet. Cattle manure residue from a large scale thermophilic methane generator was fed to feedlot cattle (Harris et al. 1982). There were no effects of the manure residue on the Hg, Pb, Cd, As, Ni, Cu, Zn, Fe, Co or Mn in muscle, liver or kidney tissues of the cattle fed the diets.

Sewage sludge was fed at 0, 10, or 20 % air and sun dried weight levels in diets to gestating sows (Beaudouin et al. 1980). The sows were fed their respective diets through two parities and their offspring were maintained on similar treatment diets from weaning until market. There was no increase in Pb, Cd, Ni, Zn, Cr, Cu, Mn, Fe, and Al in sow's milk or blood. However, liver Cu, Cr, and Ni; kidney Cd, Ni, Zn and Al; spleen Ni, Cr and Al; and muscle\Ni, Cr, and Al of the sows fed the sludge for two parities were higher than the control. Weanling pigs from sows fed the sludge had increases in some of the elements measured in tissues, however, the increases in mineral content in the tissues were not consistent between the two litters.

DRUGS AND METABOLITES

Recycling drugs or their metabolites in wastes of animals administered drugs to animals fed these wastes, might cause concern if these biological agents appear in tissues and products of the recipient animals. Feeding waste to the same animal species, or from one species to another species which have legal tolerances for a drug, was one approach that has been considered to avoid illegal residues in tissues of animals fed recycled waste. Another approach to minimize drug residues would be to refeed only wastes certified by testing to be free of drugs or use wastes from animals that have not been administered drugs. Wastes from lactating dairy cows would be a good candidate for the latter consideration. Animal wastes known to contain drugs and fed to species that have no legal tolerances for the drugs, pose a potential risk to the public who consume the tissues and products of these waste-fed animals.

Yet another approach has been to determine the clearance time for a drug or its metabolites from the tissues of animals fed drug containing wastes. This option would be limited to animals not immediately destined for slaughter. Some state feed laws specify withdrawing wastes from diets of animals 15 days before marketing the animals for food use. The issue of drug residues in animals fed wastes has not been resolved because this area of research presents formidable tasks which public-supported laboratories have neither the resources nor funds to undertake. This area of research might best be accomplished by animal drug manufacturers or their allied laboratories. An earlier report on medicinal drug residues in animal waste and in tissues of animals fed waste was published by Webb and Fontenot (1975). During the term of the S-139 cooperative project one drug study was conducted to determine the fate of halofuginone, an experimental coccidiostat, when waste from chickens fed the drug was fed to laboratory rats and sheep (Fontenot 1985). Waste from chickens administered ^{14}C labelled halofuginone was ensiled with rat chow and fed to rats for 6 days. During the feeding period fecal excretion of the drug, expressed as per cent of intake, increased to 69.6 % on day 3, then decreased to 59.4 % by day 6. Excretion through urine was 14.2 % and through respired CO_2 1.4 % on day 6. After a 5-day withdrawal period from the drug containing diet, tissues of the rats were analyzed for levels of halofuginone and its metabolites. They were not detected in any tissue except the kidney, and this level was very low. After a 10-day withdrawal ^{14}C values in tissues of rats fed poultry waste containing the drug were not different from tissues of control animals. Excreta from broilers fed a commercial diet with 12 ppm halofuginone was ensiled with ground grass hay, ground corn and dry molasses. The silage was fed to nine wether lambs to study accumulation and dissipation of the drug in ruminant tissues. The drug was detected in the feces of sheep during the feeding trial but disappeared by day 4 following withdrawal from the drug containing diet. Halofuginone was not detected in liver, kidney, muscle, omental fat or bile of sheep fed ensiled broiler excreta containing the drug.

SUMMARY

The issue of safety to animals fed animal wastes, and to humans who consume products derived from these animals, has not been fully resolved. However, studies conducted by members of the S-139 Regional Project Committee and reported here provide additional safety data on the practice of using animal waste as a feed component of animal diets.

Recycling animal wastes as a feed ingredient has caused concern for the dissemination of zoonotic diseases, but research has demonstrated that properly processed wastes are safe from potentially hazardous microorganisms such as salmonellae, *Brucella abortus*, mycobacteria and *Escherichia coli*. Animal wastes should be processed before feeding to minimize the risk of disease transmission. Processing methods that have been evaluated include fermentation (ensiling) heat treatment by pelleting and deep stacking and processing by microalgae. Fermentation and deep stacking are two of the more common methods of processing animal waste. Other methods such as direct heating

and chemical treatments have been evaluated and reported earlier (McCaskey and Anthony 1979).

The fermentation process effectively eliminates indigenous and model pathogens when the pH of the ensiled mixture of waste and feed ingredients decreases to about 4.5. Feed mixtures of whole corn plant forage or ground shelled corn with waste from beef cattle, swine or broiler chickens have been successfully fermented and demonstrated to render the feed mixtures safe from bacterial pathogens. A good fermentation can be achieved when an ample supply of carbohydrate, such as molasses or corn grain or forage, is blended with the waste and the moisture of the mixture is adjusted to about 40%.

Poultry waste is more difficult to ferment than cattle and swine waste because it has a high initial pH and high buffering capacity. Following fermentation, the pH of poultry waste-feed mixtures usually does not decrease below 5.5. However, the fermentation process destroys enteric bacteria such as Escherichia coli and salmonellae. Mycobacteria are more tolerant of acidic conditions than enteric bacteria, and these bacteria might not be eliminated. Broiler litter is usually deep stacked before it is ensiled with other feed ingredients. Deep stacked litter undergoes spontaneous heating to 60 C or more and this temperature can be maintained for a few days. Most pathogens including enteric bacteria and mycobacteria are killed in a few minutes at 60 C. Therefore, processing poultry waste by deep stacking either alone or followed by fermentation is adequate to render the waste safe from pathogens.

Animal wastes have been used as a source of dietary components for animals for over 30 years without apparent harmful effects to animals fed such diets or to humans who have consumed the products of these animals. The only documented evidence of harmful effects to animals fed animal waste (reported prior to the S-139 project) was due to copper toxicity in sheep fed broiler litter with high copper levels (Webb and Fontenot 1975).

Sheep are less tolerant of dietary copper than cattle, and the problem can be remedied by not feeding diets to sheep that contain broiler litter or other feed ingredients known to have high copper levels. Beef brood cows fed grain mixtures with 80% broiler litter with and without added Cu in wintering diets for nine years showed no evidence of abnormalities. Supplementing litter diets for ewes with Mo and SO_4 might prevent accumulation of dangerous levels of Cu, but more research is needed to determine optimal levels of these supplements (Olson et al. 1984).

Arsenic and arsenicals that are permitted in broiler chicken diets do not appear to be a problem when broiler litter is fed in diets to cattle. At the level of arsenic (.2 to 76.3 ppm) reported in broiler litter (Webb and Fontenot 1975), the feeding of broiler litter at 25% of the diet to lactating dairy cows is not likely to affect the arsenic content of milk (Calvert and Smith, 1981). Withdrawal periods from feeding animal waste have been shown to reduce elevated mineral levels of tissues to normal levels. However, feeding waste to lactating dairy animals is discouraged because safety of milk achieved by withdrawal of waste from diets of these animals for a period of time prior to marketing the milk cannot be achieved practically.

A solution to the potential risk of elevated levels of minerals in tissues and milk of animals fed animal waste might be to monitor levels of certain minerals such as copper and arsenic in broiler litter. From research data currently available a safe upper limit for these and other minerals in manure-feed diets perhaps could be established.

The concern for drugs and drug metabolites in waste of animals administered drugs, and the potential risk the drugs might have on animals fed such wastes and to the consumers of products derived from these animals, is still an unresolved issue. Residues of antibiotics and coccidiostats are present in broiler litter as the result of these medicinals being fed to broilers. However, when litter containing these drugs was fed to cattle, there was no problem with tissue residues following a 5-day withdrawal of litter from the cattle diet (Webb and Fontenot 1975). Studies with an experimental coccidiostat, halofuginone, fed in broiler waste to laboratory rats and to wether lambs showed no residues of halofuginone or its metabolites in tissues of rats after a 10-day withdrawal period, or in tissues of the lambs after a 4-day withdrawal period from the drug-containing diet.

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Acknowledgement: Other contributors to the S-139 Regional Project are: W. B. Anthony, B. G. Ruffin (AL); J. B. Martin, Jr., L. L. Behrends NFDC-TVA (AL); R. L. Shirley, M. F. Richter, C. B. Ammerman (FL); E. T. Kornegay, K. E. Webb, Jr., T. W. Westing (VA); G. R. Hrubant, B. A. Weiner USDA-NRRC (IL); C. C. Calvert, L. W. Smith USDA-BARC (MD); N. P. Thompson, Administrative Advisor to S-139 (FL).

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A Survey of Broiler Litter Composition and Potential Value as a Nutrient Resource

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(Received 21 August 1989; revised version received 12 March 1990; accepted 16 March 1990)

ABSTRACT

Broiler litter can serve as a source of nutrients for plants and ruminant animals. Analyses of litter samples collected from 106 sources in Alabama showed that the nutrient content of litter varies widely. Litter nitrogen averaged 4·0% (24·9% crude protein (CP)), but ranged from 2·3% (14·4% CP) to 6·0% (37·5% CP). Phosphorus averaged 1·56% and potassium 2·32% of dry matter. The average N:P:K ratio of the litter was 3:3:2. Ash was extremely variable, ranging from 8·9% to 64·3%, and averaging 24·7%. Ash content was higher ($p < 0{\cdot}05$) in samples taken after the litter was removed from the broiler house (28·6%) than in samples taken directly from the broiler house (20·2%). Nitrogen and acid detergent soluble nitrogen were negatively correlated ($p < 0{\cdot}01$) with ash, while acid detergent fiber and most minerals were positively correlated with ash. At current prices, average quality broiler litter in Alabama is valued at US\$113.67 Mg^{-1} (US\$104.95 Imperial ton^{-1}) as a potential low-cost feed ingredient for lactating beef cattle and US\$31.23 Mg^{-1} (US\$27.59 Imperial ton^{-1}) as a fertilizer.

INTRODUCTION

One of the major problems facing modern agriculture is the large amount of waste products generated by intensive animal production. These wastes are

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generally considered to be a liability with little economic value. However, these wastes contain nutrients that could be substituted for more costly nutrients used in production agriculture. Due to environmental constraints associated with the management of animal wastes and the need for economy in agricultural production systems, more attention has been focused on the potential resource value of these wastes. Poultry wastes contain higher concentrations of nitrogen, calcium and phosphorus than wastes of other animal species, and the potential value of poultry wastes as a source of these nutrients provides more incentive for the utilization of this resource (Fontenot *et al.*, 1983). Poultry litter is particularly well suited for use as a feed or fertilizer since it is relatively dry and essentially totally collectable.

Alabama ranks third in the US in broiler chicken production with an estimated production of 1·8 Mg ($1{\cdot}8 \times 10^3$ kg) of broiler litter annually (McCaskey & Martin, 1988). Broiler litter is a mixture of poultry excreta, feathers, wasted feed and bedding material, which in Alabama is usually pine wood shavings or peanut hulls. Broiler litter is a good source of minerals, fiber and nitrogen, which is derived from both true protein and non-protein nitrogen (NPN) (Fontenot *et al.*, 1983). The NPN is primarily uric acid, which can be converted to ammonia and assimilated by both plants and ruminant animals. The minerals in litter can be utilized by plants and animals, but the fiber is probably more valuable as a feed component for ruminants. Previous studies demonstrating the nutrient composition of animal wastes were reviewed by Bhattacharya and Taylor (1975), while the value of animal wastes as a source of nutrients for plants and animals was presented by Smith and Wheeler (1979). However, there can be considerable variability in the composition of litter (Fontenot *et al.*, 1971), which would affect its economic value.

The most important component of litter in terms of its economic value as a feed resource is nitrogen or crude protein (Smith & Wheeler, 1979). The amount of nitrogen available for assimilation by rumen microbes is, therefore, an important determinant of litter quality. The availability of nitrogen can be estimated by determining the amount of total litter nitrogen that is soluble in acid detergent fiber reagents (ADSN). The results of a previous study showed a direct relationship between this nitrogen fraction and its digestibility in rumen fluid (McCaskey *et al.*, 1988). This relationship also has been demonstrated with forages (Goering *et al.*, 1972).

Current practices of utilizing litter as a resource generally have not placed much emphasis on quantity and quality of nutrients contained in litter. Nor has there been much concern about managing this resource to maximize its value as a fertilizer or feed ingredient. How litter is managed and removed from the broiler house and how it is stored are considerations that affect the value of this resource. Because broiler litter has potential value as a fertilizer and as a feed resource, a study was conducted to survey the composition of litter collected from poultry production units in Alabama.

MATERIALS AND METHODS

A total of 106 samples of broiler litter was collected from poultry production units in 20 counties of Alabama, representing all areas of the state. Fifty-four of the samples were collected from litter which had been removed from the broiler house and stored in stacks for various periods of time. This is a common method of litter storage in Alabama. Samples were taken from several locations of each litter stack, composited and a representative subsample taken for analysis. Four samples were collected from stacks which had been stacked for an unknown period of time. The remainder of the samples (48) were collected directly from broiler houses (fresh) by sampling several locations in the house and compositing. The bedding materials consisted of hardwood or pinewood shavings or sawdust and peanut hulls. All litter samples analyzed in this study were from dirt floor broiler houses.

The samples were ground in a laboratory mill to pass a 2-mm screen and mixed well. The litter was analyzed wet and the analyses were corrected to a dry basis. Analyses for dry matter (DM), ash, total Kjeldahl nitrogen (N), crude protein as N × 6·25 (CP), crude fiber (CF) and acid detergent fiber (ADF) were performed according to AOAC (1984) procedures for feeds. Acid detergent insoluble nitrogen (ADIN) was performed as described by Goering and Van Soest (1970). All the components except DM are expressed as per cent of DM, and represent the mean of triplicate analyses. Acid detergent soluble nitrogen (ADSN) was calculated by subtracting ADIN from total N. The per cent of total N in the form of ADIN is considered to be largely unavailable for digestion by ruminants (Goering *et al.*, 1972) and is designated 'bound' nitrogen (BN). Mineral analyses were performed by the Soils Testing Laboratory, Auburn University, according to procedures outlined by Hue and Evans (1986). The values are expressed as % (Ca, K, Mg, P, S) or ppm (Cu, Fe, Mn, Zn, B) of DM.

The data were analyzed by analysis of variance procedures as described by Steele and Torrie (1980). The samples were divided into five treatment categories: fresh, stacked < 30 days, stacked 30–90 days, stacked > 90 days, and charred litter. The categorization of charred litter (subjected to excessive spontaneous heating during stacking) was a subjective evaluation based on a heated appearance and odor of the litter. Tukey's test (Gill, 1978) was used to compare fresh and stacked litter and to separate treatment means for the samples that were stacked. The same test was used to detect differences in composition due to differences in bedding material. Coefficients were calculated for the correlation of the ash content with the other components in litter which had been previously removed from the broiler house and stored in stacks.

The value of litter as a feed ingredient was computed based on its use as an energy and crude protein (E + CP) source in a diet balanced to meet the NRC requirements for E + CP of a 500-kg, high-producing (10 kg milk daily) lactating beef cow (NRC, 1984). The litter diet contained 80% broiler litter and 20% corn grain (Inter. Feed No. 4-02-931) on an as-fed basis. Although litter alone would almost meet the minimum requirements for E + CP (based on the average CP of the survey litter and the ME value of poultry litter as listed by the NRC (1984)), 20% corn is recommended to improve palatability of the diet (Fontenot, 1988). The diet used for comparison contained 42·0% corn grain, 47·1% Coastal bermudagrass hay (Inter. Feed No. 1-00-716) and 10·9% soybean meal (Inter. Feed No. 5-20-637) on an as-fed basis. The value of litter as a source of plant nutrients was based on its content of N, P (as P_2O_5) and K (as K_2O). Current prices for fertilizer and feed ingredients were obtained from the Alabama Cooperative Extension Service.

RESULTS AND DISCUSSION

The average compositional analysis of 106 samples of broiler litter collected in Alabama is shown in Table 1. Crude protein (N × 6·25) is one of the more valuable components of litter when it is considered as a feed ingredient for beef cattle. The CP of the samples surveyed averaged 24·9% and ranged from 14·4% to 37·5%. Bound nitrogen (BN), which is acid detergent insoluble nitrogen (ADIN) expressed as a per cent of total N, averaged 15% and ranged from 5·1% to 64·3%. Litter nitrogen that is soluble in acid detergent reagent (ADSN) averaged 3·4%, and ranged from 1·6% to 5·7%. As the ADSN decreases, the digestibility of the litter also decreases (McCaskey *et al.*, 1988). Therefore, proper management of litter to minimize the deterioration of crude protein should be considered when litter is to be used as a feed ingredient. However, the effect of ADSN on the availability of N as a plant nutrient is not known.

Crude fiber in litter is principally derived from the bedding material used in broiler houses. The CF of broiler litter has value in beef cattle diets as a substitute for hay and other sources of dietary fiber. As a soil amendment, fiber probably increases the water holding capacity of soil. However, nitrogen is required for the decomposition of fiber which ties up soil nitrogen for a period. Therefore, the CF of broiler litter has more economic value

TABLE 1
Proximate Analysis of Broiler Litter Collected in Alabama[a]

Component	*Minimum*	*Maximum*	*Mean (SE)*
Dry matter (%)	61·0	95·3	80·5 (0·58)
% of dry matter			
Nitrogen	2·3	6·0	4·0 (0·72)
Crude protein[b]	14·4	37·5	24·9 (0·45)
Acid detergent			
Fiber	18·0	69·1	41·1 (1·08)
Insoluble nitrogen	0·1	3·4	0·6 (0·05)
Soluble nitrogen	1·6	5·7	3·4 (0·02)
Crude fiber	10·8	51·6	23·6 (0·81)
Ash	8·9	54·4	24·7 (0·89)
Bound nitrogen[c]	5·1	64·3	15·0 (1·06)
Minerals			
% of dry matter			
Ca	0·81	6·13	2·31 (0·082)
K	0·73	5·17	2·32 (0·059)
Mg	0·19	0·88	0·52 (0·014)
P	0·56	3·92	1·56 (0·047)
S	0·22	0·83	0·50 (0·013)
ppm of dry matter			
Cu	25	1 003	473 (22·7)
Fe	529	12 604	2 377 (262·7)
Mn	125	667	348 (12·9)
Zn	106	669	315 (13·0)
B	23	125	54 (1·7)

[a] Minimum, maximum, mean and standard error of the mean for 106 samples.
[b] %N × 6·25.
[c] Nitrogen associated with the acid detergent insoluble fraction expressed as a percentage of total nitrogen.

when litter is used as a feed ingredient than when used as a fertilizer or soil amendment. The survey showed that litter collected in Alabama contained an average of 23·6% CF, and ranged from 10·8% to 51·6% (Table 1).

The ash content of the litter varied widely and was likely related to soil contamination of the litter when the litter was removed from dirt-floor broiler houses. The average ash content of litter in Alabama was 24·7%, and ranged from 8·9% to 54·4% (Table 1). The principal minerals contained in the ash were Ca, K, P, Mg and S. The average Cu concentration in the litter was 473 ppm, and ranged from 25 to 1003 ppm. The copper is derived from broiler feed and is voided by the broilers. Sheep are especially sensitive to excessive quantities of Cu in their diets, however beef cattle can tolerate higher levels of copper (Fontenot & Webb, 1975).

TABLE 2
Composition of Fresh Litter and Litter Stacked for Various Periods of Time[a]

Source	*n*	*Ash*	*N*	*ADIN*	*BN*
Fresh[b]	48	20·2 (1·2)[e]	3·77 (0·10)[e]	0·40 (0·04)[e]	11·2 (0·8)[e]
Stacked[c]	54	28·6 (1·1)[f]	4·14 (0·10)[f]	0·78 (0·04)[f]	18·6 (0·8)[f]
Days stored in stack:					
<30	13	31·5 (2·3)	3·78 (0·20)	0·39 (0·08)[e]	10·4 (1·6)[e]
30–90	15	28·1 (2·2)	4·27 (0·19)	0·55 (0·07)[e,f]	12·8 (1·5)[e,f]
>90	18	26·2 (2·0)	4·16 (0·17)	0·70 (0·06)[f]	16·8 (1·4)[f]
Charred[d]	8	30·0 (3·0)	4·42 (0·26)	2·10 (0·10)[g]	46·6 (2·0)[g]

[a] Ash, nitrogen (N) and acid detergent insoluble nitrogen (ADIN) are expressed as % of dry matter. Bound nitrogen (BN) is % of N as ADIN. Standard error of the means are indicated in parenthesis.
[b,c] Litter collected from broiler houses and litter stored in stacks.
[d] Litter stored in stacks which had excessively heated to the point of charring.
[e,f,g] Comparisons of means were made for fresh vs stacked litter and treatments within stacks (days and charred). Means in the same column of each comparison group followed by different letters differ ($p < 0.05$).

There were only minor differences in composition between litter based on the different bedding materials. Wood-based litter tended to be slightly higher in both CF and ADF than peanut hull-based litter.

The composition of litter before and after removal from the broiler house is shown in Table 2. Ash was significantly higher ($p < 0.05$) for litter that was removed from the broiler house and stacked (28·6%) as compared to fresh litter collected from broiler houses (20·2%) The N content of the stacked litter was higher ($p < 0.05$) than the fresh litter, but there was also an increase in the ADIN of stacked litter ($p < 0.05$). Litter than had excessively heated in the stack (charred) had a higher ADIN (2·1%) compared to non-charred litter (<0·71%). These significant differences are also evident in the levels of BN. Fresh litter had 11·2% BN, stacked litter 18·6%, and charred litter had 46·6% of its nitrogen bound to the ADF fraction. Storage of litter for 90 days or more increased ($p < 0.05$) the amount of ADIN and BN over litter stored for 30 days or less. Storage time did not significantly affect the ash nor the total N content of the litter.

