Controlling Struvite Buildups

Magnesium ammonium phosphate, sometimes called struvite, is a grayish-white crystalline salt that builds up on the internal pump and piping surfaces used for lagoon liquid recycling. It usually appears on metallic surfaces but can also form on plastics. Steel, cast iron, bronze, and brass are equally susceptible.

Struvite usually builds up on the internal pump components first, then moves outward to the discharge pipes. It often occurs at pipe joints, elbows, valves, or imperfections because microscopic grit and solids tend to lodge at these points, providing a base for the salt to grow. Predicting struvite is difficult because its cause is not well known. Design, maintenance, and management techniques have been researched that can reduce the buildup to acceptable levels.

Pumping and Piping System

Use only high-quality, low-pressure, self-priming centrifugal or submersible pumps. They should not be oversized in relation to the piping network, and should perhaps be on a timer. The suction pipe should also be large enough to prevent pump cavitation. Normally the suction pipe diameter should be one size larger than the discharge pipe. Locate the pump close to the high-water level to minimize suction lift. Replace fine mesh suction intake strainers with wire screens or baskets of 1-inch mesh or larger. The diameter should be at least five times the diameter of the suction pipe. Struvite will also build up on the screens.

Use nonmetallic pipes and fittings. Pipes should be large enough to maintain flow velocities between 3 to 5 feet per second; the minimum pipe diameter at any point except at the immediate discharge point should be 1.5 inches. Sharp pipe bends (elbows and tees) should be avoided. Instead, use flexible plastic pipe and long sweep elbows for the direction changes. The system (pumps and piping) should have sufficient capacity to work only one-half to two-thirds of the time, and piping systems not in continuous use should be drained between pumping events.

Electrostatic Charges

Stray voltage is also believed to contribute to struvite. Direct grounding of the pump housing can discharge any static charges. A metal rod should be placed 10 to 12 feet into the moist soil near the lagoon's edge, and cable connections at the ground rod and pump should be checked periodically for corrosion.

Lagoon Management

Lagoons should be properly sized. New ones should be charged at least half full of water before startup, and the liquid level should be brought up to design levels as soon as possible. Rainfall during normal years dilutes lagoon liquid while extended periods of hot, dry weather increase nutrient and salt levels and the rate of salt buildup in recycling systems. Flushing with fresh water or irrigating with a portion of the lagoon contents may help.

Acid Cleaning

Salts can be dissolved with dilute acid treatments. Several doses followed by flushing the spent acid solutions will be needed to treat heavy buildups. A more thorough and more costly method is to install an acid recirculation loop. Use a 150-gallon acid-resistant tank as the reservoir. You will need enough solution to fill

the pipe length and some in reserve to keep the recirculation pump primed. Use the accompanying table to determine how much acid you will need.

Table 1.—Amount of solution needed for acid cleaning using an acid recirculation loop.

DIAMETER OF PIPE (INCHES)	SOLUTION NEEDED PER FT OF LENGTH (GALLONS)
1.0	0.06
1.5	0.13
2.0	0.20
2.5	0.29
3.0	0.43
4.0	0.70
6.0	1.53

To reduce the size of the tank, isolate sections of the line with valves and circulate the acid through only one section. The flush pump suction is switched from the lagoon and connected to the bottom of the acid tank with a quick-connect coupling. A 1-inch line returns acid from the end of each treated pipe section to the tank.

Hydrochloric acid can be purchased at most chemical supply houses or paint stores. Dilute the acid with water on a 1 to 9 ratio — 1 gallon acid to 9 gallons of water. Use caution. Mixing acids with water is a hazardous operation. Partially fill the tank with water, then add the acid slowly to the water. Eye protection is essential, and heat will be generated. To treat heavy struvite buildups, recirculate the mixture overnight and count on using the mixture only once. Spent acid may be dumped into the lagoon. Acids currently cost about $14 for a 15-gallon drum or about $33 for a 50-gallon drum. Deposits on the drums are $25 and $50, respectively.