As shown in Table 2, soil contamination during removal of litter from broiler houses contributes a significant amount of ash to litter. Ash acts as a diluent and thus could be expected to correlate with lower amounts of most of the proximate components and higher concentrations of minerals. This fact is verified by the data in Table 3. The proximate and mineral analyses for the samples obtained from stacked litter were correlated with ash. Nitrogen

TABLE 3
Correlation of Ash Content with Other Litter Components[a]

Component	*Correlation coefficient* r	*Standard error*
Dry matter	−0·174	0·132
Nitrogen	−0·482**	0·117
Acid detergent		
Fiber	0·326*	0·126
Insoluble nitrogen	−0·127	0·133
Soluble nitrogen	−0·334**	0·126
Crude fiber	−0·204	0·131
Bound nitrogen	−0·078	0·133
Ca	0·365**	0·124
K	0·300*	0·127
Mg	0·012	0·134
P	0·293**	0·128
S	0·040	0·134
Cu	0·205	0·131
Fe	0·487**	0·117
Mn	0·294*	0·128
Zn	0·306*	0·127
B	0·586**	0·108

[a] Correlations were performed on litter components for those samples ($n = 58$) which had been removed from broiler houses and stacked.
* $p < 0{\cdot}05$; ** $p < 0{\cdot}01$.

and ADSN were negatively correlated ($p < 0{\cdot}01$) with ash due to dilution. Other components, DM, CF, ADIN and BN, tended to be lower as ash level increased. Acid detergent fiber was positively correlated with ash ($p < 0{\cdot}05$) because the ADF analysis also includes ash which is insoluble in acid detergent reagents. A decrease in ADSN and an increase in ADF would tend to decrease the digestibility of litter. All the minerals were positively correlated with ash, with Ca, Fe and B being the most significant. This indicates that soil contamination accounts for a significant part of the mineral content of litter. However, gains in mineral content are offset by the detrimental effect of increased ash on other litter components.

The estimated economic value of average quality broiler litter in Alabama, based on its use as a fertilizer or feed ingredient, is shown in Table 4. An 80:20 mixture of broiler litter and corn will meet the daily energy and crude protein (E + CP) requirements of a 500-kg, high-producing (10 kg milk daily) lactating beef cow (NRC, 1984). A ration of 42·0% corn grain, 47·1% Coastal bermudagrass hay (CBH) and 10·9% soybean meal (SBM)

TABLE 4
Estimated Replacement Value of Broiler Litter[a]

Use	*Component replaced*	*Amount replaced* (*kg Mg*$^{-1}$ (*lbs ton*$^{-1}$))[c]	*Dollar value* (*US\$ Mg*$^{-1}$ (*US\$ ton*$^{-1}$))[c]
Fertilizer	Nitrogen	32·2 (64·4)	17·60 (15·36)
	P_2O_5	28·9 (57·8)	6·96 (6·38)
	K_2O	22·5 (45·0)	6·67 (5·85)
	Total		31·23 (27·59)
Feed[b]	Corn	275 (550)	33·00 (30·94)
	Soybean meal	136 (273)	39·44 (36·31)
	Coastal hay	589 (1 178)	41·23 (37·70)
	Total		113·67 (104·95)

[a] Based on current local prices of nitrogen (US\$0·55 kg^{-1}), P_2O_5 (US\$0·24 kg^{-1}), K_2O (US\$0·29 kg^{-1}), corn grain (US\$0·12 kg^{-1}), soybean meal (US\$0·29 kg^{-1}) and Coastal bermudagrass hay (US\$0·07 kg^{-1}).
[b] Based on a ration containing 80% broiler litter and 20% corn as compared to a ration containing 42·0% corn, 47·1% Coastal bermudagrass hay and 10·9% soybean meal, as-fed basis.
[c] ton = Imperial ton (2000 lbs).

also will meet the E + CP requirements of the same cow. By using an 80:20 mixture, all the SBM (109 kg) and CBH (471 kg), as well as 220 kg of corn, can be replaced with litter in each Mg of the ration. These amounts were divided by 0·8 to put the weights on a basis of kg Mg^{-1} of litter. The value of the corn replaced was US\$33.00, SBM was US\$39.44 and CBH was US\$41.23 Mg^{-1}. This gave a total replacement value of the broiler litter as a feed ingredient of US\$113.67 Mg^{-1}. This compares favorably with the value of litter for a lactating beef cow (US\$125 Mg^{-1}) reported by Smith and Wheeler (1979).

The value of broiler litter as a fertilizer was calculated based on its content of N, P (as P_2O_5) and K (as K_2O). Litter collected in this survey had an average N:P:K ratio of about 3:3:2 on an as-is basis. As shown in Table 4, the value of the litter nitrogen was US\$17.71, P was US\$6.96 and K was US\$5.85 Mg^{-1}. Thus, the total fertilizer value of average broiler litter was US\$31.23 Mg^{-1}. Smith and Wheeler (1979) reported a value of US\$26.14 Mg^{-1} for broiler litter used as a fertilizer.

This survey indicates that while the nutrient composition of litter varies considerably, average (or better) quality litter has considerable economic value when used as a feed ingredient for beef cattle or as a fertilizer.

However, due to the variability in composition of litter, proximate analyses should be performed on the litter prior to its use.

ACKNOWLEDGEMENT

This study was supported in part by the Alabama Agricultural Experiment Station and by the Agricultural Research Department, Tennessee Valley Authority, Muscle Shoals, Alabama.

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FACTORS THAT INFLUENCE THE MARKETABILITY AND USE OF BROILER LITTER AS AN ALTERNATIVE FEED INGREDIENT

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Animal wastes have long been recognized as sources of nutrients that have value when the wastes are used as fertilizer or as alternative feedstuffs. Recycling the nutrients of animal wastes is important for two reasons. In recent years there has been a trend toward low-input sustainable agriculture. This trend has focused attention on animal wastes as sources of nutrients that can substitute for more costly sources of nutrients. When wastes are used as resources, the economic benefit derived from the wastes can help offset costs, that are generally regarded to be excessive, necessary to comply with environmental guidelines. The second reason to recycle animal wastes is to manage the wastes in an environmentally sound manner that minimizes the impact of the waste on surface and ground water supplies. Animal wastes that have economic value as recyclable sources of nutrients are also sources of pollutants to the environment. Therefore, animal wastes can be a resource or a liability depending on how they are managed.

OBJECTIVES OF THE STUDY

The objectives of this study were to: a) determine the extent of marketing of animal wastes in the U.S. as a fertilizer and as a feed ingredient, b) focus attention on broiler poultry litter as the major animal waste in Alabama that has potential for marketing as a resource, and c) suggest guidelines, based on research data, for broiler litter intended to be marketed as a resource, especially as a feed ingredient.

In past years, several attempts have been made to develop commercial processes for the marketing of animal wastes as a fertilizer, a soil amendment and as an alternative feed ingredient for ruminant animals. To determine the extent of this industry, a questionnaire was prepared and mailed to all the state departments of agriculture in the U.S. One part of the questionnaire was devoted to the marketing of animal wastes for fertilizer use and the other part focused on the marketing of waste as a feed ingredient.

SURVEY OF STATE DEPARTMENTS OF AGRICULTURE

Forty-seven responses were received from the 50 states queried in late 1989 relative to the marketing of animal wastes as a fertilizer (Table 1). Thirty-seven of the states had regulations pertaining to the utilization and/or marketing of animal wastes, and 29 of those required registration or licensing of the operation. In those 29 states, about 500 firms were

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This manuscript was published in the Proceedings of the Sixth International Symposium on Agricultural and Food Processing Wastes, held December 17-18, 1990, Chicago, Illinois, as ASAE Publication 05-90:197-203.

licensed to market animal wastes as a fertilizer, and the tonnage of waste sold was estimated to be 136,000 metric tons annually. The tonnage of animal wastes that is marketed is likely to be much higher because transactions among sellers and users, particularly on a private basis, are not likely to be reported to the state departments of agriculture.

Table 1. Responses of State Departments of Agriculture Relative to Marketing of Animal Wastes as Fertilizer

Number of state responses	47
Have regulations relative to marketing	37
Require product registration or licensing	29
Number of licensed firms	500
Metric tons sold annually	136,000

The 50 state departments of agriculture also were queried relative to marketing of animal wastes as a feed ingredient (Table 2). Of the 47 respondents, 45 do not prohibit the marketing or feeding of animal wastes, but two specifically prohibit the practice. Of the 45 states that do not prohibit the practice, 21 states have regulations on marketing and/or utilization of animal wastes as a feed source. Nineteen of the 21 states with regulations patterned their regulations based on the model regulations developed by the Association of American Feed Control Officials (AAFCO 1983). Seventeen of the 21 states with regulations require product labeling that indicates minimum and maximum levels of components required for marketing animal wastes as a feedstuff. The survey indicated that there are 10 firms licensed to market animal wastes as a feed in the 21 states with regulations. The tonnage of animal wastes actually used as feed is difficult to determine because most of the wastes that are used for feeding are not sold through commercial operations. In most cases the waste is purchased locally, directly from a producer, and usually at a nominal cost. Most states that regulate the marketing of animal wastes do not regulate on-farm use of the wastes. In 1979 it was reported that ten states had regulations that permitted the marketing of animal wastes as a feed ingredient (Taylor and Geyer 1979). This survey indicates that there are now 21, and four additional states are considering the adoption of regulations to permit the marketing of animal wastes as a feedstuff.

Table 2. State Departments of Agriculture Responses on Marketing and Utilization of Animal Wastes as Feed Ingredients

Number of state responses	47
Prohibit utilization as feed	2
Do not prohibit utilization as feed	45
Have regulations on marketing as feed	21
Considering regulations	4
Regulations follow AAFCO[a] guidelines	19
Regulate on-farm use as feed	6
Require stated guaranteed analysis	17
Number of licensed firms	10

[a]Association of American Feed Control Officials

In Alabama, animal wastes intended to be marketed as a fertilizer or as a feedstuff are regulated by the State Department of Agriculture and Industries (Lane 1981). The animal waste that has received the most attention as a potentially marketable product is broiler poultry litter. Alabama ranks third in the U.S. in broiler chicken production, with an annual production of broiler litter estimated at 1.8 million metric tons (McCaskey et al. 1989). During the drought of 1986-1988, when feedstuffs were in short supply, litter was viewed as an alternative feed ingredient for beef cattle. In recent years, the concern over environmental quality also has focused attention on all animal wastes, and especially broiler litter, as a contributor to surface and ground water pollution. These concerns have stimulated some entrepreneurs to develop strategies to market broiler litter as a fertilizer, soil amendment or as a low-cost, alternative feed ingredient. In most cases, little attention has been focused on the composition or quality of litter, and the effects of litter management practices on the intended use of this resource. Regulations imposed by state departments of agriculture for sale of broiler litter and other types of animal wastes set broad limits for acceptable composition. The product must be labeled to indicate minimum and maximum concentrations of litter components based on its use as a fertilizer or as a feed ingredient. For example, in Alabama broiler litter offered for sale as a feed ingredient must not contain more than 45% ash. However, litter with less ash would be preferred as a feed ingredient. In addition to the maximum allowable ash, the seller must declare with the State Department of Agriculture and Industries that all lots of the litter that are offered for sale will not exceed a level of ash which the seller claims on the label for the product. Therefore, current practices permit the sale of broiler litter and other types of animal wastes with a wide range of composition.

SURVEY OF BROILER LITTER COMPOSITION

A study was conducted to determine the average composition of broiler litter in Alabama. Litter samples were collected from 106 farms over the state and analyzed for a variety of components to assess the potential value of the litter as a feed resource. The analyses were performed according to procedures in AOAC (1980). The average dry matter content of the 106 samples of litter was 80.5% (Table 3). Expressed on a dry weight basis, the ash averaged 24.7%, nitrogen (N) 4.0%, crude protein (CP) 24.9% and crude fiber (CF) 23.6%. Acid detergent fiber (ADF), which includes all components of litter that are not soluble in acid detergent, including ash, averaged 41.1% of the dry weight of the litter. Nitrogen associated with the ADF (Goering and Van Soest 1970), which is insoluble and termed here as acid detergent insoluble nitrogen (ADIN), averaged 0.6%. Acid detergent soluble nitrogen (ADSN) ranged from 1.6 to 5.7%. When ADIN was expressed as a percent of the total litter N it was termed "bound" nitrogen (BN). The average BN content of the 106 samples of litter was 15%. Dry matter disappearance *in vitro* (IVDMD) was performed on the litter samples (Tilley and Terry 1963) to determine their solubility in bovine rumen fluid during a 48-hour incubation period. This test was used as a crude index to determine the digestibility of the samples by cattle. The average IVDMD of the litter samples was 40.9, which indicates that approximately 41% of the dry matter in the litter samples was solubilized in rumen fluid in 48 hours.

Table 3. Composition of 106 Broiler Litter Samples

	Average	Range
DM	80.5	61.0 - 95.3
Ash	24.7	8.9 - 54.4
N	4.0	2.3 - 6.0
CP	24.9	14.4 - 37.5
CF	23.6	10.8 - 51.6
ADF	41.1	18.0 - 69.1
ADIN	0.6	0.1 - 3.4
ADSN	3.4	1.6 - 5.7
BN	15.0	5.1 - 64.3
IVDMD	40.9	9.0 - 77.0

It has been recommended that litter intended to be used as a feed ingredient should have less than 30% ash, 3.0% or more N (18.8% crude protein) and not more than 25% of the N should be bound (McCaskey et al. 1989). When the 106 litter samples were categorized into those that met all three compositional criteria and those that did not, 66 of the samples (62.3%) would have had acceptable quality as a feed ingredient and 40 samples (37.7%) would have been unacceptable (Table 4). The ash content of the 66 samples of litter that met all three compositional criteria averaged 21.0% versus 30.9% for those that did not. Crude protein was 26.1% versus 22.8% and bound nitrogen was 11.5% versus 20.6%. The average composition of the litter samples that met all three criteria also showed other compositional improvements such as lower CF, ADF, and a higher IVDMD value compared to the average analysis of those samples that did not meet the criteria.

Table 4. Classification of Broiler Litter Based on Compositional Criteria as a Feed Ingredient

Component	All samples (n=106)	Samples meeting 3 criteria[a] (n=66)	Samples not meeting 3 criteria[a] (n=40)
DM	80.5	79.6	82.1
Ash	24.7	21.0	30.9
N	4.0	4.2	3.7
CP	24.9	26.1	22.8
CF	23.6	23.0	24.7
ADF	41.1	35.6	50.2
ADIN	0.6	0.5	0.8
ADSN	3.4	3.7	2.9
BN	15.0	11.5	20.6
IVDMD	40.9	44.3	35.0

[a] Litter quality criteria (<30% ash, >3.0% N and <25% BN)

The data in Table 3 indicate that high ash content is a problem with much of the litter in Alabama. Nearly all the broiler chickens produced in Alabama are reared on dirt-floor broiler houses. When litter is removed from the houses, soil contamination of the litter is possible. The ash content of litter in broiler houses prior to litter cleanout is 15 to 18% of the dry matter. Therefore, ash contents above 18% are indicative of litter contaminated with soil. Of the 106 litter samples analyzed for composition, 48 were collected from broiler houses prior to litter cleanout and 58 of the samples were collected after litter cleanout (Table 5).

Table 5. Effect of Litter Removal from Dirt Floor Broiler Houses on Compositional Criteria of Broiler Litter Acceptable for use as Feed Ingredient

Criteria	All Samples (n=106)	Before Removal (n=48)	After Removal (n=58)
	- - Percent of samples meeting criteria - -		
<30% Ash	76.4	89.6	65.5
>3.0% N	92.5	85.4	98.3
<25% BN	90.6	100.0	82.8
All three	62.3	79.2	51.7

About 76% of the 106 total samples had less than 30% ash. When the litter was categorized into those analyzed before litter cleanout and those analyzed after cleanout, 90% of the samples before cleanout had less than 30% ash, whereas 66% of those after cleanout met this criterion. Prior to cleanout, 100% of the litter samples had less than 25% bound nitrogen. After cleanout and storage for various periods of time, 83% of the samples met the criterion. When all three compositional criteria (<30% ash, >3% N, < 25% BN) were imposed on the litter, 79% of the samples collected prior to cleanout of the broiler houses would have had acceptable composition as a feed ingredient, whereas 52% of the samples collected after litter cleanout would have been acceptable.

The number of broods of broiler chickens reared on the litter also has an effect on the composition of the litter. Depending on the broiler operation, the litter might be removed from the broiler house once a year, or as frequently as after each brood. Forty-four of the 48 samples of litter collected directly from broiler houses were taken from houses where the number of broods reared was known. These samples were categorized into three groups as follows: a) litter on which one or two broods were reared, b) 3 to 4 brood litter, and c) litter from houses on which five or more broods of birds were reared. Of litter sampled on which 1-2 broods of birds had been reared, 85% had less than 30% ash, 77% had 3.0% or more nitrogen and all of the samples had less than 25% bound nitrogen. Sixty-nine percent of the 1-2 brood litter samples met all three compositional criteria (Table 6). All of the five or more brood litter met all of the criteria. These results indicate that when more broods are reared on the litter prior to cleanout of the broiler house, the litter will have a higher nutritive value relative to the compositional criteria used to judge acceptance of broiler litter as a feed ingredient.

Table 6. Effect of Number of Broiler Broods on Percentage of Litter Samples Meeting Compositional Criteria as Feed Ingredient[a]

	- Number of Broods of Broilers Reared on Litter-		
Criteria	1-2 (n=13)	3-4 (n=20)	5 or more (n=11)
	- - Percent of samples meeting criteria - -		
<30% Ash	84.6	90.0	100.0
>3.0% N	76.9	85.0	100.0
<25% BN	100.0	100.0	100.0
All 3	69.2	75.0	100.0

[a]Only samples collected from broiler house before removal

The *in vitro* dry matter disappearance (IVDMD) method was used to compare the solubilities of the litter samples in rumen fluid from a cannulated steer (Tilley and Terry 1963). The purpose of the test was to determine the relative digestibilities of the samples by ruminant animals. Since this test does not determine the true digestibility of litter by the ruminant animal, it was used here only to compare differences among litter samples collected from various sources in Alabama.

There was no significant difference (P<.05) between the average IVDMD of litter before removal from broiler houses (38.3%) and those after removal (42.6%), although there were significant differences (P<.05) between ash, nitrogen and bound nitrogen levels for the two groups (Table 7). Samples of litter collected after the litter was removed from broiler houses were categorized into four groups based on the length of time the litter had been removed from the house and stored in a stack. The category referred to as "charred" is a designation which the authors use to describe litter which has excessively heated in the stack, because it has a characteristic burnt wood appearance. There was no difference in IVDMD for samples stored in stacks for various periods of time. However, "charred" litter was only about half as digestible as litter stored in stacks which had not excessively heated (Table 7). The bound nitrogen level showed a significant increase with time of litter storage. The percent of bound nitrogen for the "charred" litter samples averaged 46.6%, which indicates that 47% of the litter nitrogen was insoluble in acid detergent. Feed ingredients that are heat damaged have increased levels of bound nitrogen and lower IVDMD values (Goering et al. 1972). Litter stored in stacks, and particularly composted litter, is susceptible to heat damage. If spontaneous heating of litter stored in stacks is excessive (>60 C), heat damage can occur which will decrease the feed value of the litter. As a general guideline, litter with more than 25% of its nitrogen bound or insoluble should not be used as a feed ingredient.

Table 7. Solubility of Broiler Litter in Rumen Fluid by IVDMD-Method as Affected by Litter Composition

Litter Source	n	IVDMD[a]	Ash	N	BN[b]
		-Percent of litter dry matter -			% of total N
A. <u>From House</u>					
Before Removal	48	38.3	20.2c	3.77c	11.2c
After Removal	54	42.6	28.6d	4.14d	18.6d
B. <u>After Removal and Stored in Stack</u>					
Days stored in stack:					
<30	13	45.6c	31.5	3.78	10.4c
30-90	15	48.8c	28.1	4.27	12.8cd
>90	18	43.9c	26.2	4.16	16.8d
Charred	8	23.4d	30.0	4.42	46.6e

[a]Data expressed as % of litter dry matter solublized in rumen fluid after 48 h (Tilley and Terry 1963).

[b]Percent of litter nitrogen "bound" to acid detergent fiber.

[cde]Means in same column, within A or B, followed by different letters differ.

CONCLUSIONS

There is a growing interest in the use of animal wastes, particularly broiler chicken litter, as a low-cost, alternative feed source for ruminant animals. There is also much interest in commercializing animal waste as a feed ingredient. There are currently 21 states that have regulations that permit the marketing of animal waste as a feed ingredient, and four additional states are considering adopting regulations. The major collectable animal waste in Alabama is broiler poultry litter, which has an estimated annual production of 1.8 million metric tons. Incentives to better manage litter include its negative impact on the environment and its recognized value as a source of low-cost fertilizer and feed nutrients. Most attempts to commercialize this resource have failed because all commercial processes add cost to the finished product and most processes decrease the nutritive value of the resource.

The composition of all types of animal waste is highly variable. Management practices on the farm can have an effect on the composition of animal waste and on its potential value as a resource. Broiler poultry litter that is improperly removed from dirt floor broiler houses can have elevated levels of ash which decrease its value as a feed ingredient. High ash levels in litter potentially can dilute out other nutrients. A survey of broiler litter composition in Alabama showed that after litter was removed from dirt floor broiler houses, only 66% of the litter samples were acceptable as a feed ingredient based on the guideline of less than 30% ash. When guidelines were also imposed on nitrogen (>3.0%) and bound nitrogen (<25%) in addition to ash, approximately one-half of the litter samples would have been unacceptable as a feed ingredient for ruminants. A variety of management practices influence the composition of broiler litter and, therefore, its potential value as a resource. Further attempts to market this resource successfully will undoubtedly have to address the effects of these practices or be more restrictive on the selection of litter for its intended market.

ACKNOWLEDGEMENTS

This study was supported in part by the Alabama Agricultural Experiment Station and by the Tennessee Valley Authority, Muscle Shoals, Alabama.

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MANAGEMENT PRACTICES THAT AFFECT THE VALUE OF POULTRY LITTER AS A FEED INGREDIENT

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Environmental and economic constraints on livestock production have focused attention on the need to utilize recyclable agricultural by-products. Broiler litter is a by-product of the poultry industry that is a potentially major source of dietary nutrients for ruminants. In Alabama, an estimated 1.3 to 1.8 million metric tons of broiler litter are produced annually. Broiler litter, which is a mixture of wasted feed, feathers, bedding material and excreta, contains nitrogenous compounds, fiber and minerals which can be utilized by ruminants. However, some practices involved in the management of litter affect the composition and, therefore, the value of litter as a feed ingredient.

Broiler litter must be processed to render it safe from potential microbial pathogens. In addition, processing may improve the handling characteristics of litter by decreasing moisture and may increase the nutritive value of the litter (McCaskey and Martin 1988). However, some processes are detrimental to the nutrient composition of litter, thereby reducing its value as an alternate feed resource. For example, deep-stacking broiler litter can be an effective method for rendering the product safe from microbial pathogens. During the stacking process, microorganisms generate heat in the litter which destroys pathogenic organisms, but excessive heating can be detrimental to the dietary value of litter. Feed ingredients subjected to high temperatures during drying or other heat processes can become less digestible to ruminants (Goering et al. 1973). For this reason, a balance must be achieved between adequate heating to render the product safe while limiting excessive heating to prevent insolubilization and volatilization of litter nitrogen.

High temperature over a short period of time, such as during pelleting, does not appear to adversely affect litter nutrient quality (McCaskey et al. 1989). Long exposure of silage to a temperature of 60C is known to decrease *in vivo* digestibility of nitrogen (Goering et al. 1972). This indicates that insolubilization of nitrogen might occur when high temperatures are achieved and maintained in litter over a prolonged period.

MATERIALS AND METHODS

Effect of Heat on Litter

Spontaneous heating occurs in broiler litter stored in deep stacks, however, little research has documented the effect of heat on the nutrient composition of broiler litter. Moisture, high pH, and heating over a

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This manuscript was published in the Proceedings of the Sixth International Symposium on Agricultural and Food Processing Wastes, held December 17-18, 1990, Chicago, Illinois, as ASAE Publication 05-90:219-225.

prolonged period have been shown to increase insolubilization of nitrogen in forages (Goering et al. 1973). To determine if this phenomenon might also take place in broiler litter stored in stacks, a 90 metric ton (100 ton) stack of litter was monitored over 107 days for changes in temperature, nutrient composition and *in vitro* dry matter disappearance (IVDMD). The litter was stored in a barn at a depth of 2.5 to 3 meters. Thermocouples for temperature monitoring were placed in the stack at about 1.5, 1.0 and 0.5 meters from the top of the stack. Samples of litter for analysis were collected by sampling several areas of the stack and compositing.

Effect of Moisture on Litter Temperature

Management practices can affect the moisture content of litter. Retention of moisture in the litter due to poor ventilation, or addition of water from leaky waterers can increase the moisture content of litter. Moisture tends to increase bacterial activity in litter which increases ammonification (Elliott and Collins 1982). An increase in bacterial activity of the litter might also increase heat generated in deep-stack processed broiler litter. For this reason, a study was conducted to determine the effect of litter moisture content on the temperature of stacked litter.

Thirty-six metric tons (40 tons) of litter were removed from a broiler house with a box blade and front-end loader. The litter was divided into two stacks of about 18 metric tons each. Litter in one stack was 22% moisture, which is typical of well managed litter, and water was added to the litter in the second stack, increasing its moisture content to 38%. Both stacks were covered with 6 mil polyvinyl plastic. Thermocouples were buried in the center of each stack at about 0.3 m intervals from the ground to the top of the stack. The thermocouple leads were attached to a strip chart recorder and temperatures were monitored for 63 days.

Effects of Acid Treatment and Covering of Litter

Acid treatment and covering of stacked litter with polyvinyl plastic were evaluated to determine their effects on spontaneous heating and on composition of litter stored in stacks. Broiler litter from two broiler houses of equal size (242 m^2) with similar management practices were used in this study, with a 2X2 factorial arrangement of treatments. Litter in one house was not treated (pH 8.2), while litter in the other house was treated with technical grade sulfuric acid to pH 7.1. The total weight of litter in the house to be treated with acid was estimated by removing and weighing all the litter encircled by a 929 cm^2 (1 ft^2) metal ring in several areas of the house. The initial pH of the litter was taken by mixing 50 ml of distilled water with 10 g of litter and averaging four replications. Sulfuric acid (1 *N*) was added to each litter sample until a pH of 7.1 was obtained. The amount of technical grade sulfuric acid (93%) needed to treat the litter in the whole broiler house to obtain a pH of 7.1 was then calculated.

The acid was spread evenly over the surface of the litter using a hand-held sprinkler and mixed into the litter with a garden tiller. Litter was removed from the houses using a box-blade and front-end loader. The litter from each house was split into two stacks of approximately equal size (about 13 metric tons each). Samples were taken several times during the removal process and these were composited and placed in polypropylene mesh baskets. Eight baskets of litter (2 kg each) were buried in each stack at about 0.5 m from the sides and 1 m from the top of the stack. Four thermocouples were placed in each stack at the same location as the baskets. One stack of acid treated and one stack of the non-treated litter were covered with 6 mil polyvinyl plastic, while the other two stacks (acid treated and not acid treated) were not covered. Temperature in the four stacks was monitored at 5-day intervals for 100 days. A basket of litter was removed from each stack for proximate analysis at 10-12 day intervals. The data consisted of the changes in the composition of the litter and were analyzed for the main effects of treatment (acid treated or covered) and their interactions. Dunnett's procedure (Dunnett 1955) was used to compare changes in composition occurring in the control stack (no acid, uncovered) with the three treated stacks. Tukey's test (Gill 1978) was used to compare means for changes occurring in stacks as a result of treatment.

Litter Analysis

Broiler litter samples from each study were ground in a laboratory mill to pass a 2-mm screen and were mixed well. The litter was analyzed wet and the analyses were corrected to a dry basis. Analyses for dry matter (DM), ash, total Kjeldahl nitrogen (N), crude protein as N x 6.25 (CP), crude fiber (CF) and acid detergent fiber (ADF) were performed according to AOAC (1984) procedures for feed. Analysis for acid detergent insoluble nitrogen (ADIN) was performed as described by Goering and Van Soest (1970). Acid detergent soluble nitrogen (ADSN) was calculated as the difference between total Kjeldahl nitrogen and ADIN, while bound nitrogen (BN) represented the percent of total N in the form of ADIN. All components except DM and BN are expressed as percent of DM and represent the mean of triplicate analyses. Dry matter disappearance *in vitro* was determined on the samples after incubation in rumen fluid for 48 hours (Tilley and Terry 1963) as described by Stephenson (1989).

RESULTS AND DISCUSSION

Effect of Heat on Litter

When litter moisture was excessive (>25%) and access to air was not limited by covering the litter, the temperature of stacked litter reached 87C in 107 days (Table 1).

Table 1. Effect of Heat on Nitrogen Loss and Insolublization and IVDMD of Broiler Litter Stored in a Stack

Day	Temp. (C)	N	BN	IVDMD
0	53	3.90	12.1	48.1
10	63	3.52	14.4	46.3
22	69	3.63	14.7	44.1
36	74	3.49	21.0	42.2
52	77	3.44	24.3	38.9
71	77	3.55	28.6	37.2
107	87	2.19	53.9	14.0

Nitrogen (N) and *in vitro* dry matter disappearance after 48h in rumen fluid (IVDMD) are expressed as % of dry matter. Bound nitrogen is acid detergent insoluble nitrogen expressed as a % of total N.

Nitrogen was lost from the litter due to volatilization, decreasing from 3.9 to 2.2% after 107 days. During the same period, nitrogen associated with the acid detergent fiber fraction (BN) increased from 12.1% to 53.9% of total nitrogen, indicating that over half of the total N in the litter was insoluble. This decrease in solubility resulted in a decrease in *in vitro* insoluble. This decrease in solubility resulted in a decrease in in vitro dry matter disappearance (IVDMD). At day 0, 48.1% of the litter dry matter was solubilized in rumen fluid after 48 hours. IVDMD decreased to 14% after the litter had been stored in the stack for 107 days.

Effect of Moisture on Litter Temperature

Steps can be taken to limit excessive heating of litter stored in deep stacks. By limiting the moisture content of litter, less heat is generated. In a stack of litter with 22% moisture, the temperature was kept below 60 C (Fig. 1). When the moisture level of another stack of litter was increased to 38%, the litter temperature rose above 60C and was maintained for about 30 days. No charring (burnt appearance and odor) was observed in the 22% moisture stack, while the 38% moisture stack began to exhibit charring at about 50 days. Both stacks were covered with polyvinyl plastic, which probably prevented even higher temperatures from being achieved in the 38% moisture stack. Ambient temperature did not appear to influence the temperature of either stack.

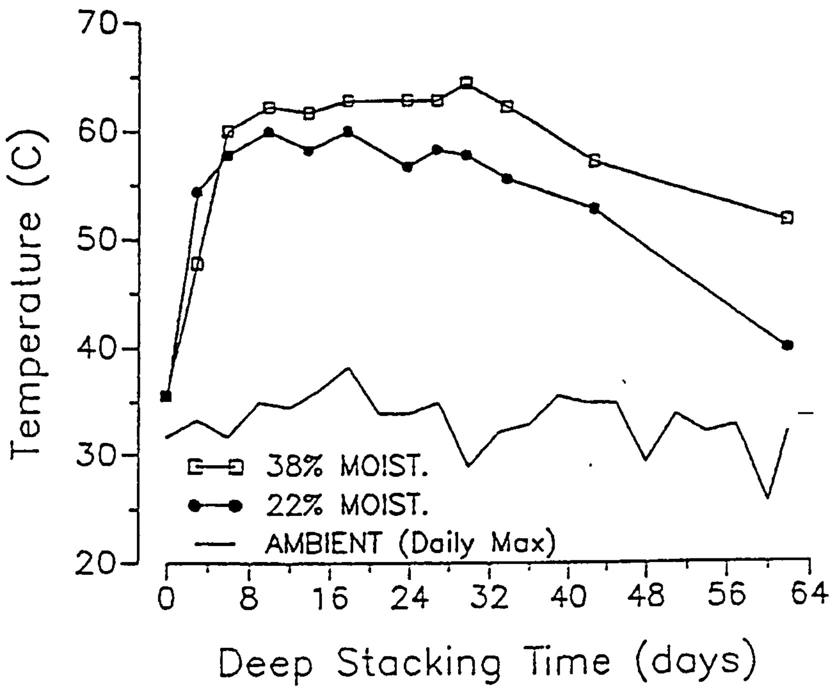

Fig. 1. Temperature Achieved in Stacks of Broiler Litter at two Moisture Levels.

Effect of Acid Treatment and Covering of Litter

Covering stacks with polyvinyl plastic and acid treatment were studied as other methods of preventing excessive spontaneous heat generation in stacks of litter. The highest maximum temperature (75 C) was achieved in the control stack which contained 22% moisture and was not covered or treated with acid (Fig. 2). The same litter treated with acid to lower the pH from 8.2 to 7.1 and covered with polyvinyl plastic reached a maximum temperature of 44C. No difference in maximum temperature was observed between acid treated, uncovered (53C) and no acid, covered (53C) stacks.
Acid detergent insoluble nitrogen (ADIN) and bound nitrogen (BN) changed more ($p<.05$) in the control stack than in any of the treated stacks (Table 2). ADIN increased 0.34% in the control stack, while the other three stacks showed very little change. The increase in ADIN of the control stack represented a 9.2% increase in BN. Soluble nitrogen (ADSN) decreased 0.50%

stack, compared to 0.28% or less in the treated stacks. The decrease in availability of nitrogen of the control stack appears to be a direct result of the higher temperatures achieved in the control stack. Total nitrogen decreased in all of the stacks regardless of treatment.

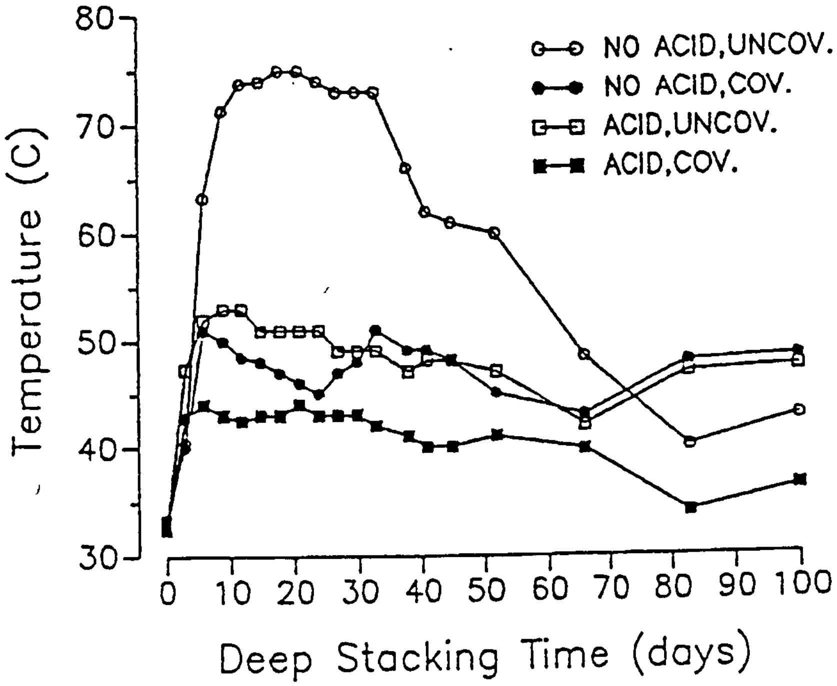

Fig. 2. Effect of Acid Treatment and Covering with Polyvinyl Plastic on Temperatures Achieved in Deep Stacked Broiler Litter.

Table 2. Mean Changes Occurring[a] in Composition of Deep Stacked Broiler Litter as a Result of Acid Treatment and/or Covering

Component	- - - - - Treatment[b] - - - - -				sem
	1	2	3	4	
Dry matter, %	1.96c	2.86c	-0.6d	3.4c	0.4
% of dry matter					
Ash	0.1	0.0	2.9	1.4	0.7
Nitrogen	-0.20	-0.15	-0.26	-0.16	0.03
ADIN	-0.01d	0.01d	0.02d	0.34c	0.04
ADSN	-0.19d	-0.16d	-0.28d	-0.50c	0.04
ADF	-1.0	-2.3	-1.5	0.7	0.8
Crude fiber	-0.2d	-1.4c	-4.4c	-3.2c	0.7
% of total N					
BN	0.6d	0.8d	0.3d	9.2c	1.2

[a]Means of samples taken at intervals for 100 days (n=8).
[b]Treatments:
1. Acid treated, covered with 6 mil polyethylene.
2. Acid treated, not covered.
3. No acid, covered
4. No acid, not covered (control).

[cd]Means in same row followed by different letters than control (treatment 4) differ from control (Dunnett's 5% level).

The effect of covering the stack with polyvinyl plastic to limit access of the litter to air was studied as one factor in this experiment (Table 3).

insolubilization of litter nitrogen. Soluble nitrogen decreased 0.33% in the uncovered stack, compared to 0.23% in the covered stack.

Table 3. Effect of Stack Covering on Changes in Nutrient Composition of Deep Stacked Broiler Litter

Component	Initial concentration Covered	Initial concentration Not Covered	After stacking[a] Covered	After stacking[a] Not Covered	Change Covered	Change Not Covered
Dry matter, %	78.7	78.7	79.4	81.9	0.7b	3.2c
% of DM						
Ash	27.7	27.7	29.4	28.4	1.5	0.7
Nitrogen	3.38	3.38	3.15	3.23	-0.23b	-0.15c
ADIN	0.39	0.39	0.39	0.57	0.00b	0.18c
ADSN	2.99	2.99	2.76	2.66	-0.23b	-0.33c
ADF	46.3	46.3	47.6	47.1	1.3	0.8
Crude fiber	27.3	27.3	29.6	29.6	2.3	2.3
% of Nitrogen						
BN	12.1	12.1	12.5	17.1	0.4b	5.0c

[a]Means of 8 samples taken at intervals over 100 days.

[bc]Means in same row followed by different letters differ ($p<0.05$).

The pH of litter usually ranges between about 8.0 and 8.5. At this high pH, litter nitrogen can be lost through volatilization of ammonia. Acid treatments have been studied by various researchers as a means of decreasing ammonia released from litter in the broiler house. In this study, acid treatment was examined as a method of preventing ammonia loss from broiler litter during storage in deep stacks. Acid treatment appeared to help decrease spontaneous heating of broiler litter. The initial pH of the litter was 8.2, and dropped to 7.1 after addition of the acid.

There was no difference ($p<.05$) in dry matter increase or nitrogen loss from deep stacks of broiler litter whether acid treated or not (Table 4).

Table 4. Effect of Acid Treatment on Changes in Nutrient Composition of Deep Stacked Broiler Litter

Component	Initial concentration Acid	Initial concentration No Acid	After stacking[a] Acid	After stacking[a] No Acid	Change Acid	Change No Acid
Dry matter, %	81.2	76.1	83.6	77.6	2.4	1.5
% of DM						
Ash	32.6	22.8	32.7	25.0	0.01b	2.2c
Nitrogen	3.10	3.66	2.93	3.45	-0.17	-0.21
ADIN	0.37	0.41	0.37	0.59	0.00b	0.18c
ADSN	2.73	3.27	2.56	2.86	-0.17b	-0.41c
ADF	49.6	43.0	47.9	42.6	-1.7	-0.4
Crude fiber	25.0	29.6	24.2	25.8	-0.8b	-3.8c
% of Nitrogen						
BN	11.9	12.2	12.6	16.9	0.7b	4.7c

[a]Means of 8 samples taken at intervals over 100 days.

[bc]Means in same row followed by different letters differ ($p<0.05$).

Both treatments lost about 0.2% of their initial nitrogen concentration. However, due to the lower temperatures achieved in the acid-treated stacks, less nitrogen became insoluble. Insoluble nitrogen did not change in the acid treated stacks, but increased 0.18% (from 0.41 to 0.59%) in the stacks which were not acid treated. Coupled with the loss of total N, ADSN decreased 0.41% in the non-treated stacks but only 0.17% in the acid treated stacks. In other words, more of the soluble nitrogen in the broiler litter prior to stacking was retained by treating the stack with acid to lower the pH to 7.1.

CONCLUSIONS

Management practices can have a dramatic effect on the dietary quality of broiler litter for use as a ruminant feed ingredient. Due to the variability in the composition of broiler litter, care must be exercised to ensure that litter of suitable dietary value is selected for use as a feed ingredient. Prudent management during use and storage can help ensure that the dietary value of litter is maintained or enhanced. The detrimental effect of excessive heating of litter stored in deep stacks should be a major concern. High moisture and aeration exacerbate spontaneous heat generation in deep stacks of broiler litter. High temperatures over extended periods can significantly increase the insoluble nitrogen content of broiler litter stored in stacks, which decreases its dietary value. Keeping moisture levels low (<25%) and limiting aeration by covering the litter stacks with polyvinyl plastic helps reduce spontaneous heating. Similarly, acid treatment of litter prevents excessive heating and thus helps preserve the feed value of broiler litter.

ACKNOWLEDGEMENTS

This study was supported in part by the Alabama Agricultural Experiment Station and by the Tennessee Valley Authority, Muscle Shoals, Alabama.

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Composting Agricultural Wastes In Alabama

James O. Donald, *Extension Agricultural Engineer*
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Charles H. Gilliam, *Professor Of Horticulture*

Through composting, waste products produced in Alabama's livestock, poultry, forestry, cotton, and peanut production systems can be converted into organic fertilizers, soil amendments, or potting media. Municipal garbage and sewage sludge can also be composted, after the non-biodegradable material such as glass, plastic, and metal objects have been removed. Some municipal wastes have restricted uses, however, because they contain metals such as mercury, lead, cadmium, and chromium.

The purpose of composting organic waste is to dispose of the material in a way that is safe for the environment. A great advantage of composting is that it creates a biologically stable product with a value equal to or greater than the cost of composting. The final composted product has less odor and breeds fewer flies than the raw waste. The volume and weight of the final product is less than that of the raw waste because the biological activity of composting converts much of the carbon-containing material to carbon dioxide, which is released as a gas. Because of the reduced volume, it will cost less to haul and spread the compost than the raw waste. Also, the heat created by the composting process destroys pathogenic organisms and weed seed that might be present in the raw waste.

This circular presents several composting methods and processes and gives brief recommendations for using the compost. Composting can be valuable for both the large agricultural producer and the homeowner, but, as with any endeavor, an individual should carefully investigate costs and benefits before beginning composting on a large scale.

The Composting Process

Composting is the partial decomposition, or breakdown, of organic materials by microorganisms such as bacteria and fungi. These microorganisms cannot break down, or *degrade*, inorganic materials such as plastic, glass, and metal objects. For this reason, these materials are called *non-biodegradeable*. So, for the composting process to function properly, non-biodegradeable materials must be removed from the waste by physical separation. The presence of these materials can be a major problem in composting municipal wastes. Most agricultural wastes, however, contain only small amounts, if any, of these non-biodegradable materials.

The physical and chemical properties of the raw waste affect the rate of composting. These properties include:

- Particle size and surface area, which influences aeration and the degree of biological activity and type of microorganisms active in the composting process.
- Moisture content.
- Carbon:nitrogen (C:N) ratio, which also regulates the rate of biological activity.
- Concentrations of other elements such as phosphorus and potassium required for growth of the microorganisms.

The action of bacteria and fungi, which creates heat in the compost pile, is the driving force for the composting process.

Particle Size

The size of the particles of raw waste determines how porous the waste is. The porosity affects aeration, or the amount of oxygen available for aerobic (oxygen-requiring) bacteria. The porosity affects the moisture-holding capacity of the waste, which also affects the biological activity in the compost pile. Finely ground organic material, such as shredded leaves, bark, and wood, provides a larger surface area for microbial activity than coarse material.

Moisture Content

The ideal moisture content of the compost pile is about 60 percent. As the moisture content approaches 70 percent, the oxygen in the compost pile becomes limited, and the aerobic process is transformed into an anaerobic process. This shift results in a change in the type of microorganisms at work, and the process becomes putrid, producing unpleasant odors. When the moisture content decreases to 50 percent or below, microbial activity and, therefore, the rate of composting slow down.

C:N Ratio

The carbon:nitrogen (C:N) ratio of the raw waste influences the rate of composting. Bacteria and fungi use the carbon and nitrogen in the waste to produce proteins for their growth and reproduction. They use about 30 parts of carbon to 1 part of nitrogen from the waste. When the C:N ratio exceeds 30:1, the composting process slows. Inorganic nitrogen, such as urea or ammonium nitrate, can be mixed with carbon-containing material, such as sawdust, to provide the desired 30:1 ratio. If the C:N ratio decreases to 25:1 or less, the bacteria and fungi cannot

The minimum composting time is 1 month in the turned windrow followed by at least 2 months in a curing pile. Afterwards, the compost is ready to be spread or bagged and marketed.