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Protection Against Pests, Predators, and Darkling Beetles

Pests are vectors because they may be a point of entry for disease or other nuisances in the poultry house. They are also an aspect of waste management that should not be overlooked. Vectors can be either living or nonliving carriers of disease. Especially troublesome on the poultry farm are house flies, rats, and darkling beetles. Wildlife, especially feral dogs and coyotes, must also be controlled. Having proper waste management facilities and maintenance procedures on the farm will contribute to productivity, nutrient management, and environmental safety. A cost-effective and safe pest control system is essential.

Uncontrolled pests cause irritation to birds and workers, carry poultry disease pathogens, increase mortality, lower carcass grades and production, damage building materials, and interfere with feed conversion. In addition, and if they did nothing else, poultry pests must be carefully controlled because they can migrate from litter to nearby residences, where they may become a serious nuisance among the neighbors.

Rats and Mice

Voles, field mice, and cotton rats are not usually the source of problems for poultry growers. Norway rats and roof rats, however, are two non-native species of rats that can be troublesome — and they proliferate rapidly. A pair of rats will produce six to 12 young in 21 days — and each of these becomes sexually mature in three months. A single pair of rats, if they find food, water, and shelter, can produce a colony of 640 rats in a year.

Poultry houses provide everything the rats need: food, water, and shelter. Norway or wharf rats usually nest under buildings and concrete slabs and in garbage dumps. They are great burrowers and may have an extensive system of burrows under the poultry house, with several escape routes. They eat anything but prefer nuts, grains, meats, and some fruits. They can easily find meats and grains in the poultry house.

Roof or black rats are more aerial than Norway rats. They enter buildings from the roof or utility lines. They usually live in trees, so access to the poultry house is easy: up the walls, across vines, along pipes. Exterior walls should be hard, flat surfaces, and all entrance holes should be plugged up. Rats can make themselves "paper thin" to come in under doors and through holes as small as one-half inch in diameter.

The best rat control program is proper resource management, maintenance, and sanitation; but the food supply in the poultry house makes rat occupation probable. Some chemical controls or rodenticides may, and probably should be, added to your control program. To administer rat poison effectively, first know how many rats you are dealing with; then, establish bait stations near the walls in areas of rodent activity.

To determine how many rats are in the poultry house, observe the area at night as well as in the daylight. Rats are nocturnal; if you see no rats in the day or at night, there probably are not many around. If you see old droppings or gnawed areas, no rats during the day, and only a few at night, rats are probably pre-

sent in medium numbers only. Finally, if you see fresh droppings and tracks, some rats during the day, and three or more at night, large numbers are probably present.

To control the infestation, use single or multiple doses of a rodenticide in the bait stations. Avoid making the rats sick; if they get sick and do not die, they will become bait-shy and not eat the poison. Place the bait stations appropriately and protect them from moisture, dust, and weather to encourage the rats to eat from these stations. Rats, like many animals, prefer fresh food.

Because rats are colorblind and have poor eyesight, rodenticides can be marked for safety. If other conditions make poisons inadvisable, rats can be trapped with common snap traps, glue boards, or in live traps.

Darkling Beetles

Known as litter beetles, lesser mealworms, or "black bugs," the darkling beetle (*Alphitobius diaperinus*) is found in large numbers in poultry houses, in the woods, and around feed bins. These black or reddish-brown beetles are troublesome in turkey and broiler production because deep litter and open-floor housing provide an ideal habitat in which the beetles can survive and reproduce.

The total effect of darkling beetles on poultry production is not known. They may be more problematic as a nuisance than as a vector (carrier of disease). However, beetles are thought to harbor a number of disease organisms — for example, fowl pox, *E. coli*, *Salmonella* spp., Newcastle disease, and avian leukosis — and to be involved in the transmission of the causative organism for Marek's disease, although immunization against Marek's disease is now available. Darkling beetles are also an intermediate host for poultry tapeworms and cecal worms. If they are in litter that is land applied, their possible effects on wildfowl must be considered.

An undisputed second concern related to the darkling beetle is that they can damage the insulation in poultry houses. Larvae bore into the insulation to find safe places to pupate. But adult beetles who eat the pupae soon enlarge the larval tunnels in their search for an easy meal. Birds and mice then claw at the insulation to get at the adult beetles, larvae, and pupae. In a severe darkling beetle infestation, as much as 25 percent of the insulation can be lost in a single year.