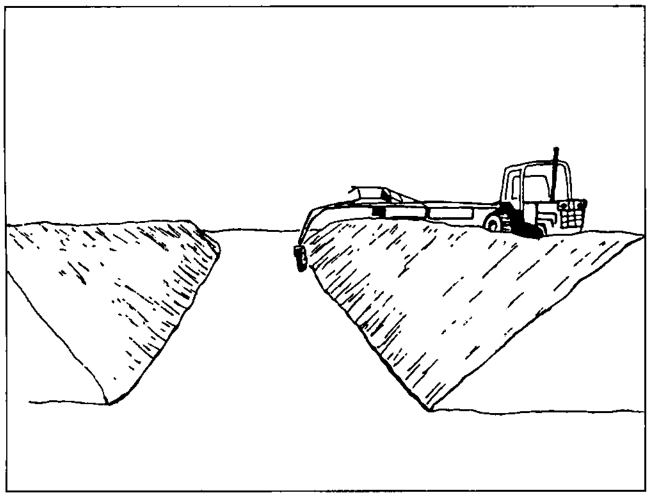

Figure 2. Layout of a typical windrow composting operation showing turning of windrows.

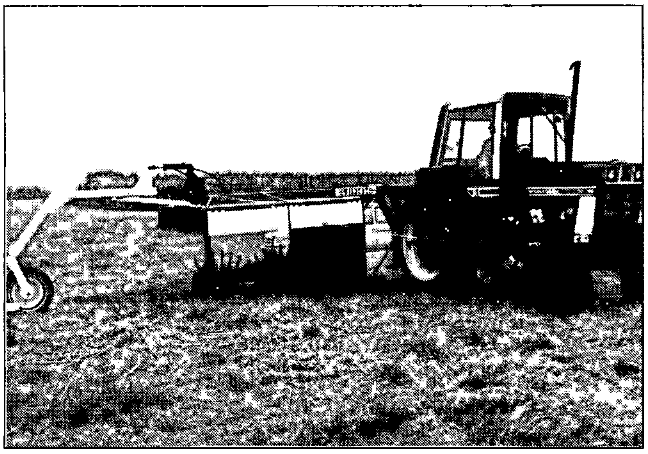

Figure 3. Typical windrow turning machine attached to a farm tractor. Photo courtesy of Wildcat Manufacturing Company.

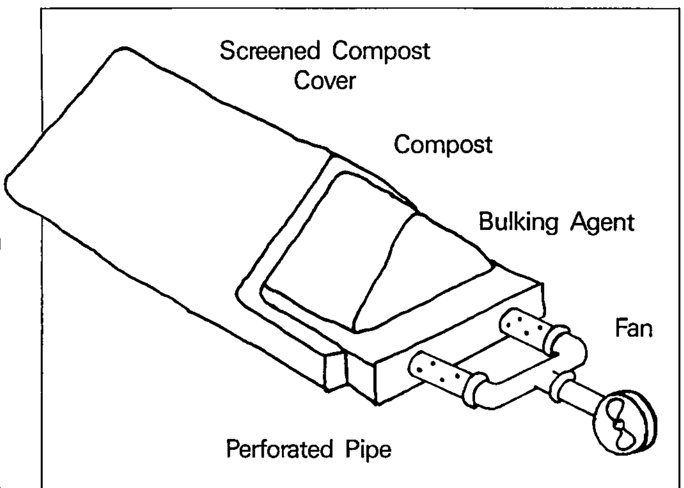

Figure 4. Cutaway diagram of a typical aerated windrow for composting.

Aerated Static Piles

Composting can also be performed in static windrows or piles through which air is forced. The material is placed in a windrow or pile over perforated pipes. Air is blown through the pipes and upward into the compost through the perforations. Forced aeration eliminates frequent turning but requires an electric compressor/blower and pipe network to distribute the air. At least 5 to 10 standard cubic feet per minute (scfm) of air per cubic yard of compost is required initially. This aeration rate may be gradually reduced to 1 scfm of air per cubic yard during the third or fourth week, with no aeration after 4 weeks.

Aerated Bins

Aerated-bin composting systems are either continuous-flow (mechanically stirred) operations or batch-operated systems (unstirred). Continuous-flow systems are more highly mechanized than batch systems. Following the preparation of the materials (grinding, mixing, and moisture adjustment), the mixture is gradually fed into the aerated composting bin using wheel loaders, gravity-fed hoppers, or belts.

Environmental conditions in the aerated bin are controlled so that the bacteria maintain a steady rate of decomposition. Aeration within the reactor is done by mechanically turning the composting material, by forced draft compressors/blowers, or by a combination of the two. Mechanical mixing or turning is usually done daily to make sure that oxygen reaches all microorganisms. Forced aeration usually requires a minimum of 5 to 10 scfm per cubic yard the first 2 weeks, 1 to 2 scfm per cubic yard the third week, and 1 scfm per cubic yard or less the fourth week. Temperature and oxygen probes should be used to time turning and aerating schedules, which may differ for each composting mixture.

A continuous-flow aerated bin often produces well-stabilized end products within 1 month. These products should then be cured in a stockpile for several weeks before spreading or bagging.

Aerated-bin composting can also be carried out in batch mode. Aeration is provided by perforated pipe, with the air under positive or negative pressure or some alternating combination of the two. At intervals of several days, materials are transferred into an adjacent bin. Transfer methods include wheel loaders, flighted lifter-mixers, or conveyors.

Uses For Compost

As A Soil Amendment

Composted organic wastes are valuable soil amendments because of the organic matter and the slow release of plant nutrients in the compost. Compost can be added to existing gardens and flower beds to improve tilth and to enrich the topsoil. It is often used around new home construction to amend the fill dirt so new lawns and shrubs can grow in a favorable environment. Composts can also be mixed with other materials such as sand, bark, perlite, vermiculite, peat, etc., to make suitable media for bedding plants, house plants, and container-grown nursery stock. Composted broiler litter has produced excellent

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Litter Storage Facilities

James O. Donald
Extension Agricultural Engineer

Common procedures for managing broiler litter manure after removal from the broiler house result in losses of valuable fertilizer nutrients and also have the potential of contaminating ground and surface waters. The method of stockpiling manure uncovered on the soil for the winter season before application on cropland can result in a fivefold reduction of nitrogen in the manure. The nitrogen lost from the manure can be carried by water to surface streams or ditches and into the ground water. The nitrogen lost represents a loss of farm income because manure nitrogen can be used to replace purchased fertilizer nitrogen.

Why Is Storage Necessary?

The cleaning period of a broiler house depends on the schedule of the broiler flocks. This does not always coincide with the availability of open cropland or the proper soil moisture conditions that allow distribution of the manure. Storage must be provided to hold the manure until the proper time for the manure nutrients to be applied to cropland.

How Much Manure Is Produced?

Poultry litter manure is a combination of litter material plus manure. Litter manure production varies with management and other factors. An average litter manure production rate can be estimated as 1 ton (or about 81 cubic feet) per 1,000 birds produced. With an average production frequency of 5.5 flocks per year, the annual litter manure production is estimated at 5.5 tons (446 cubic feet) per 1,000 birds of house capacity.

Manure litter that becomes saturated with water because of spillage around bird watering systems is called "cake" and must be removed from the broiler house between each flock. The remainder of the manure litter that is dry can be used for many flocks. Total broiler house cleanout has sometimes been delayed for up to 3 years.

Can Management Reduce the Storage of Manure?

Proper management of the litter in the broiler house will reduce the need to remove manure between flocks. It also will provide for a cleanout schedule that allows direct application of manure to cropland without intermediate storage. Direct field application will allow the most efficient utilization of the manure nitrogen by avoiding potential losses and reducing handling costs.

The primary management objective should be to select and operate bird watering systems to minimize water spillage on the litter. A trough-type watering system can allow production of 20 to 30 cubic feet of cake per 1,000-bird flock. Round-type waterers reduce the cake production by about 25 percent. Closed-system drinkers allow less than 1 cubic foot of cake production per 1,000-bird flock. Reduced spillage will:

- save water,
- improve bird quality,
- improve production environment,
- reduce ammonia release from the litter,
- reduce the volume of wet manure cake, and
- extend the time between litter cleanout.

Dollars spent on water system management provide economic and environmental returns to all phases of bird and manure management.

What Kinds of Manure Storage Can Be Used?

The storage method must protect the manure from prolonged contact with rainwater. This requires a surface on the stockpile that sheds water. A protective surface can be provided by covering the pile with plastic sheeting or by providing a permanent roofed structure. A deep, well-rounded stockpile of compacted manure also will shed water.

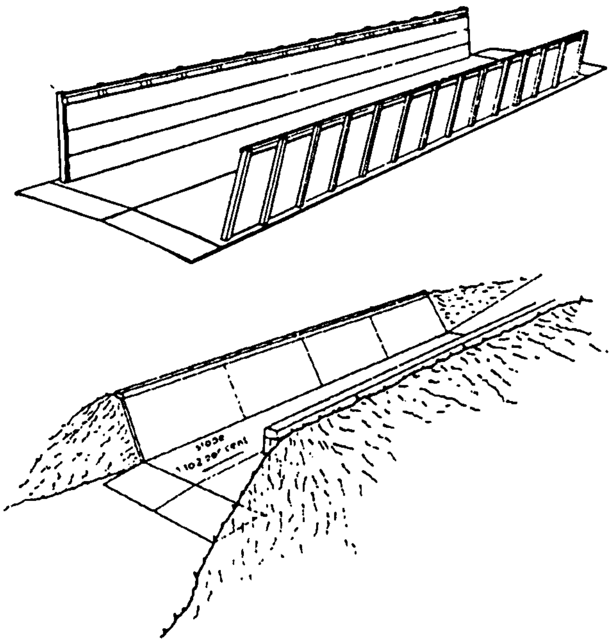

Figure 2. Bunker Storage Structures

Storage Structures With Permanent Roofs

You can construct concrete slabs, bunkers or other structures with permanent roofs to eliminate the need for plastic covers (Fig 3). The roof structure must be a clear span supported by the outside walls or perimeter posts. Interior posts will obstruct loading and unloading of the structure. Wood posts within a manure pile might be ignited if spontaneous combustion conditions are present. Roof structures must be of sufficient height to allow manure piling. Compaction loading will be difficult under a roof. Roofs 12 feet or higher may require wall panels to protect the stored manure from excessive blowing rain.

Summary

Improved storage techniques for broiler manure litter are required to allow the most effective use of the nutrients contained in the manure. The primary goal of manure management is to retain the nutrients in the manure during storage. Broiler litter manure storage can take many forms with a great range of investment costs. All available storage techniques and structures must be managed carefully to fully realize their potential for nutrient retention and environmental protection.

The use of manure storage structures is considered a "best management practice" for the protection of environmental quality. Any improvement in manure management will help improve environmental quality. Your local Cooperative Extension Service representative can provide assistance in planning for proper manure management.

Both state and federal programs exist which will assist with the construction of manure storage structures through cost share activities. However, structures must meet specific requirements to qualify for cost share money. Some storage methods mentioned in this circular may not meet the current requirements for cost sharing. Before constructing a manure storage structure, contact your local Soil Conservation District office to determine the design and construction procedures required of the cost share program.

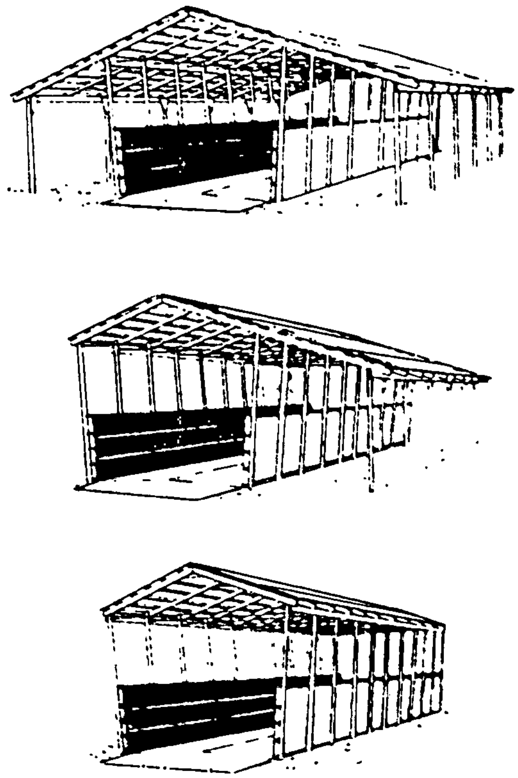

Figure 3. Storage Structures With Permanent Roofs

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Economics of Transporting Poultry Litter as a Fertilizer

James O. Donald, *Extension Agricultural Engineer*
John P. Blake, *Extension Poultry Scientist*

Environmental regulatory agencies continue to become more watchful of waste application practices. To avoid problems, all industries, including farming, must be able to dispose of their wastes without adversely affecting surface and ground water resources or creating nuisance conditions for neighbors. For poultry growers this means finding ways of effectively utilizing manure and litter. Farmers, as the traditional caretakers of the land, have been spreading manure as fertilizer since the origins of agriculture. The problem today is that in many cases land suitable for spreading is not available or is not under the control of the poultry operator.

One way to help solve the problem of poultry waste is the creation of a market for the by-product. A major challenge in recent years has been finding ways to make manure and litter more useable as a substitute for commercial fertilizer. An integrated handling industry must be developed to serve growers in moving the waste from the point of production to where it can be utilized in an environmentally safe manner in place of commercial fertilizers.

Concentration of Poultry Manure Production

The concentration of birds surrounding an integrated poultry complex is typically quite high. Normally, integrators locate their production units within a radius of approximately 25 miles of the hatchery, feed mill, and processing plant. Aho (1989) estimated that the cost of production increases one cent per pound when a broiler complex expands its production radius from 25 to 50 miles. Major contributors to this increase are additional transportation and labor costs. Such an increase in the area size results in additional costs of about $2 million annually for a typical broiler complex.

With increased interest in the quality of ground and surface water (and rightfully so), one question being asked is whether it is more economical to keep the production radius of a complex to a minimum and transport the excess manure out, or expand the size of the production radius so as to accommodate the manure locally. A broiler complex, including pullets and breeders, that processes 1 million birds a week will produce approximately 65,000 tons of manure annually. When used at a rate of 4 tons per acre, 16,250 acres of land are required for applying this quantity of manure. Compounding the difficulty, more than one integrated company may be operating in the same area. This means a much greater volume of manure production and therefore a greater number of acres required for its application.

Using Poultry Manure as a Fertilizer

Poultry manure and litter are valuable as soil amendments, especially when compared to other types of farm manure. But, like other organic fertilizers, they vary widely in nutrient levels available for crop fertilization. Poultry house management factors such as type of bedding used, frequency of litter change, moisture content, handling, and degree of storage prior to field application all contribute to the nutrient variability of manure and litter. While manure analyses can help determine an effective utilization plan, the inconsistent nature of poultry wastes complicates

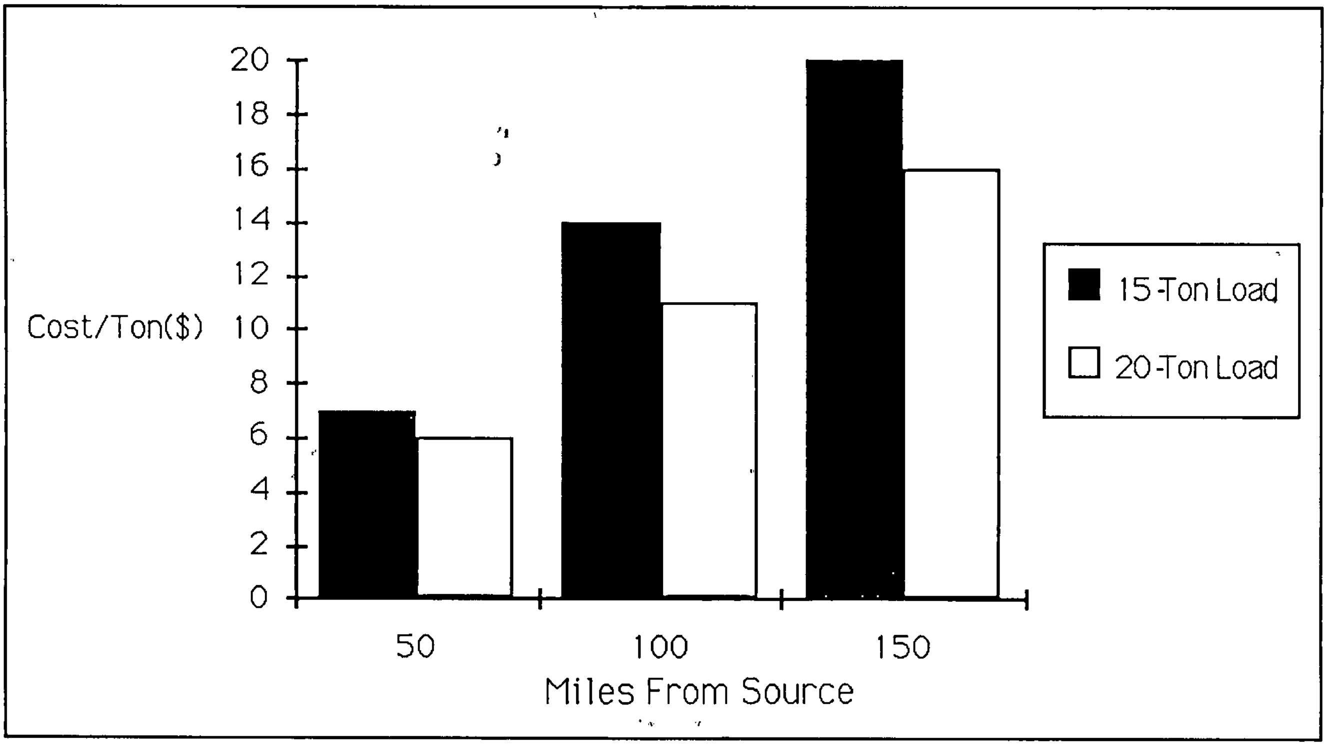

Figure 2. Cost of transporting 15- and 20-ton loads of broiler litter.

structure. Finally, both the seller and the buyer must have roads and turn-around areas that can accommodate tractors with 30-foot trailers.

Proper biosecurity management procedures must be followed to minimize the risk of transporting diseases. First, litter should be procured from well managed, disease-free farms. Buyers must be aware that they are dealing with a product that may contain avian (and possibly human) pathogens. Trucks and front-end loaders, if they move off the farm, must be properly cleaned and disinfected. Temperatures produced under properly maintained deep-stacking conditions will rid litter of most harmful microorganisms. Therefore, litter should be deep-stacked and allowed to go through a heat before marketing.

Developing Acceptance

Since virtually all farmers use some type of fertilizer, it is often assumed that poultry manure should be

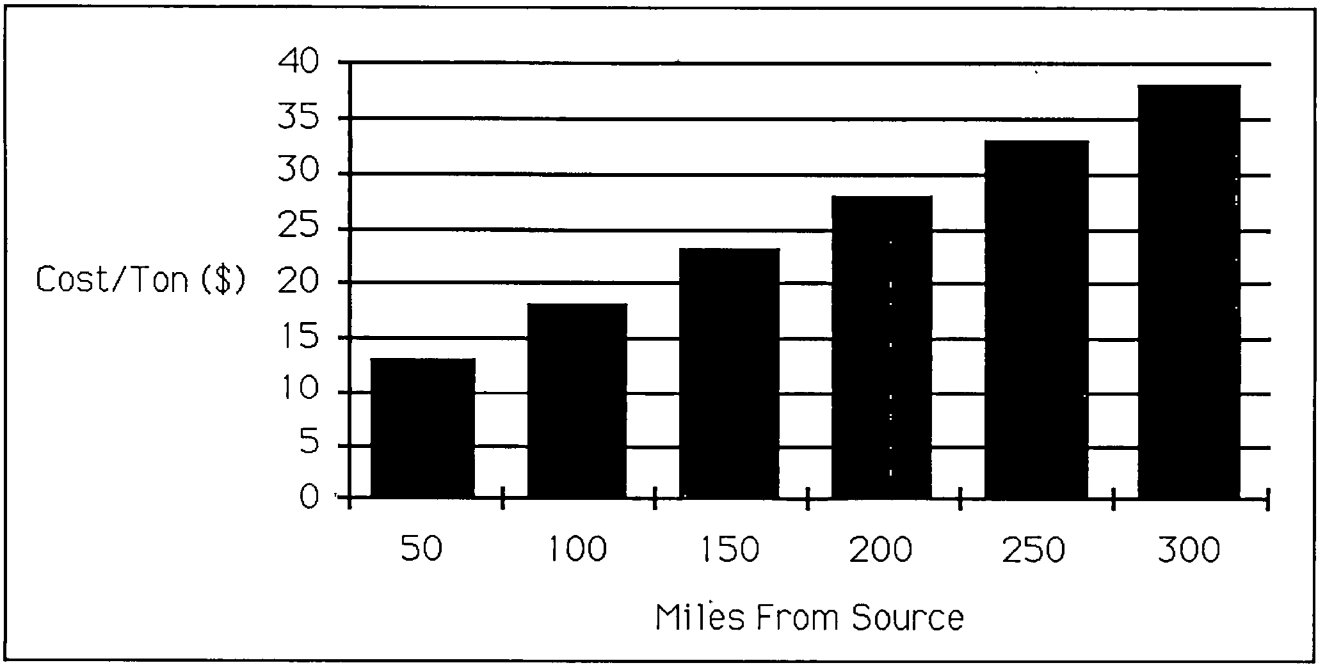

Figure 3. Cost of delivered litter away from source assuming a 20-ton load valued at $8.00 per ton transported at $1.00 per mile round trip.

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Lagoons for Animal Waste Disposal

Harold Watson, *Extension Agricultural Engineer*

For several years lagoons have been used for disposing of livestock and poultry manure with varying degrees of success. Design, construction, and management of lagoons determine their effectiveness.

Major advantages of lagoons are (1) labor requirements for manure disposal are less than with systems where manure is spread onto the fields and (2) lagoons can normally be constructed at a lower initial cost.

There are three major disadvantages of lagoons. (1) Objectionable odors are sometimes associated with the use of lagoons. The odor problem can be minimized, however, through proper design, construction, and management. (2) Poorly constructed lagoons, or lagoons built over improper soil types, can present a possible source of ground and surface water pollution. (3) Periodic sludge removal is required. The biological decomposition process occurring in lagoons does not completely decompose or break down all solids present in livestock and poultry manure. These undigested solids accumulate on the bottom of the lagoon, necessitating periodic cleanout.

Lagoons should be constructed and managed to obtain a non-overflow operation. Overflow from any single-stage lagoon represents a potential source of surface water pollution and will require additional processing and handling.

Additional information on location, planning, design, construction, and management of lagoons is available from your local Soil Conservation Service office.

Lagoon Types and Processes

Aerobic Lagoons. The aerobic process decomposes organic or solid material present in animal wastes by aerobic microorganisms or bacteria which require free oxygen to exist. Oxygen is supplied to the wastes, making it available for the growth of aerobic bacteria. The aerobic bacteria decompose the wastes into more basic compounds such as water, carbon dioxide, nitrates, and sulphates.

In the naturally aerated aerobic lagoon, oxygen is supplied by direct absorption from the air through the lagoon surface and by algae or plant life living in the lagoon. The algae utilize the nitrate nitrogen, which is produced by the aerobic process with the aid of sunlight to grow and produce additional oxygen for sustaining the aerobic decomposition. To provide sufficient area for absorption of oxygen and for the input of sunlight, aerobic lagoons must be designed on the basis of surface area. This process is commonly used by municipalities for the treatment of sewage and can be an effective means of animal waste treatment. However, the rather large surface area required makes it impractical for most livestock and poultry operations. Aerobic lagoons produce little or no odor; thus, they should be considered in areas where odors may be highly objectionable.

Mechanically Aerated Lagoons. The aerobic process can also be maintained by using mechanical aeration devices. Mechanical aerators agitate the lagoon surface water or force air up through the water with a portion of the oxygen

Table 1. BOD Production and Surface Area Requirements for Non-overflow Aerobic Lagoons.

	BOD Pounds per Day	Square Feet of Surface Area per Head	Number of Head per Surface Acre
Swine (200 lb.)	0.45	390	110
Dairy* (1000 lb.)	1.32	1150	38
Beef (1000 lb.)	1.02	890	49
Poultry (5 lb.)	0.02	17	2500

*Values in this table assume all manure production enters the lagoon. For dairy cows on pasture, however, waste will come only from milking parlor and holding pens. In this case, 230 square feet of lagoon surface area per head or 140 head per surface acre will suffice.

Table 2. Volumetric Requirements and Aerator Sizes for Non-overflow Mechanically Aerated Lagoons.

	BOD Pounds per Day	Volume per Head (cubic feet)	Aerator Size Head per Horsepower
Swine (200 lb.)	0.45	125	80
Dairy* (1000 lb.)	1.32	410	28
Beef (1000 lb.)	1.02	325	35
Poultry (5 lb.)	0.02	6	1800

*Values in this table assume all manure production enters the lagoon. For dairy cows on pasture, however, waste will come only from milking parlor and holding pens. In this case, 82 cubic feet of lagoon volume per head or 140 head per horsepower will suffice.

Table 3. Minimum Volumetric Requirements for Non-overflow Anaerobic Lagoons.

	Volume per Pound of Livestock (cubic feet)	Volume per Animal (cubic feet)
Swine (200 lb.)	1.2	240
Dairy*(1500 lb.)	1.4	2100
Beef (1000 lb.)	1.4	1400
Poultry (5 lb.)	3.0	15

*Values in this table assume all manure production enters the lagoon. For dairy cows on pasture, however, waste will come only from milking parlor and holding pens. In this case, 400 cubic feet of lagoon volume per 1500-pound cow will suffice.

goon sizes and volumes are shown in Tables 4, 5, and 6.

Proper construction is important for good lagoon performance. These pointers should help you in constructing your lagoon.

1. Make top of dike around lagoon 8 feet wide to allow for equipment travel.

2. Steep bank slopes below waterline discourage weed growth. Use 1:1 side slopes where soil stability permits.

3. Flat bank slopes above waterline make mowing easier. Use 3:1 side slopes generally, but no steeper than 2:1.

4. Seed banks with grass and keep them mowed.

5. Fill the new lagoon with surface or well water before using.

6. Waste will be distributed more uniformly if

Table 4. Water Volume of Anaerobic Lagoons With 10-Foot Total Depth and 8-Foot Water Depth.

Top		Waterline		Bottom		Volume to Waterline
Length (feet)	Width (feet)	Length (feet)	Width (feet)	Length (feet)	Width (feet)	(cubic feet)
70	70	58	58	26	26	14,700
80	80	68	68	36	36	22,300
90	90	78	78	46	46	31,400
100	100	88	88	56	56	42,100
150	100	138	88	106	56	70,900
200	100	188	88	156	56	99,700
150	150	138	138	106	106	119,700
250	100	238	88	206	56	157,300
300	100	288	88	256	56	157,300
200	200	188	188	156	156	237,300
250	250	238	238	206	206	394,900
300	300	288	288	256	256	592,500

Table 5. Water Volume of Anaerobic Lagoons With 12-Foot Total Depth and 10-Foot Water Depth.

Top		Waterline		Bottom		Volume to Waterline
Length (feet)	Width (feet)	Length (feet)	Width (feet)	Length (feet)	Width (feet)	(cubic feet)
70	70	58	58	18	18	15,700
80	80	68	68	28	28	24,300
90	90	78	78	38	38	34,900
100	100	88	88	48	48	47,500
150	100	138	88	98	48	81,500
200	100	188	88	148	48	115,500
150	150	138	138	98	98	140,500
250	100	238	88	198	48	149,500
300	100	288	88	248	48	183,500
200	200	188	188	148	148	283,500
250	250	238	238	198	198	476,500
300	300	288	288	248	248	719,500

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Liquid Manure Handling Systems

Harold Watson, *Extension Agricultural Engineer*

Disposing of animal wastes has become a major problem in livestock and poultry production. The problem has been complicated by the confinement housing system in which large volumes of manure are produced in a relatively small area and must be cleaned out frequently.

Manure must be disposed of efficiently to preserve the health and safety of people and livestock. Contamination of water supplies is a major sanitation problem. Recently, public interest and legislation have focused on water pollution control. An adequately designed and installed liquid manure handling system will minimize odor and fly problems.

The liquid manure system handles and disposes of the wastes efficiently. The system collects and stores manure, usually in an underground tank. The farmer removes manure from the storage tank by adding water, if necessary, and then agitating and pumping the mixture into a tank wagon to spread it on fields.

A liquid manure system is not a complete solution for all manure disposal problems. This publication points out some of the advantages, disadvantages, design considerations and operating techniques involved.

Advantages

Following are four major advantages of an adequately designed liquid manure handling system.

1. Nearly all the fertilizer value in manure–both feces and urine–may be returned to the land. Reclaiming the manure will, in many cases, offset the total cost of operating the system.
2. In a liquid manure system with adequate storage capacity, manure can be spread over fields at the farmer's convenience.
3. Labor costs are lower than when handling manure in the solid form. With a liquid manure system, manure is usually spread monthly or bimonthly. But with a solid manure handling system, spreading is usually done daily.
4. Odor and fly problems may be reduced when manure is stored in an underground tank with a good cover.

Disadvantages

There are three major disadvantages of a liquid manure handling system.

1. Initial cost is higher than for some other methods of manure disposal.
2. Water must be added to the manure to produce a slurry, which is pumped into spreader tanks and transported to fields. Considerable water must be handled.
3. In a large operation, there may not be enough land on which to spread the manure.

Physical Properties of Liquid Manure

The fertilizer value of liquid manure is determined primarily by its plant food nutrients. The most important of these are nitrogen (N), The pumping characteristics of a given slurry depend on the solid content of liquid manure. To maintain an efficient and economical manure handling operation, the solid content of the slurry must be kept at the highest point which will still allow the slurry to be agitated and pumped properly. Table 2 indicates the solid content and dilution requirements for liquid manure slurries.

Planning a Liquid Manure System

A liquid manure system has six essentials:

1. Equipment to remove manure from house and lot.
2. Underground collection tank or storage pit.
3. Method of agitating the material within storage tank or pit.
4. Pump for emptying storage tank.
5. Tank, spreader wagon, or irrigation system to distribute manure slurry on fields.
6. Land area on which to spread manure.

Equipment To Remove Manure. Manure can be removed from livestock and poultry buildings and lot areas either hydraulically or mechanically. For cleaning swine facilities, milking parlors, and in some cases laying houses, a hose can be used with water pressure at 100 psi and flowing at 10 gallons per minute. Lot areas and alleyways in cattle barns may be cleaned by scraping manure into the storage tank with a tractor-mounted blade.

Liquid manure systems may be readily used with slatted floor swine facilities. Manure falls through the slots into a concrete collection pit where it is stored for spreading at the farmer's convenience. Exterior pump openings can help in emptying the pit.

A caged laying operation is adaptable to the use of liquid manure systems. In houses where mechanical pit scrapers are used, manure is conveyed from the house by the pit scrapers and a cross conveyor located across one end of the house. Then it is placed in a manure storage tank outside the house.

Underground Storage Tank or Pit. The size storage tank or pit required for an operation depends upon the number and type of livestock or poultry and their manure production. Table 3 lists some averages for the maximum and minimum daily manure production for certain livestock and poultry. The values include enough dilution water to get a pumpable slurry.

Table 3. Liquid Manure Production Of Various Livestock And Poultry.

Type Waste	Production per Day [1]
Dairy Cattle	14 to 18 gal. per head
Beef Cattle	8 to 10 gal. per head
Swine	1.5 to 2.0 gal. per head
Poultry, Layers	4 to 8 gal. per 100

[1]Including dilution and wash water.

The length of the storage period affects the size of the storage tank required. One advantage of liquid manure handling systems is that manure may be stored for long periods and spread at the farmer's convenience. Storage periods commonly range from 30 to 90 days. A storage period of less than 30 days is not recommended because it would defeat a primary purpose of a liquid manure system.

Figure 1 shows storage tank requirements for storage periods of 30, 60, and 90 days for dairy cattle, beef cattle, poultry and swine. Storage capacities for any type operation may be determined from this figure.

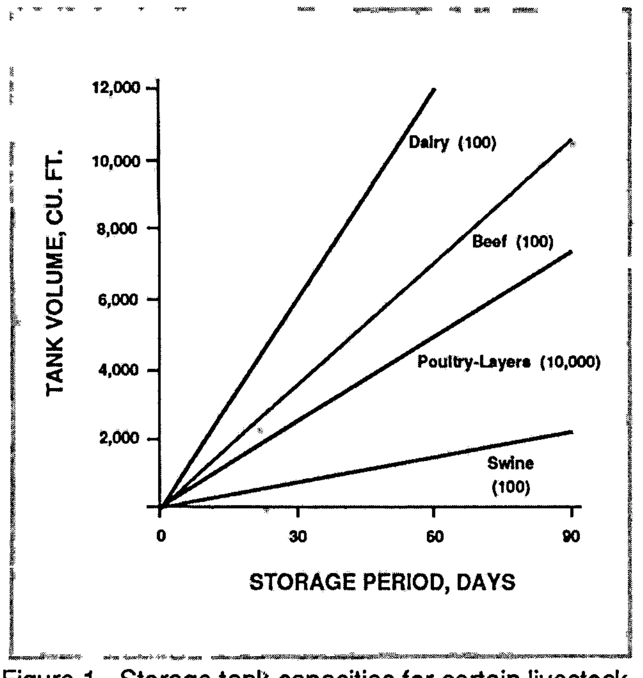

Figure 1. Storage tank capacities for certain livestock and poultry for various storage periods.

Construct manure storage tanks with reinforced concrete or concrete staves of the type used in upright silos. Detailed designs (plans H-502 and H-503) for reinforced concrete tanks are available free at your county Extension office.

Concrete stave tanks should be installed by silo construction firms. They should be 12 to 15 feet deep and located below ground level. The concrete bottom of the tank should be 6 inches thick. Have the sidewall sealed with sand-cement plaster to prevent seepage from the tank, and have corrosion-resistant silo reinforcing bands installed around the outside of the tank. The area around the tank should be carefully backfilled and sloped to provide surface drainage away from the tank.

Locate the tank just outside the paved lot areas and buildings it serves, so that manure will have to be moved only a minimum distance and so that wash water from feeding floors, lot areas, milking parlors, and other areas can be channeled into it. Often this wash water produces a slurry that is pumpable without adding dilution water. To prevent excessive dilution of the slurry during rainy periods, divert water from lot and roofs away from the tank opening.

Openings on reinforced concrete tanks should be covered with steel grates to keep out large debris and to prevent injury to animals if the tank must be located in a lot. Install a fence around concrete stave tanks.

In some swine feeding operations the pit or tank is underneath the feeding floor and covered with slats. Labor is saved because the manure is deposited directly into it. The slurry is then pumped from several locations along the length of the pit. The system's big disadvantage is that the long, narrow pit makes it difficult to agitate the slurry properly when pumping it from the pit.

Agitation of Liquid Manure. Generally, the slurry must be mixed at least once a week to ensure a homogeneous solution. Many farmers agitate the solution during the daily lot or barn cleaning.

The recirculation method is the simplest and cheapest way to agitate slurries within the tank. The same pump that removes the slurry from the tank is used, and a separate agitator is not needed. A bypass line is installed within the pump discharge outlet line, and the material is recirculated through the pump and back into the tank until the desired consistency is reached.

Pumps. A good pump is central to a liquid manure handling system. One of two ar-

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Dead Poultry Composting

J. O. Donald, *Extension Agricultural Engineer*
Charles Mitchell, *Extension Agronomist*
Vic Payne, *Environmental Engineer,* Soil Conservation Service

Alabama poultry producers are facing increasingly difficult problems disposing of dead poultry on their farms. Current practices include incineration, burying the carcasses in approved pits, and rendering. Current disposal methods may not be environmentally sound or cost effective.

Composting

Recent work at the University of Maryland's Poultry Research and Education Facility at Princess Anne, MD has sparked new interest in the old organic gardening practice of composting. In this case, composting dead chickens. Composting is a controlled, natural process in which beneficial microorganisms—bacteria and fungi—reduce and transform or change organic wastes into a useful end product—compost. In dead bird composting operations, a prescribed mixture of dead chickens, manure, straw, peanut hulls, or coastal hay, and water provide the necessary ingredients for changing the mixture to compost. This mixture will have a carbon:nitrogen ratio (C:N) of about 23:1 and a moisture content of about 55 percent. Acceptable C:N ratios are between 15:1 and 35:1. Acceptable moisture content ranges are between 40 and 60 percent.

Composter Size

Composter size is based on broiler farm capacity, overall bird size at the end of the production cycle, and mortality. Studies show that the composter should be designed using the following formula:

Capacity of the first stage composter bins in cubic feet = 0.0025 x Final bird weight x Farm capacity per cycle.

Example: What capacity of first-stage composter bins in cubic feet is required for a poultry grower with a 100,000-head capacity farm with final bird weight of 4.2 pounds.

First stage capacity in cubic feet = 0.0025 x 100,000 x 4.2 = 1,050 cubic feet.

Field studies have shown that at least 1 cubic foot of secondary composting bin is necessary for each cubic foot of first-stage or primary bin capacity.

Table 2. Formula For Dead Poultry Composting.

Materials	Parts By Weight
Dead Chickens	1
Chicken Manure	2 to 3
Straw (Wheat)	$^1/_{10}$
Water (add sparingly)	0 to ½

Composter Operation

A simple mixture of straw, hay, or peanut hulls with dead chickens, poultry litter, and water and oxygen will produce the readily available beneficial bacteria and fungi needed to convert these materials into an inoffensive and useful compost. In field studies, odors and insects have not been a problem. Tests on certain pathogens (such as *E. coli*) and on Gumboro and New Castle disease viruses show that they do not survive the pasteurizing effects of composting.

Daily Operation

Once the weight and volume relationships of one day's dead poultry are determined, the other elements can be weighed out according to the formula in Table 2. Weigh the elements in buckets on scales the first day. On subsequent days, a loader can be used once the weight of a full loader/bucket is determined for each element except water. One gallon of water weighs about 8 pounds. Or, use

Table 1. Number Of First-Stage Composter Bins Required Based On Number Of Broilers On Hand (Based On 4.2 lb. Bird).

Farm Capacity	Required Cubic Feet For First Stage Bins	No. Of First Stage Bins (5' x 5' x 8')	Required Cubic Feet For Second Stage Bins
20,000	210	1	210
40,000	420	2	420
60,000	630	3	630
80,000	840	4	840
100,000	1,050	5	1,050
120,000	1,260	6	1,260

Figure 2. Composter floor plan (not to scale).

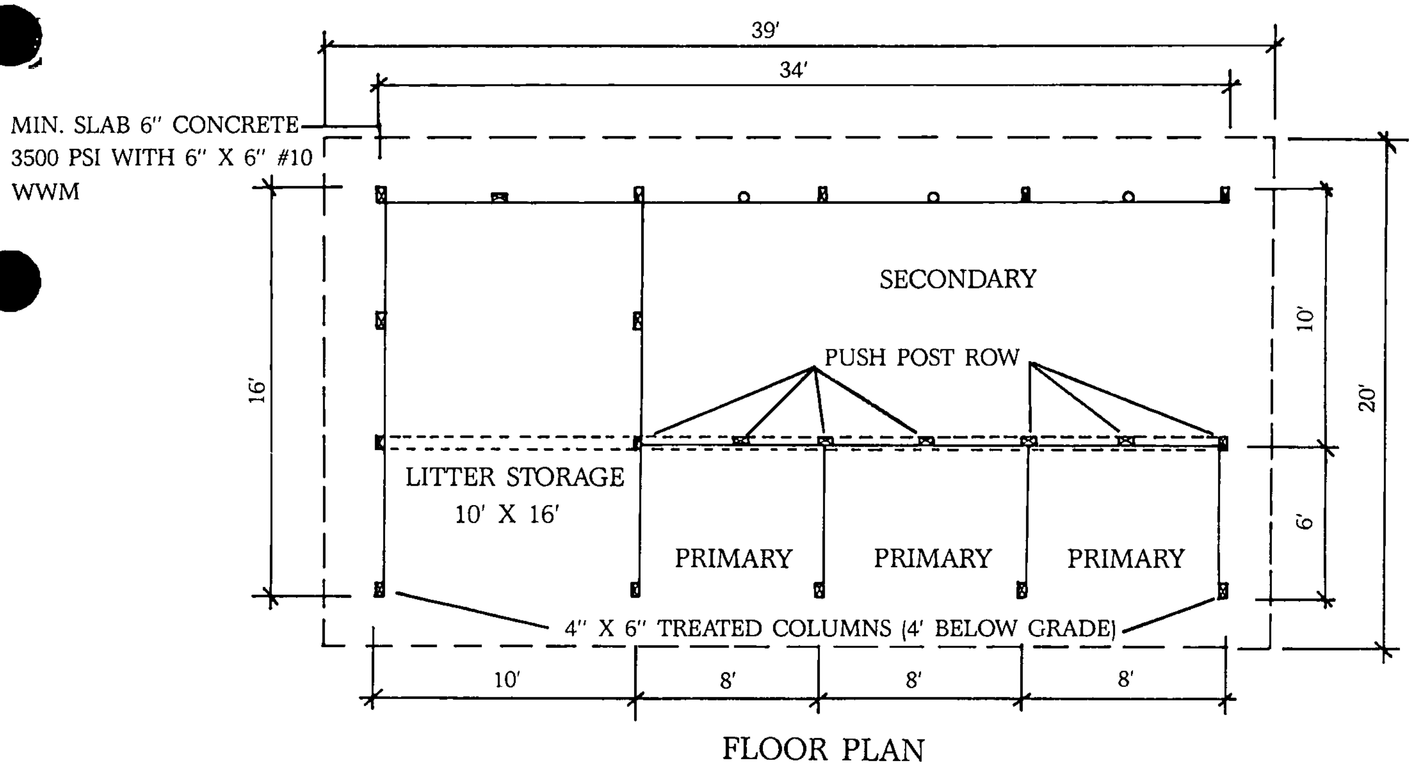
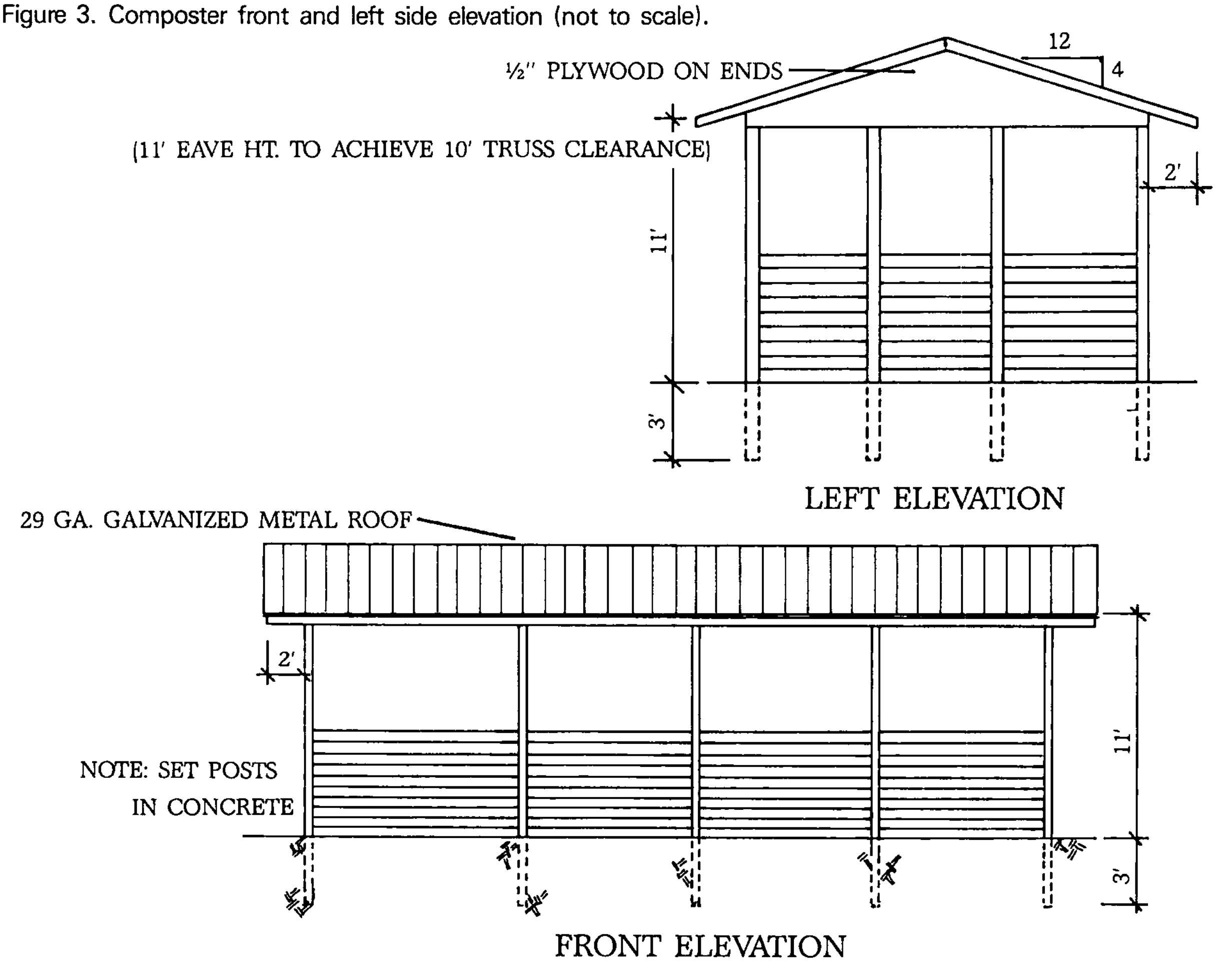


Figure 3. Composter front and left side elevation (not to scale).