Another potential problem arises if infested litter is spread on crops. Adult beetles may migrate from the field into nearby residences; the result can be a nuisance complaint to the health department — and sometimes lawsuits.

Temperature and moisture affect the amount of time an insect needs to complete its life cycle. Temperatures between 60 and 100 °F and moisture levels above 12 percent are optimum for its survival. Food sources, decaying litter, an occasional bird carcass, and the absence of major predator and parasite complexes in the poultry house help the beetle population to increase.

The life cycle of the beetle takes 35 to 60 days to complete. The adult female lays eggs individually or in clusters at intervals of one to five days throughout her life cycle. The eggs hatch into tiny larvae after four to seven days and grow through five to nine stages, called instars. This period lasts for seven weeks; then the beetles pupate in cracks and crevices, in the soil and lower strata of the litter, and in building insulation. The pupal state lasts for seven to 11 days, after which a new adult emerges.

To manage darkling beetles effectively requires monitoring, cultural practices, and some insecticide applications. Treatment should be maintained regularly, even if beetle numbers are low. Individual beetles or larvae (100 or fewer per house) pose no problem; however, their presence indicates a need for continued monitoring, ideally on a weekly basis, from the time the birds are brought into the house until they are removed. Visual inspection is the best way to monitor the open-floored, deep litter house. The grower should look at litter, carcasses, cracks and crevices, equipment, and insulation at intervals of 30 to 40 feet throughout the house.

- Litter should be examined along walls, around support posts, and under brooder hoods and feeders. Dig down 1 to 2 inches in caked litter to look for small, early instars.
- Keep litter dry and consider using recycled paper as the bedding material. Some recy-

cled paper is treated with boric acid that creates a fog when first applied. The fog settles in about two hours. The litter can be replaced after the third flock each year, but no other treatment for darkling beetles should be necessary (i.e., when using the boric-acid treated recycled paper litter.

- Carcasses should be examined during daily collections. A large number of beetles on a large number of carcasses may point to a heavy infestation.
- Equipment and cracks and crevices are favorite beetle habitats. Be sure to check the framing joints and other cracks as well as the brooder guard, house dividers, drinkers, and feeders.
- Insulation in new houses should be checked for clusters of small holes along seams, in corners, at the eaves, and along the gable. Insulation board may also be discolored. If mice damage appears, look also for beetle tunnels. In older houses, it will be hard to distinguish between old and new beetle damage.

Trapping beetles has also been used to control their numbers. Traps can be made using a 2-inch schedule 40 PVC pipe, a 10-to-12-inch section for each trap. Put a roll of corrugated cardboard (brooder guard) inside the pipe, and place six or so traps between the wall, feeder, and brooder locations from one end of the house to the other. To prevent the birds from moving the traps, stake the traps in place. Remove the cardboard and count the beetles on a weekly schedule. Their presence or a rapid rise in their number indicates a need for treatment.

Cultural methods for controlling beetles are nonchemical ways to reduce the pest population. Cold weather is the most effective measure, and proper litter handling is also an essential for good control. If the weather cooperates, open the house to the cold between flocks. If the temperature drops below 30 °F, all stages of the darkling beetle will die. As soon as the birds are moved, the grower can remove litter and litter cake from the poultry house. Darkling beetles will move to protected areas in the empty house within a few days; therefore, moving the litter before that time will more effectively control the beetle population.

Fresh litter that is applied to cropland should be incorporated to prevent any return of the darkling beetle. Stockpiled or composted litter should be turned every two weeks to promote enough heat to kill beetle eggs and larvae.

Although all insecticides registered as controlling darkling beetles will work, none controls the house for more than one flock. Therefore, a treatment program should be maintained year-round. Most products remain active about a week and are designed to be applied when the birds have been removed from the house. The best time for application is on the first day after the birds have been removed followed by cleanup immediately on the second day. Treating the house again — and its outside perimeter — just before the placement of a new flock, is also useful. Surface sprays, dusts, and baits are available for making these applications.

Beetles love temperatures between 70 and 90 °F; they are nocturnal and can be found everywhere. Seeing them during the day is a sure sign of infestation — of their presence in great numbers. Young chicks will eat them. Darkling beetles can fly up to one mile a night. If a million or so are taken from a house, 15,000 of those taken will return in the direction of the house from which they came. Approved insecticides are Rabon, Sevin, and boric acid compounds. Best control methods are careful cleanout and spraying.