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Dead Poultry Composter Construction

James O. Donald, *Extension Agricultural Engineer*
John P. Blake, *Extension Poultry Scientist*

Every broiler production facility is faced with the reality of farm mortalities. Sixteen million broilers are processed weekly in Alabama, generating approximately 750 tons of carcasses. Disposal of these mortalities has been identified as a serious environmental problem that, if not solved, may limit future industry expansion in Alabama.

Open-bottom burial pits are presently the most commonly used method for the disposal of poultry farm mortalities. But there is concern over the possible decline in water quality where open-bottom pits are located in certain soil types having high groundwater tables. Residue remaining in pits after years of use is recognized as an emerging reason for considering alternative methods of disposal for poultry farm mortalities.

Incineration is recognized as one of the biologically safest methods of disposal. However, it tends to be slow and expensive, and can generate nuisance complaints even when highly efficient incinerators are used. Particulate air pollution is also generated by incinerators.

Rendering is one of the best means for the conversion of poultry farm mortalities into a valued, biologically safe protein by-product meal, but the spread of pathogenic microorganisms during routine pickup and transport to a rendering facility presents a substantial threat.

Due to increasing burial or incineration costs and newly imposed local, state, and federal water and air quality regulations, alternative methods of disposal are of interest to the producer. Dead bird composting is one such alternative. This method has been approved in Alabama by the state veterinarian's office, state and local health departments, and the Alabama Department of Environmental Management. Alabama broiler growers have shown great interest in the composting technique with at least 25 full-size composters in operation in the state, and plans for many more to be in operation by early 1991.

Preliminary studies of composting as a method for the disposal of poultry farm mortalities were undertaken at the University of Maryland's Poultry Research and Education Facility (Murphy and Handwerker, 1988). For the composting of poultry farm mortalities, a prescribed mixture of poultry farm mortalities, poultry litter, straw and water is required for transformation of the mixture into compost (Murphy, 1988). Caked or used poultry litter, which can be comprised of pine shavings, sawdust, peanut hulls, or rice hulls, and manure is used as the primary compost medium, supplying ammonia nitrogen for microbial growth. Since a mixture of poultry carcasses has a disproportionately large supply of nitrogen (N), straw is added to the mixture to supply additional carbon (C) and adjust the C:N ratio.

The mixture should be composed of 1 part poultry farm mortalities, 2 parts poultry litter, 0.1 part straw, and 0.25 part water, based on weight, not on volume. Such a mixture will have a C:N ratio of about 23:1 and a moisture content of about 55 percent. Acceptable C:N ratios are between 15:1 and 35:1, while moisture content ranges are between 40 and 60 percent.

The alternatives for the disposal of poultry farm mortalities are limited, and composting presents a very desirable environmental and economic alternative. The proper design and construction of composters for the disposal of poultry farm mortalities are, however, important considerations.

Table 1. Number of First-Stage Composter Bins Required Based on Number of Broilers on Hand (based on 4.2-pound bird)

Capacity	Required Cubic Feet for First Stage Bins	No. of First Stage Bins (5' X 5' X 8')	Required Cubic Feet for Second Stage Bins
20,000	210	1	210
40,000	420	2	420
60,000	630	3	630
80,000	840	4	840
100,000	1,050	5	1,050
120,000	1,260	6	1,260

round operation and controls rain water and percolation, which can be major problems (Figure 2). Gutters may be needed to divert water away from composting bins. Composters built with excessively high eave heights to allow easy moving of equipment may expose compost and raw materials to blowing rain. This has been a problem on several large units in Alabama, and partial sidewalls or curtains have been added along with gutters to minimize this problem.

Raw Ingredient Storage: Some parts of the U.S. are seeing an increase in the number of manure storage barns being built in order to facilitate the flow of manure as it leaves the poultry house. Because of the limited number of manure storage barns in Alabama, most composters are being built with the capacity to hold enough manure for the composting cycle. This is imperative in light of the wet weather experienced in Alabama and the inability to acquire and transport poultry litter for

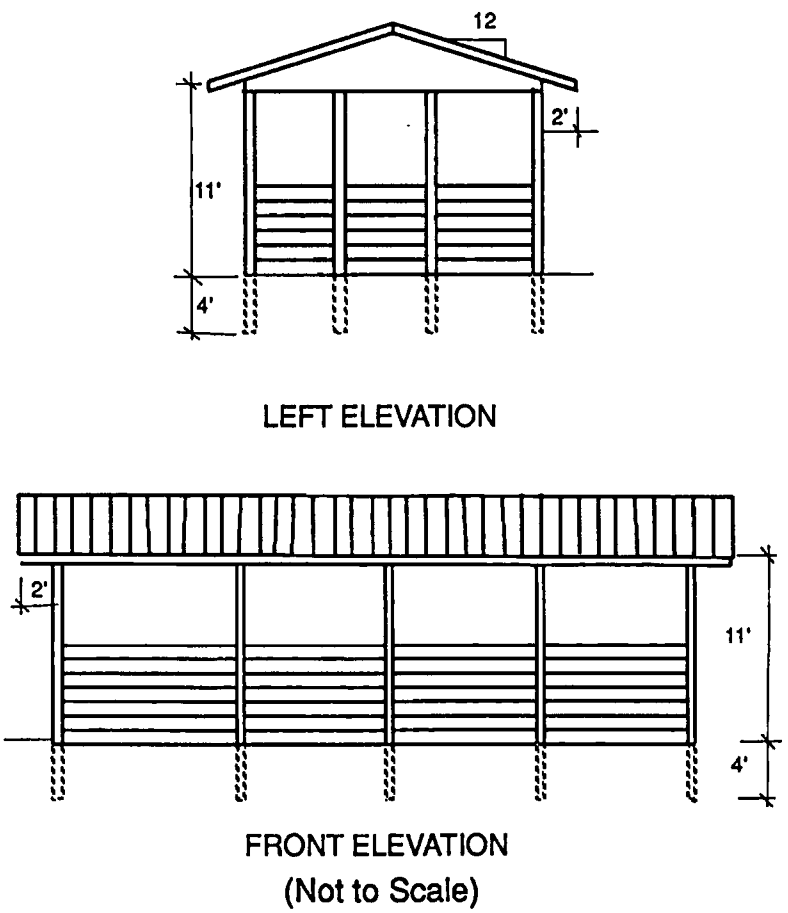

Figure 2. Elevations of free-standing farm composter.

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Frequently Asked Questions About On-Farm Poultry Carcass Composting

John P. Blake, *Extension Poultry Scientist*
James O. Donald, *Extension Agricultural Engineer*

What is essential during the poultry carcass composting cycle?

For the cycle to work properly, temperatures in excess of 130° F must be achieved and maintained for approximately 16 to 20 days. Exposure of carcasses to these temperature conditions requires a minimum of two 10- to 14-day composting cycles.

Are special ingredients required for composting?

The process described does not employ inoculants, chemicals, or other commercial additives. These may (or may not) improve the operation of a composter. The simple process and materials discussed will produce the required decomposition of carcasses.

Do composters produce an odor?

Except when moving compost, there should be no objectionable odor from the composter. Movement of compost from the primary to the secondary bin releases some odor. The odor is not that of decomposing carcasses, and it abates quickly after moving is completed. Except when moving primary compost, there should be no objectionable odor in or around poultry carcass composters.

Are flies a problem?

Fly breeding has not been a problem with composters. If the composter is operating properly, temperatures in excess of 130° F generated throughout primary and secondary masses are sufficient to kill maggots already in carcasses when they are placed into the composter. Covering the birds in primary bins with dry manure discourages flies.

Do composters fail, and why?

Occasionally, composters fail to reach an adequate temperature, or they may produce odors and seepage. Composting is a biological process that depends on providing nutrients in an environment favorable for microbiological decomposition. Common mistakes are failure to provide all the materials needed for food and aeration, or sloppy loading of primary bins so that materials are not "sandwiched." Too little straw (or alternate carbon source) results in a dense, anaerobic mass which will not compost.

Too much water is also a common problem. Saturated compost piles are anaerobic and will not support the desired aerobic, thermophilic bacterial growth required for rapid, odorless decomposition of carcasses.

Compost materials can be amended. When primary compost is turned, dry manure or straw can be added to compost that is "too wet," water can be added to compost that is "too dry," and improperly mixed materials can be remixed. A little experience and perseverance usually give good results in a short time.

Are composters biologically safe?

A. Mode of operation: Composters are intended to deal with normal mortality on the farm. It is not recommended that carcasses be transported from the farm where they originate, either to another poultry farm or to a central processing facility.

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Questions And Answers About Using Mini-Composters

What are the main differences between mini-composting and full-scale composting?

One difference between mini-composting and full-scale composting is in the equipment. Full-scale composting requires a tractor with loader for loading, turning, and removing large amounts of litter and compost whereas mini-composting requires manual labor to move small amounts of litter. Another difference is that full-scale composting requires a secondary bin for turning the compost. Mini-composting is a single-stage process that does not require turning.

What are some of the advantages of mini-composting over full-scale composting?

The major advantage of mini-composting over full-scale composting is cost. A mini-composter can be constructed for approximately 25 percent of the cost of a full-scale composter. In addition, front-end loading equipment is a major cost for full-scale composting. Such equipment is unnecessary for mini-composting. Another advantage is that less litter is required to operate a mini-composter than is required for a large-scale composter.

Why is turning the compost not necessary in mini-composting?

Turning the compost increases the air flow through the composting material. Mini-composters are constructed with spaces between side boards to allow air to flow easily through the material. The use of cake litter also helps to increase the air flow. These two factors make turning unnecessary.

What are the components of a mini-composting operation?

The components of a mini-composter are wooden boxes to hold dead poultry and other composting materials and a shed with a concrete slab. The 4 × 4 × 4 foot boxes are constructed from pressure-treated lumber with 1/2-inch air spaces between the side boards. The boxes are placed on concrete under a shed, which is separate from the poultry house. A shed ensures all-weather operation and controls the moisture content of the compost. Concrete prevents soil contamination, excludes vermin, and most importantly, provides an excellent working surface for manure-handling equipment.

How is the mini-composter operated?

The mini-composter is easily operated by an individual. First, place a 4- to 6-inch layer of litter on the concrete floor. If you are using straw, add it now. Next, place a layer of birds. When placing carcasses, be sure to keep them at least 6 to 8 inches away from the sidewalls of the bin. Cover the layer of carcasses with another 3- or 4-inch layer of litter. Repeat layers beginning with straw, then adding carcasses and litter. When the bin is full, cap the bin with a 6-inch layer of litter.

Should water be added?

Water is added to maintain a moist but not saturated condition. The use of cake litter may reduce or even eliminate the need to add water, depending on the moisture content of the cake itself. If it is necessary to use water, apply it to the cake. Add it only if you think the moisture content of the litter is insufficient.

Is the use of straw necessary?

Straw is used as a carbon source and as a passageway for air. If you use litter from a broiler house, it will contain wood shavings that should provide a sufficient amount of carbon. The mini-composter box is constructed with 1/2-inch spaces between the side boards. These spaces usually allow enough air flow. If you use caked litter, which does not pack down, straw is usually not necessary.

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Mini-Composters In Poultry Production

In 1992, Alabama ranked second in the nation in broiler production and produced approximately 900 million broilers, valued at nearly $1 billion. The poultry industry generates nearly half of every agricultural income dollar in Alabama, and current research estimates that production will expand 20 percent within the next 3 years.

While Alabama's poultry industry produces 18 million broilers every week, it generates 800 tons of carcasses weekly, as well. Every broiler production facility must face the reality of dead birds. Disposal of dead birds could be a serious environmental problem that may limit future expansion of the industry in Alabama.

Disposal Methods And Environmental Concerns

Producers most commonly use burial pits for the disposal of poultry carcasses. However, when residue remains in pits after years of use or in soils with high groundwater tables, reduced surface and groundwater quality is a serious potential problem. In some states, such as Arkansas, legislation has been enacted to prohibit the use of burial pits.

Incineration is biologically the safest method of disposal. However, it is slow, expensive, and generates nuisance complaints even when highly efficient incinerators are used. Incinerators also generate particulate air pollution.

Concern over possible environmental damage and newly imposed local, state, and federal water and air quality regulations make alternative disposal methods of interest to the producer. Dead-bird composting is one such alternative that the state Veterinarian's office, state and local health departments, the Alabama Department of Environmental Management, and the Soil Conservation Service (SCS) have approved.

Poultry Carcass Composting

Testing and adoption of composting as a method for the disposal of poultry carcasses began in Alabama in the late 1980s. Since 1989, Alabama poultry farmers have constructed more than 500 freestanding carcass composters. Poultry producers have readily accepted the composting of poultry carcasses, but operating the composter requires a tractor with loader for loading, turning, and removing the compost.

Because large broiler farms—those with more than two poultry houses—use tractors and loaders in their farming operations, they have adopted poultry carcass composting. On the other hand, small broiler farms—those with only one or two broiler houses—do not have tractors or loaders and have not adopted composting. About 50 percent of the 6,000 Alabama broiler farms fall into this last category.

Small-Scale Composting

In other states small-scale producers have constructed mini-composters for use in the broiler house. Researchers at the University of Delaware tested simple, single-stage composters (Scarborough, et al., 1992). These small composter bins were placed within the confines of the broiler house, and carcasses, straw, caked litter, and water were added daily. In Alabama, however, most producers usually place mini-composters outside of the broiler house.

Mini-composting works well for grow outs of approximately 7 weeks. If producers are growing large birds, added capacity may be required.

Building The Mini-Composter

The simplest design for a mini-composter consists of a wooden box to hold dead poultry and other composting materials. The portable compost box developed at Auburn University is 4 feet by 4 feet and 4 feet high with removable side panels. The box is constructed from pressure-treated lumber with ½-inch air spaces between side boards (figure 1).

The box can handle normal bird mortality (two to four carcasses per thousand per day). An

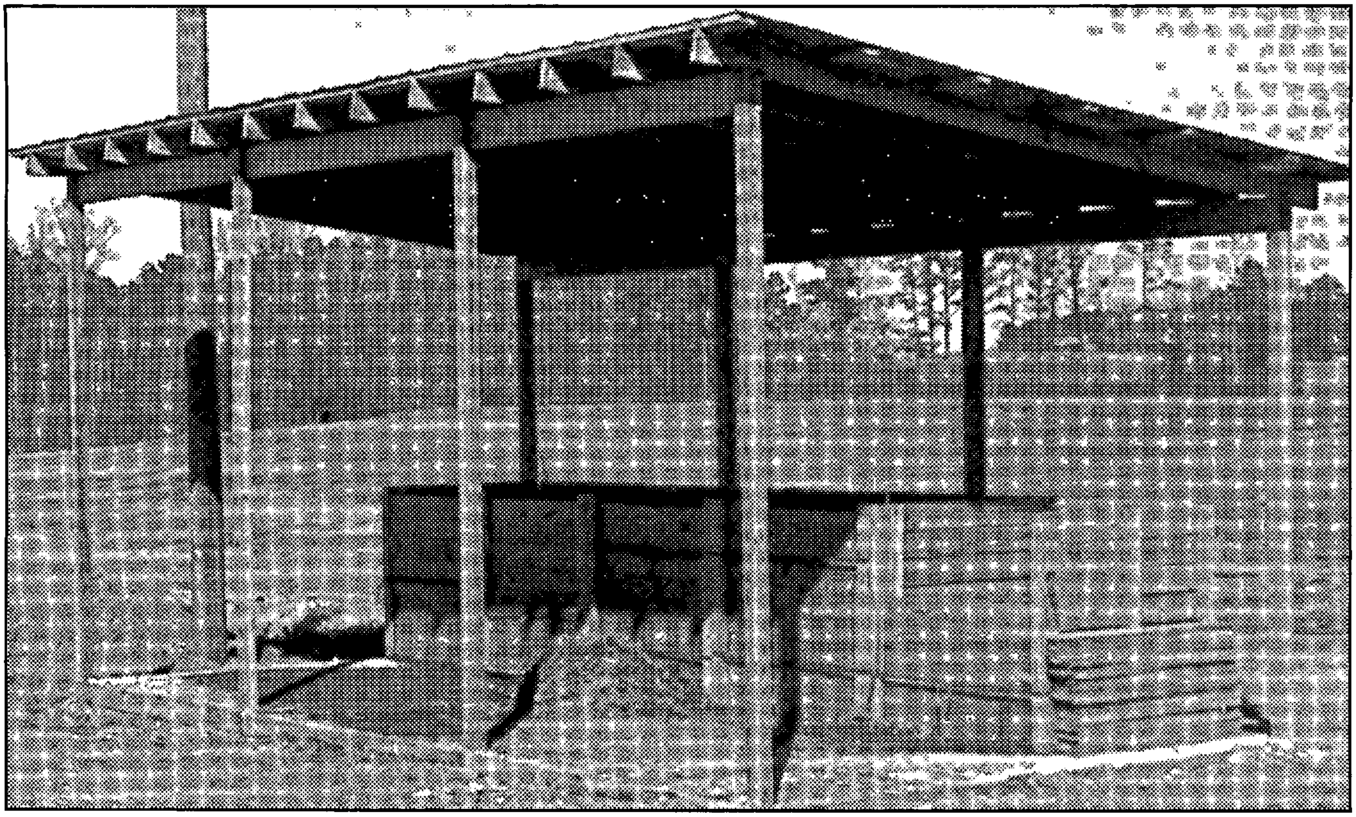

Figure 2. Mini-composting structure with compost boxes.

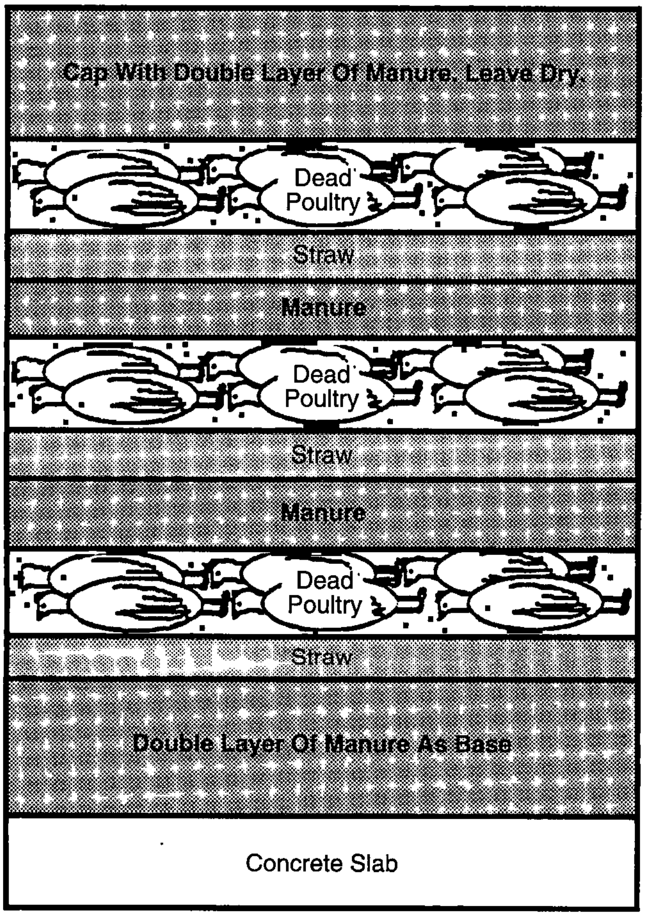

Figure 3. Layering of ingredients in composter box.

When adding additional water for composting, keep in mind the moisture content of the litter. The moisture content of poultry litter or cake may vary from 20 to 40 percent depending on the source. In small-scale composting, adding water to achieve a 50- to 60-percent moisture content is much more important than in large-composter management.

Monitor the temperature in the compost bin with a 20-inch, probe-type thermometer. After a few days, temperatures increase rapidly because of bacterial action, rising to 130°F or greater. After 7 to 10 days, the pile reaches its high reading of 130° to 150°F, which helps stabilize the compost. Once temperatures begin to decrease, you can easily move the composted material to storage.

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Use and Construction of Poultry Burial Pits

James O. Donald, *Extension Agricultural Engineer*
John P. Blake, *Extension Poultry Scientist*

Poultry, meat, and egg production facilities must deal with the disposal of farm mortalities on a regular basis. Newcomers to poultry production often do not contemplate this management requirement. It is, however, a never-ending chore.

Burial

An age-old method for the disposal of flesh and bones is burial. This offers a feasible method for the disposal of farm mortalities. If they are properly sized, located, and constructed, burial pits will operate satisfactorily. A disposal pit requires minimal labor and supervision but must be maintained in a sanitary, legal, and socially acceptable manner.

In the past, a trench was dug somewhere on the farm, and as sections of the trench were filled with mortalities, a back fill was made with dirt. There are many reasons why an open ditch on the farm is a hazard. Hunters, children, or trespassers of any kind can be injured by falls into such trenches, resulting in lawsuits. Dogs and wild animals may unearth dead birds or drag uncovered ones over much of the area. Weather is also a factor, particularly in winter, when wetness may prohibit access to the area and make back filling difficult. Due to these limitations, the trench method is no longer acceptable.

Approved Disposal Pits

Although it is impractical for a modern day poultry grower to dig a hole every day for the disposal of carcasses, burial is an appropriate means of disposal. Properly constructed poultry disposal pits are a convenient, sanitary, and practical method for handling poultry mortalities. They have been used with varying degrees of success by poultry growers. A disposal pit is simply a shored up hole in the ground with a small diameter opening at the top through which carcasses are dropped. The pit provides an environment for both aerobic and anaerobic microorganisms to decompose organic materials. If kept tightly covered, little if any odor is produced.

It is possible that future research may implicate burial pits with the contamination of ground water. The use of this method in relation to specific soil types may then be disallowed. At present, however, alternative means for disposing of mortalities are limited, and burial pits are in widespread use. Therefore, proper location, design, and construction of burial pits for the disposal of poultry farm mortalities are important considerations.

Location

Disposal pits should be located at least 25 feet from the poultry house and 200 feet from dwellings and wells. This type of disposal should be used only at locations where ground water level is well below the pit bottom and where soil type permits good infiltration of effluent from the disposal pit. Before constructing a disposal pit, make certain that the soil composition is acceptable. Technical assistance on location and design of burial pits is available from your county Soil Conservation Service office. Locate pits in soils where good surface runoff will occur.

The potential for disposal pits to cause ground water contamination is considerably less than occurs with septic fields; little water is produced from decomposition. However, water seeping into pits can cause problems. Avoid construction on a slope to keep rainwater from running into the pit. Do not construct a disposal pit on a flood plain or in low-lying areas, where water can seep into the pit. A minimal amount of rainwater will percolate through the pit floor, provided the pit is constructed to avoid accumulation.

Pit Size

A pit should be constructed to accommodate normal mortality. If heavy, unexpected losses occur, alternative methods of disposal must be considered. Determining the appropriate pit size will ensure proper operation for a long time. The poultry grower should consider the expected mortality rate, size of birds, and environmental conditions. The loading rate is a function of the mortality rate and size of the bird. During the first 3 weeks of growth, carcass size is small and insignificant. Beyond 3 weeks of age, loading rate sharply increases due to the rapid increase in growth rate of the birds. The following guidelines may be used for determining pit capacity:

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Installation and Use of Incinerators

James O. Donald, *Extension Agricultural Engineer*
John P. Blake, *Extension Poultry Scientist*

Every day the poultry grower is faced with the responsibility of disposing of dead birds. Mortality losses due to congenital defects, disease, or accident occur daily. In a flock of 100,000 broilers grown to 49 days of age, approximately 5,000 will be lost. That is an average loss of 0.1% each day.

Dumping carcasses into ditches, streams, and fields is not only unacceptable but also illegal. Proper disposal methods will reduce nuisance complaints from neighbors as well as safeguard the environment and reduce chances of disease transmission.

Methods suitable for the proper disposal of poultry farm mortalities are burial, incineration, composting, and rendering. Incineration is often the chosen alternative in areas where drainage is so poor that pits are not acceptable or where rocky soil makes digging expensive. Recognized as one of the most biologically safe methods of disposal, incineration curtails the spread of disease and does not create water pollution problems. The comparatively small amount of waste by-product (ash) does not attract insects or scavengers and can be disposed of easily. The main environmental concern is the emission of particulates that may be generated during the burning process.

Proper and acceptable cremation of dead birds is not obtained by merely drenching the carcasses with a flammable fluid and then igniting the stack. Not only is such an approach usually incomplete, but the resulting odors may prompt nuisance complaints. Home-made incinerators, usually constructed from 55-gallon barrels or other drums, are unsatisfactory because they do not meet current air pollution controls.

Commercial incinerators are the best equipment to ensure proper burn and to avoid creating pollution. The Alabama Department of Environmental Management requires the use of Class 4 incinerators for disposing of poultry mortalities. Units are available with oil or gas burners. Smoke discharge stacks may be fitted with afterburning devices which make use of high heat levels for near complete gas combustion. When purchasing an incinerator consider the following points:

Sturdiness: The unit should be able to operate under heavy loading conditions and withstand high operating temperatures.

Automatic Controls: A unit that can be loaded, ignited, and allowed to run on a timer is a real convenience.

Capacity: The poultry grower must estimate the expected daily mortality rate and consider bird size when calculating the incinerator capacity needed. The incinerator should be able to accommodate normal daily mortality. When heavy, unexpected losses occur, alternative methods of disposal should be considered. Selecting an appropriately sized unit will avoid overloading and ensure proper operation for a longer period of time. Manufacturers of commercial incinerators typically establish a burn rate for their units. This information can help in deciding the size unit to purchase.

Placing the incinerator unit in an appropriate location will promote convenient use and avoid potential problems. The unit should be down wind from poultry houses, farm residences, and neighbors. Exposure to the destructive elements of nature can greatly reduce the life of the unit. It is wise to place the incinerator on a concrete slab under a shelter to extend the life of the unit. Because of the intense heat that is generated, clearance between the discharge stack and any

CENTRAL PICK-UP OF FARM DEAD POULTRY

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Recycling of farm dead turkeys (mortality) is a better alternative than the environmentally negative on-farm practice of burial or incineration. Recycling by composting can be done on the farm, however, rendering or feeding to furbearers requires that the birds be transported from the farm in order to be utilized. Disease transmission is a serious risk when farm dead birds are hauled around and it is expensive. Another factor to be considered is the quality of the end product as it is affected by carcass spoilage and degradation, medication residue, and variation in size.

During an 18 month trial period in 1988-89, two integrated turkey operations and a large chicken layer operation participated in a cooperative pick-up and transport system to deliver farm deads to a renderer who already had a market developed for the rendered end product. We contracted with a local garbage hauler who spotted dumpsters of various sizes as needed on each of our farms to hold the dead birds and then scheduled daily or every second or third day pick-up depending on ambient temperature. We each paid a monthly rental fee for the dumpsters and shared in a daily pick-up service cost.

An accessible, but remote or end of the driveway, location was picked on each of our 15 turkey growout farms that were involved in the trial in order to minimize disease transmission. The other turkey grower/breeder operation involved 10 of their farms in the trial, but spotted all of the dumpsters they needed on one remote site off the farmsite and hauled their birds to the site from each farm with a special dumpbox pick-up truck. A separate trip from farm to the dumpsters was made for each pick-up and the truck was washed and disinfected between each trip. A chicken layer operation also used a remote on-farm dumpster site.

There was no indication or suspicion in any of our operations that transmission of disease occurred because of the pick-up system. Minnesota has avian influenza (AI) each year and two of the farms involved in the pick-up system did experience an AI outbreak during the trial, however, there was no spread to other farms or flocks in the system.

The raw bird material averaged 600 to 850 pounds per cubic yard depending on bird size and time of year. The daily quantity from all three operations ranged from 4 to 16 yards and from 1.5 to 6 tons. The tandem axle garbage truck could hold 17 yards. The renderer determined that when outside

CARCASS PRESERVATION SYSTEMS - EXTRUSION

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The poultry industry in the state of Missouri is expanding at a very rapid rate. Chicken broiler numbers and turkeys are expected to double in the next five years. This expansion is due to increased numbers at current production and processing facilities and new broiler and turkey processing plants under construction.

There is increased activity by EPA and DNR emphasizing the need to develop non-polluting utilization programs for poultry mortalities. This emphasis on clean land, air and water will play a vital role in the development of the poultry industry. A desirable disposal method would be to process the mortalities, converting them into a high quality feedstuff or feed that could be fed to poultry or livestock. One of the processing alternatives would be to develop the use of high pressure-temperature extrusion to cook and convert the mortalities into a sterile product that could be recycled. For the most part, the poultry industry is vertically integrated. This provides an opportunity to review the possibility of different processing techniques to stabilize the mortalities producing a product that would be suitable for use in feeding programs.

The estimated annual broiler, turkey and layer mortalities in the United States represent over 1 billion pounds of product. This quantity demonstrates that the magnitude is sufficient to warrant processing evaluation. The quantity available at one general location will dictate the processing technique. If the project is sufficiently large a normal rendering operation would probably be justified. On the other hand if the operation is more modest in size it could be feasible to use an extruder to process the mortalities. It is important to take into consideration all of the cost factors when deciding on the type of process. Some things to take into consideration are:

- -the feasibility of the process
- -the logistics of storing and transporting the mortalities
- -the overall economics of producing a product for feeding or sales

This discussion will be restricted to extrusion and its association with carcass preservation.

barrel, is sterile. The challenge is to minimize recontamination producing a feed or feedstuff with a very low microbiological count.

The chemical composition of broiler and turkey mortalities are shown in Table 1. It is evident from these results that there is a marked difference between broilers and turkeys with respect to protein and fat and that there is an increase in fat as both broilers and turkeys get older. The procedure utilized in the studies reported here was to blend soybean meal 48% protein at 75% and ground broiler or turkey mortalities at 25% on a wet basis to produce new ingredients for evaluation. Table 2 provides you with the level of broiler and turkey in the complete broiler starter diets. The level of mortalities included in the various diets was approximately 4%.

Table 1. Chemical composition of poultry mortalities

	Moisture	Protein	Fat
Broiler Mortality		(%)	
3 Wk	70.08	58.41	29.15
5 Wk	65.94	54.32	33.08
Turkey Mortality			
6 Wk	72.42	70.90	10.57
12 Wk	69.91	71.86	13.89

Table 2. Composition of broiler diets (DMB)

Ingred.	Corn-Soy Control	Broiler Mortality 3 Wk	Broiler Mortality 5 Wk	Turkey Mortality 6 Wk	Turkey Mortality 12 Wk
			(%)		
Corn	49.83	52.42	52.42	53.68	53.68
Soy 48	37.87	----	----	----	----
Fat	8.19	6.47	6.47	6.96	6.96
Soy 48*	----	33.20	33.20	31.70	31.70
Broiler Mortality					
3 Wk	----	4.10	----	----	----
5 Wk	----	----	4.10	----	----
Turkey Mortality					
6 Wk	----	----	----	3.92	----
12 Wk	----	----	----	----	3.92
Other	4.11	3.81	3.81	3.74	3.74

* Amount of Soy 48 extruded with mortalities

Table 4. Aerobic microorganisms in poultry mortalities before and after extruding[1]

	Before Extruding	After Extruding
Broiler mortality	----- (cfu[2]/g)	-----
3 Wk	200	0
5 Wk	200	0
Turkey mortality		
6 Wk	4500	0
12 Wk	32	0

[1]75% Soybean meal+25% mortalities.

[2]cfu =Colony forming units.

Conclusions: There are certain factors that need to be considered when preparing diets using extruded mortalities. These include; nutrient composition of the mortality, moisture or water content of the mortality and the nutrient requirement of the species that is scheduled to consume the new feedstuff. The extrusion process can be used to manufacture nutritionally adequate broiler diets containing ground broiler and turkey mortalities.

Ground broilers and turkeys can be included at approximately 4% in broiler starter diets. The extrusion process produces a sterile product.

The philosophy with respect to mortality utilization should be "Waste Not, Want Not". With proper management mortalities can be utilized effectively minimizing pollution problems.

CARCASS PRESERVATION SYSTEMS — LACTIC FERMENTATION

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Dobbins (1988) described a method of preserving poultry carcasses by lactic fermentation, and he reviewed studies showing the efficacy of the fermentation for destruction of a wide range of viruses. His report, and others (Hassan and Heath, 1986, 1987; Szakacs et al., 1985), stimulated studies at the University of Maryland to investigate lactic fermentation as a means of disposing of normal broiler mortality, and of recovering valuable nutrients for refeeding.

Maryland studies are addressing three major objective areas: 1) the fermentation process per se, and its' variables, 2) the economic value of the endproduct and, 3) the biological and engineering technology needed to process and recover mortality from broiler farms. Todays' presentation will review results of studies of the fermentation process.

THE PRODUCT: Reactions described in the remainder of the paper are relating to the production of a characteristic product, "broiler silage", which has a pH of 4.3-4.5, is semi-liquid, which is cidal for enterobacteria, and which is stable at room temperature. Typical broiler silage produced by Maryland methods is composed of 62% water, 17% protein and 16% fat.

FERMENTATION VARIABLES: Among the variables that are critical for the conversion of dead birds to "broiler silage" are:

a. Acidophilic, anaerobic bacteria capable of fermenting carbohydrates to short-chain organic acids.

b. A fermentable carbohydrate, mixed with ground carcass and in proportions to carcass which will support a complete and vigorous lactic fermentation and,

c. Suitable temperatures and reduction/oxidation conditions for the rapid metabolism of carbohydrates to organic acids.

BACTERIA: Bacteria capable of converting carbohydrates to organic acids may be found in the normal, healthy gut of the broiler (Barnes et al., 1972) or may be added to fermentations from any of several strains of lactobacilli or S. faecium (Hassan and Heath, 1986/87; van Wyck and Heydenrych, 1985). Figures 1 and 2 show effects of supplemental L. plantarum and S. faecium inocula on acid production and bacteriocidal activity of broiler silage fermentations. Unsupplemented (control) fermentations depending solely on normal intestinal flora were comparable to those with a variety of L. plantarum and S. faecium commercial fermentation strains. Further studies of fermentations with decomposed carcasses are needed before concluding that normal flora are adequate for lactic fermentation in all cases, however.

ground, whole, broiler carcasses are possible using the normal gastrointestinal microflora of the broiler, with a variety of mono- and disaccharides, and at incubation temperatures of from 37-41° C. Further studies of the feeding value of "broiler silage", and of methods to further process it, are in progress now.

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FIGURE 3. Effect of Carbohydrate Type on Acid Production

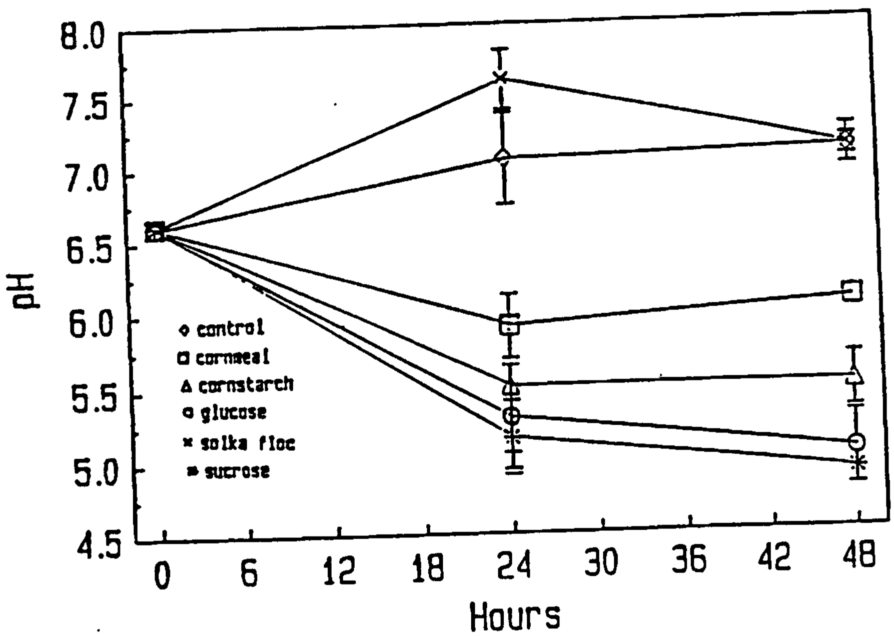


FIGURE 4. Effect of Carbohydrate Type on Survival of Enterbacteria

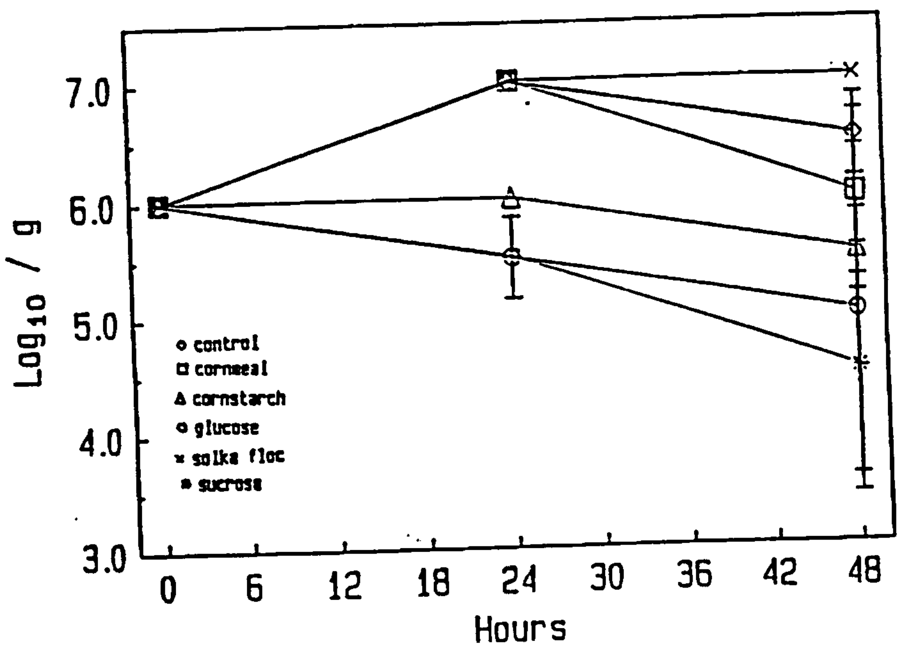


FIGURE 7. Effect of Varying Proportions of Industrial (CH_2O) by-products on Acid Production

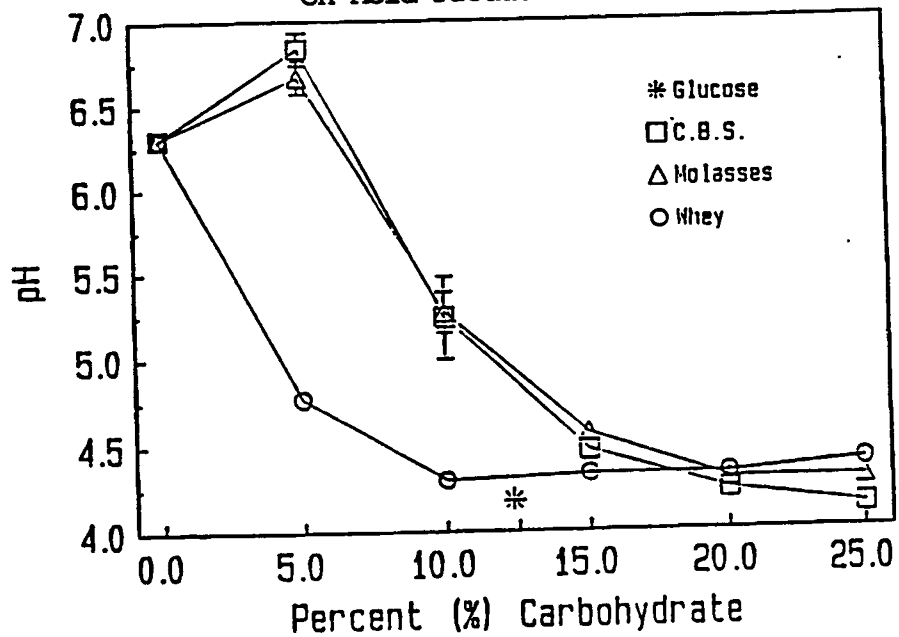
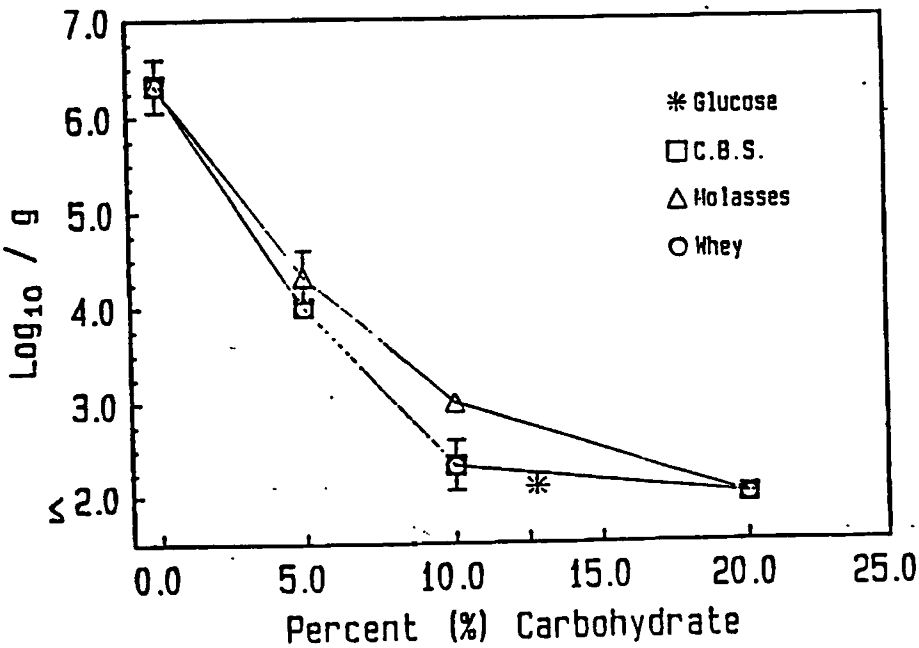


FIGURE 8. Effect of Varying Proportions of Industrial (CH_2O) by-products on the Survival of Enterobacteria



Poultry By-Product Management
POULTRY SCIENCE
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The Poultry Farmstead

R. N. Brewer, *Extension Head, Poultry*

A poultry farm is an agribusiness and should project pride of ownership which will indicate careful production of a high quality product. Success in business depends upon many factors: sound operating practices, committed employees, an adequate financial base, proper equipment and facilities, public perception, and pride of ownership. The latter two may be the most important of all! The face you show to the public determines the attitudes the public will have about the quality and acceptability of the products you market. The consumer equates a neat, orderly business with quality products and considers with suspicion the output from a shabby operation.

Appearance

Too often, when planning the location of buildings on a poultry farm, consideration is given just to labor efficiency and convenience. If the total appearance of the farmstead is overlooked, a negative impact on the image of the farm *business* may result. A general farm plan, designed with both utility and beauty in mind, will have no additional building costs and may require fewer hours each week to maintain. Proper landscaping can be incorporated into the plan to add beauty and reduce harborages for insects and animals that can be a problem for poultry production.

Research at Auburn University has shown that there is a direct correlation between appearance of the farmstead and performance in the poultry house. A recent study involved 200 poultry farms, half of which were consistently in the top one-third of all company growers and half of which were in the bottom one-third. Those having neat, well-cared-for farm homes, yards, storage facilities, and farm buildings were always the most profitable! How can this be? The conclusion was that farmers who take pride in their farmstead and pay attention to details also want the best possible management of the poultry house. This extra care always pays off in better performance and top money. Your company field representative is charged with advising you on the proper care of the poultry flock. Contact your county Extension agents for help with general farm planning, landscaping and management. It will pay dividends.

Housekeeping Around the Poultry Facility

As owner of a poultry farm, you will be setting priorities for yourself and others employed in your operation. Working to be a top poultry producer requires that you first be a good husbandman for your chickens. This means providing them with the best in-house care that you can muster. Proper temperature, ventilation, litter conditions, feeding, watering and flock health management are critical and will be monitored by you and your company field representative. However, there are many variables outside the poultry house that can have an impact on bird performance and on the long-term success of your business. The following is a list of some of these and suggestions for management:

Water Control - Since not many poultry houses are located on level ground, the poultry

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Guidelines For Proper Siting Of New And Expanded Poultry Facilities

James O. Donald, *Extension Agricultural Engineer*
John P. Blake, *Extension Poultry Scientist*

Today's poultry producers share increasing concern for the state of the environment. As a result they are examining their facilities closely to make certain that operations are in compliance with new and proposed regulations. The greatest impact on these farmers will come from the manure management and farm mortality disposal guidelines. In order to add necessary waste management structures, future growers should incorporate farmstead planning to a greater extent than has been done in the past.

Poultry production began as a part-time enterprise; either the growers worked full-time away from the farm, or poultry production was a small part of a larger overall farm operation. As a result, environmental factors such as siting, drainage, and manure disposal were not seriously addressed. It was not uncommon to have two 40' x 400' houses with 21,000 birds each on 5 acres of land. Manure from cleanout was piled outside until contractually removed; often dead birds were buried on site. Such practices have been shown to lead to ground water contamination.

Environmental planning of poultry facilities should include proper site selection, waste storage, and waste application. Guidelines concerning the first two factors involve farmstead planning.

Site Selection

Site selection for poultry housing was previously based on the idea that buildings should be close enough to the farm center to minimize travel time but far enough away from the home to keep odors and dust from residents. With the pressure of increased commercial and residential development in rural areas, visual attractiveness and sources of possible contamination from poultry operations must also be considered. Broiler houses should be located so as not to be visible from the road. When this is not possible, a viable alternative is to screen the houses with a vegetative windbreak or fence. Screening will not only lessen the visual impact of the production facilities but will reduce dust and odor emissions leaving the immediate area. A grower who constructs poultry houses close to a property line must consider that adjoining property may not continue to be used for agricultural purposes and could be subdivided in the future.

In determining the location of a poultry facility, the prevailing direction of wind should also be considered. It is best to locate a poultry facility downwind from the farm residence. An adequate windshed area should be established so that the prevailing winds will disseminate odors and dust with little effect on neighboring residences (Figure 1). Following such common-sense guidelines assures that poultry facilities will be located to reduce the impact of nuisance complaints.

Drainage

Surface and subsurface drainage around the site must be examined closely. Obviously, no buildings should be located in low-lying areas which are subject to periodic flooding. Surface

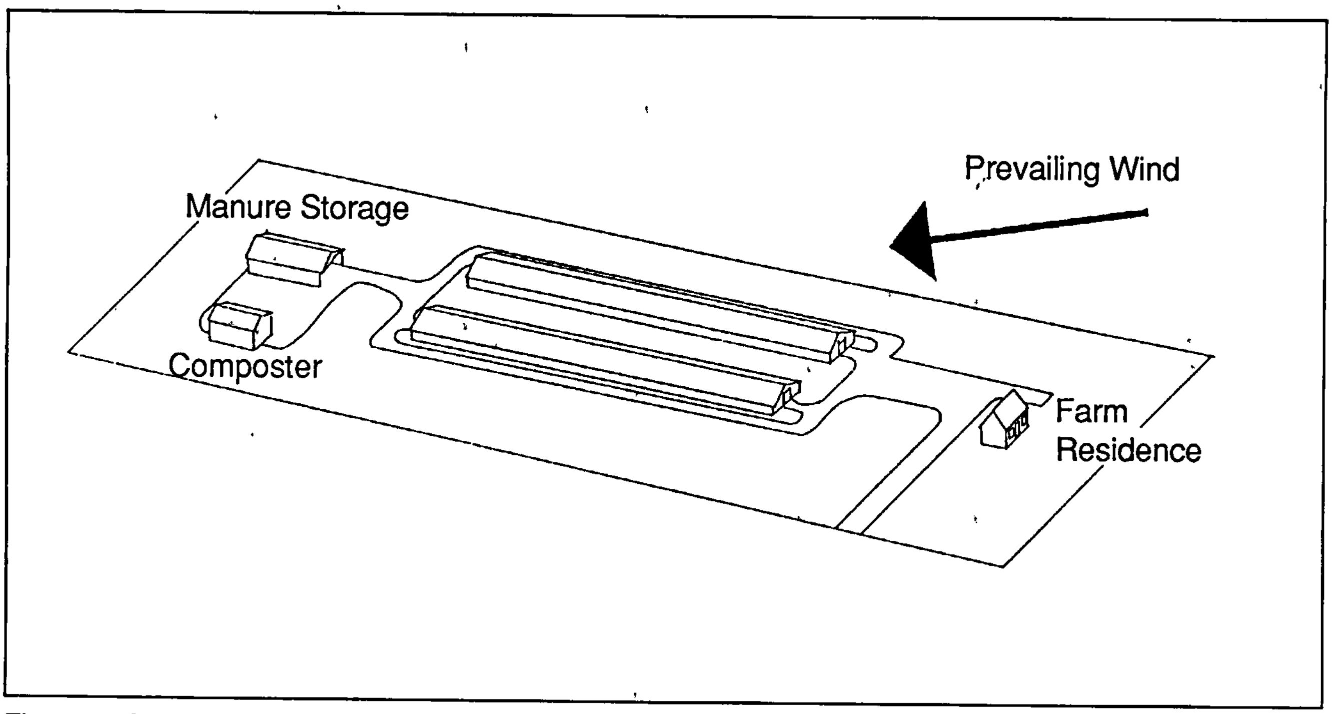

Figure 2. Siting of a typical broiler operation.

broiler houses are no closer to the residence than 100 feet. Normal summer and winter prevailing winds will carry odors away from the residence. The broiler houses and manure storage shed/composter may be screened from the road and from adjoining neighbors by a vegetative windbreak or fence. Surface water flow is away from all buildings toward the back of the property. All roads are crowned and ditched to flow water away from the complex. By using such practices, a poultry producer can greatly reduce or eliminate environmental problems.

Manure Storage Structures

Manure storage sheds are generally 40 feet wide with a 12-foot to 16-foot clearance. Structure length varies according to the amount of manure stored. Construction is post frame with a 2' x 6' double wall interior of treated lumber to withstand the strain of piled manure and front end loaders. Above the double wall, plywood is used on the outside to within about 2 feet of the eave. The building is typically three-sided, a rectangle with one end open.

If a separate manure storage structure cannot be economically justified, a stack or windrow may be used if the site is properly prepared beforehand. If manure is to be stored for more than one month, an impervious (concrete, etc.) pad must be available for stacking the manure. Manure can be stacked for short periods of time on bare earth if the site is well drained with no surface water flowing toward it. A stack or windrow should be covered with a well-secured synthetic tarpaulin. This will not only keep the stack dry for ease of handling but also reduce fly and odor problems. If the stack is on bare earth, care must be taken to remove all the manure to avoid creating an area of high salinity and nitrate-nitrogen with a potential for ground water contamination.

Manure storage buildings should be located close enough to the poultry facilities to minimize travel time. However, they should be located far enough away to reduce any disease transmission between flocks in houses. A distance of about 100 feet is a reasonable compromise. All manure storage structures should be screened from the road and neighbors to avoid potential nuisance complaints.

Dead Poultry Disposal

Part of any waste management plan should include a means for carcass disposal. In the past, farm mortalities were often buried on site, and no real problems were recognized. Such practices are now inadvisable and even illegal in some areas due to the potential of ground water contamination in areas of high water tables. One solution is to compost the carcasses in solid manure and then apply the resultant compost to

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Preventing Ground and Surface Water Contamination by Poultry Waste

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Poultry waste has the potential of being either a resource or a pollutant. It can be utilized as fertilizer, soil amendment, plant bedding, or cattle feed. However, without proper management, poultry waste can have an adverse environmental impact.

In explaining why poultry waste management is a water quality concern it is necessary to (1) identify the characteristics of poultry waste, and (2) describe possible impacts on surface and ground waters.

Value of Poultry Waste

Many characteristics of poultry waste which give it potential value as a resource are the same characteristics that make it a potential pollutant. The value of poultry manure as a nutrient source for corn, small grains, fruits, and vegetables has been recognized for a long time. When poultry manure is applied to land, the amount of nitrogen in the manure will depend upon how the manure was handled and stored. If manure is not incorporated when it is applied to land, 60 percent of the available nitrogen in poultry manure may be lost after 7 days. The values in the following table provide an estimate for the nutrient content of poultry manure while accounting for storage losses (Isaac and Harris, 1987).

Impact of Poultry Waste on Water Quality

The effects of poultry waste on water quality depend in part on the physical, biological, and chemical characteristics of the water body. The effects are considered a water quality problem if they impair the designated use of the water. Poultry waste can enter a water body by leaching through the soil, from runoff in areas where the waste has been applied to the land, or by direct discharge. Potential water pollutants in poultry waste may be classified as (a) nutrients and salts, (b) oxygen-demanding substances, (c) suspended materials, and (d) pathogens.

Nutrients and Salts

Potential ground water contamination from poultry manure may occur from stored poultry manure or land application sites. The major ground water contaminant is nitrate nitrogen.

Applying high levels of poultry manure has been shown to produce high nitrate concentrations in

Table 1. Nutrient Content of Poultry Manure*

Type	Total Nitrogen	Available Nitrogen	P_2O_5	K_2O
	pounds per ton			
Broiler total cleanout	80	50	80	44
Broiler crust	44	24	36	24
Layer manure	40	24	20	10

*Values given in terms of wet weight of manure as applied to land.

the reproductive process. As a high level of suspended matter settles, it can interfere with channel flow and reduce reservoir storage. Suspended matter can give the water a turbid appearance and reduce visibility. Low density organic matter floating to the surface can be aesthetically unpleasing. However, it may be costly to remove suspended matter from domestic and industrial water supplies.

Pathogens

"Pathogens" as used here include all disease-causing organisms, including but not limited to bacteria, viruses, fungi, and parasites. Animal waste is a potential source of approximately 150 diseases. Pathogens in water can infect humans through drinking water, through contact with the skin, and through consumption of aquatic animals. The presence of pathogens is not just a concern for humans. It can also cause problems through reinfection of the animal chain. Most pathogens will die off in a relatively short time, but under the right conditions they may live and persist longer in ground water than in surface water. Often the presence of non-pathogenic organisms (most notably E. coli) is used as an indicator for determining the presence of pathogenic organisms.

Factors Affecting Runoff Characteristics

The quality of runoff from a given area is influenced by the quantity of runoff, and thus by those factors that determine runoff generation. These include soil characteristics (structure, texture, organic matter content, etc.); topographic features (slope, drainage, etc.); soil cover; surface micro- and macro-features (soil roughness, etc.); precipitation type, rate and duration; antecedent soil moisture content; and, in some cases, location of the water table below the soil surface. Humans have varying degrees of control over these factors ranging from no control to total control.

Runoff quality is influenced also by the characteristics of the media (soil/plant ecosystem) with which the runoff comes in contact. These include the physical, chemical, and biological properties of the soil/plant system, which are in turn influenced by the characteristics of any amendments that may be added to the system. Further, the rate at which amendments are applied and the manner in which they are applied affect runoff quality.

Two other influences may be less obvious: time between manure application and runoff, and environmental conditions. Animal manures are unstable, biological products, the characteristics of which are changed by a variety of physical, chemical, and biological processes. All of these are influenced by the environment in which they occur, as defined by such parameters as temperature, relative humidity, and wind velocity. These processes are also a function of time, which determines the rate and extent to which reactions proceed.

Best Management Practices

Best management practices (BMPs) should be used for both poultry manure storage and manure application. If broiler manure is to be stockpiled for long periods of time, a polyethylene liner should be installed on top of the pile to prevent leaching and downward movement of nitrogen from the pile. Care should be taken to remove all manure from the stockpiled site when the manure is applied to land. A small layer of manure left on the site could result in downward movement of nitrogen. An alternative to a polyethylene liner is to construct a permanent manure storage structure.

In applying poultry manure to cropland, the key to reducing ground water contamination is nutrient management. The following BMPs emphasize nutrient management:

1. applying only enough manure for the nutrients to be utilized by the crop,
2. manure nutrient analysis,
3. soil testing,
4. calibration of manure spreader,
5. timing of application, and
6. liming.

Only enough nitrogen to supply crop requirements should be applied. In order to determine the correct amount of manure to apply, it is important to have the soil tested and the manure analyzed and to know the rate at which a particular manure spreader will apply manure at different ground speeds.

Broiler management and manure cleanout practices in the broiler industry have changed significantly in the past 15 years. This has caused a change in the nutrient content of the manure being applied to cropland. In some cases, growers are removing only the cake, which would have a nitrogen content different from that of the manure removed by a complete cleanout. A farmer can have his manure analyzed by a commercial laboratory at a cost of $20 to $30 per sample.

When precise amounts of nitrogen are being applied to cropland, it is important to have the manure spreader calibrated. Circular 006 in this series outlines the manure spreader calibration process.

The awareness of potential water quality problems associated with poultry waste emphasizes the importance of poultry waste management. With proper management, not only can pollution from poultry waste be prevented, but the value of poultry waste as a resource can be realized.

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Fly-Control in Poultry Operations

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Many species of manure-breeding flies can create problems on the farm and within the community if manure-handling systems are not managed properly. With the development of residential districts within prime agricultural areas, flies dispersing from poultry operations can become a significant public nuisance and a health problem, which can lead to poor community relations and even litigation.

Most fly-control problems develop in caged-layer operations and, less frequently, on breeder hen farms. Occasionally, problems may develop on broiler farms because the poultry houses become flooded with water or because unprotected litter is stored outside.

Flies have four stages of development: egg, larva (maggot), pupa, and adult. The rate of development, which varies with the species and the environmental conditions, is affected by the temperature and moisture levels within the breeding area. Moist manure attracts adult flies and provides ideal breeding conditions.

House flies are usually the predominant species present around poultry operations. For this reason, they will be the only species discussed in this manual. However, producers should be aware that stable flies may become a serious problem during the summer months if broiler litter is stored outside in unprotected piles.

House flies are non-biting flies that breed in fresh manure, decaying silage, spilled feeds, bedding, and other decaying organic matter. Adults feed on manure and animal secretions with their sponging mouthparts.

Under ideal conditions, house flies can complete their life cycle in as few as 7 days. On the farm, most generations of flies require about 2 weeks to develop in summer. Each female can produce 120 to 150 eggs, which are laid in at least six batches at 3- to 4-day intervals. Eggs hatch in 8 to 24 hours, and maggots feed for 4 to 7 days. Mature maggots usually crawl away from their breeding site, seeking a drier environment for pupation. Adult flies emerge in 3 to 4 weeks.

Moisture levels of 75 to 80 percent are best for the egg-laying, larval development, growth, longevity, and survival of house flies. Fresh poultry manure is 75 percent moisture. Female flies usually will not lay eggs in manure with less than 70 percent moisture, and larvae develop poorly with less than 65 percent moisture. So the producer should keep the litter as dry as possible, unless a flush-lagoon system is used. The best moisture levels for pupation range from 40 to 60 percent.

From twenty to thirty generations occur during the fly season. Within environmentally controlled livestock housing (such as high-rise or deep-pit poultry houses), suitable breeding conditions may be present year round. Broken eggs, leaky waterers, and dead birds in the manure storage add to the problem.

Sanitation, moisture control, and manure management are critical to a successful fly-control program because these measures can break the fly reproduction cycle. The number of suitable breeding sites must be kept to a minimum, and the development of the fly's natural predators must be encouraged. The producer may use appropriate insecticides when necessary, but chemical control works best in conjunction with good sanitation practices. Preventing heavy fly buildup is easier and less expensive than controlling large fly populations after buildup has occurred. If pesticides are applied directly to the manure or fed through animals for fly control,

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Rat Control In Poultry Houses

James B. Armstrong, *Extension Wildlife Specialist*

Rats may be harmful to poultry production by transmitting disease, killing or injuring stock, or eating and contaminating poultry feed. Norway rats (Rattus norvegicus) and roof rats (Rattus rattus) are not native to North America. They arrived on boats from Europe along with the early settlers. While these introductions were not intentional, these adaptable species have established themselves as permanent residents.

Problem Rats

For the most part, native rodents such as voles, field mice, and cotton rats do not cause many problems to poultry producers. These species are generally held in check by natural predators, habitat restrictions, and other limiting factors. Most rat complaints in the poultry industry involve the non-native Norway rats and roof rats.

Norway rats, sometimes called wharf rats, weigh about 1 pound. Their hairless tail tends to be shorter than the head and body. The body is thick, the eyes and ears small, and the nose blunt (see Figure 1).

One characteristic that makes Norway rats so troublesome is their ability to live in close association with humans. They will nest under buildings and concrete slabs, along stream banks, or in garbage dumps. Often they will burrow under the foundations of poultry houses and develop an elaborate burrow system with an entrance and several escape holes.

As with all animals, Norway rats need food, water, and shelter to survive. Poultry houses provide all three habitat components in close proximity. Norway rats prefer grains, meats, nuts, and some fruits. Grains and meat generally are available in poultry houses. While Norway rats will eat nearly any type of food, they prefer fresh items to stale or contaminated foods. When one considers the habitat preferences of the Norway rat, it is evident why poultry houses are often plagued with these pests.

Although Norway rats can climb, they tend to inhabit the lower floors of multi-story buildings. In poultry houses, Norway rats may be troublesome close to the ground, while roof rats may inhabit the rafters.

Roof rats are sometimes called black rats. As their name implies, roof rats are more aerial than Norway rats. They may be found in trees, vine-covered fences, or the rafters of poultry houses. They often enter buildings from the roof or from utility lines.

Like Norway rats, roof rats will eat almost anything. However, they differ in appearance from Norway rats in that they are generally not as large, the body is light and slender, and the tail is long. They have a pointed muzzle, and have larger eyes and ears (see Figure 2).

Figure 1. Norway rat.

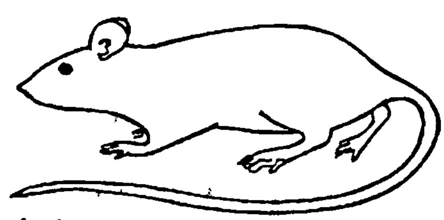

Figure 2. Roof rat.

lowing them to feel more secure; keep non-target animals away from bait; and help prevent accidental spilling of bait. In addition, bait stations allow easy inspection of bait to determine use.

Bait stations do not have to be elaborate structures. They can be made by nailing flat boards at an angle to the wall. This provides a protected area between the board and the wall. An 18-inch length of pipe (2 to 3 inches in diameter) may be used as a bait station. A more elaborate design is a wooden box with a 2 1/2 inch hole in each end. The top of the box is hinged to allow inspection of the bait. Some of the rodenticides may be purchased in a commercially-manufactured bait station.

Bait stations should be placed in areas of rodent activity. Placing the stations between the rodents' shelter and food supply will increase exposure and use. Bait stations should be placed near the wall, as rats will normally use these areas for travel.

Traps are the best method of rodent control where poisons are inadvisable. Common snap traps, glue boards, and live traps may all be effective if rat numbers are low. For roof rats, the traps should be placed along beams, rafters, or other travel ways.

Conclusion

Controlling rats in poultry houses involves a combination of exclusion, sanitation, and wise use of rodenticides. Where possible, rodents should be excluded by blocking or sealing all areas where rats may enter the building. Excess grain, waste materials, and carcasses should be properly stored and disposed of. A judicious program of rodenticide use will help control rat populations before they increase. Rodenticides also may be used to bring problem rat populations into check. However, only using rodenticides will not provide long-term relief from rat infestations. Rodenticides must be used in conjunction with exclusion and sanitation efforts.

Portions of this publication were adapted from Prevention and Control of Wildlife Damage, R.M. Timm, editor, Nebraska Cooperative Extension Service, University of Nebraska-Lincoln.

Poultry By-Product Management
Natural Resources
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Controlling Coyotes and Dogs Around Poultry Houses

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Coyotes are not new to Alabama; there are records of coyotes being killed in Alabama as far back as the early 1920's. Whether these coyotes were introduced or native is not clear. However, coyotes were introduced into Alabama by fox hunters during those same years. These introductions, coupled with a natural eastward expansion of their range, has led to an increasing coyote population in the state. Evidence of this expansion in Alabama is supported by the increase in incidental coyote kills. Hunters reported killing 5,264 coyotes in all the years from 1965 to 1986. Yet more than double this amount–10,995–were killed in 1986-87, and 13,137 in 1987-88. A survey of county Extension agents in Alabama indicated more than 1100 complaints about coyotes in one year.

Coyotes are opportunistic feeders, preferring a food source that may be obtained most easily. An examination of coyote droppings, or scat, along travel lanes will reveal the presence of a variety of food sources, ranging from the hair and bones of small mammals to persimmon seeds. Given this opportunistic tendency, if there is an available food source associated with a poultry house, coyotes may use the area. In addition to coyotes, free-ranging or feral dogs may visit poultry houses in search of an easy meal. While coyotes and dogs will kill poultry, proper construction of holding facilities should exclude them.

Damage Identification

Exclusion and control techniques for coyotes and feral dogs are essentially the same. However, it may be useful to know which animal is involved in the damage. Pure coyotes may be identified by the erect ears, white lip, and a tail that hangs down. Mature coyotes will weigh between 25 and 35 pounds. Feral dogs vary greatly in size, depending on the domestic breeds in their background. Dogs may have erect or drooping ears and a tail that is held in an up position. The coat color of a coyote is salt and pepper gray; the coat color of feral dogs is extremely variable.

Coyote tracks are similar in appearance to dog tracks. However, they are generally longer and narrower, and the middle toes turn inward. There is a great deal of variation in paw sizes and shapes, so it is not always possible to make a positive identification based on a track. Coyote scat is very similar to that left by dogs. However, the free-ranging nature and omnivorous food habits of coyotes will generally be evidenced in the scat. Depending on the time of year, coyote scat may contain rodent hair, deer hair, persimmons, and a host of other food items.

The presence of coyotes and feral dogs may also be verified by locating dens. They will "den up" under old brush piles, trash, hollowed stumps, or any other available protective site.

Dogs that are harassing and killing poultry may be strays that have been abandoned, or they may be family pets that are allowed to roam freely throughout the country. Whether the depredating species is a coyote or a dog, many of the ways to reduce the damage are the same.

Ways to Control Coyotes and Dogs

The adage about an ounce of prevention being worth a pound of cure is applicable in almost any animal damage control situation. Coyote/dog