Beetles cause reductions in feed conversions and weight gains, and possible disease. Under dry conditions, they will eat the flesh of dead or down birds, and at night crawl up the feathers of resting birds and bite the skin around the feather follicals. Bitten birds may have weeping skin lesions or pink and swollen areas around the feather follicals that resemble skin leukosis. The birds are forced to wander all night instead of eating and sleeping as they would in properly managed houses.

Darkling beetles are a general nuisance because they are attracted by light; therefore, they will crawl out of the litter and move toward the light at night. Large numbers of beetles on or in houses create a negative public image and give rise to complaints against the broiler producer. To prevent migration, spray the house walls and posts, or use well-sealed, angled, metal

flashing attached to pit walls at posts and masonry frame wall joints.

Coyotes and Feral Dogs

Coyotes and feral dogs are opportunistic feeders. If they live in the area, their presence around a poultry house is not remarkable. They will kill the poultry for food, but they can easily be prevented from gaining access to the house. Complete confinement of the poultry is the best way to stop predation. Heavy wire should be used to cover all openings. Sanitation and the proper disposal of mortalities will cut down on the attraction of coyotes to the area.

Predator calling and shooting may be used in most states to harvest these animals. Predator calling is a mechanical device that attracts the animals within shooting range. Trapping is also an effective control method. Traps and trap sizes as well as hunting and trapping seasons may be regulated in some places. Leghold traps that do not harm the animal or traps with padded jaws may offer the best control in some situations.

Controlling animals and pests in poultry houses involves a combination of resource management, sanitation, and exclusion, and some special measures such as chemicals, hunting, or trapping.

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Protection Against Pests — Controlling Flies

For a growing industry in a rapidly changing environment, the presence of pests is an ongoing concern that readily appears — numerous species of flies can breed in litter and manure, come to maturity (some in as few as seven days; most in two weeks), and disperse up to a mile or more from their breeding place. Manure handling systems must be carefully managed to prevent these annoying creatures from spreading disease (always a serious problem) or becoming a public nuisance and a focus for bad feelings.

Identifying the Enemy

Moist litter is not only a threat to surface and groundwater; it is also an ideal breeding ground for flies. Caged layer operations are the most susceptible to this problem, followed by breeder farms and, occasionally, broiler farms. Wherever poultry houses are susceptible to flooding, or litter is stored outdoors, the potential exists for fly-control problems.

Several species, including house flies (*Musca domestica*), blowflies, and *Fannia* spp., are bothersome, but it is the common house fly that creates the greatest outrage and danger. It crawls over filth and food products, breeds in all kinds of organic matter (plant material, spilled grains, and animal wastes), and reproduces by the thousands. A nuisance? Yes, but also a carrier of disease for animals and people.

Flies, which generally become active in the early spring (mid-March in many areas), have four stages of development: egg, larva, pupa, and adult. Most generations require about two weeks to develop. Females will produce 120 to 150 eggs in three or four days, and hatching occurs between eight and 24 hours later. House flies can complete their entire life cycle in as few as seven days; therefore, many of the newly hatched 150 flies will also breed within a few days. Twenty to 30 generations in a fly season is not unusual. As many as 1,000 flies can develop in a single pound of suitable breeding material. The actual rate of development depends, however, on the temperatures and moisture levels in the breeding area.

Management of manure so that it is not conducive to fly breeding is the most effective means of control. Fresh poultry manure generally contains 60 to 80 percent moisture. Fly breeding in this material can be minimized by reducing the moisture content to 30 percent or less. This reduction also encourages the development of beneficial insects which can displace developing houseflies or serve as predators of fly eggs and larvae, or both.

Dry manure management is practiced under two types of systems: (1) frequent manure removal (at least weekly), and (2) long-term, in-house storage of manure. Frequent manure removal systems to prevent fly breeding are based on weekly (or more often) removal, spreading, and drying of manure to break the fly breeding cycle. This system is effective if done regularly and thoroughly, but it requires adequate agricultural land where manure can be spread.

In-house storage of manure calls for drying the manure to about 30 percent or less moisture level and the capacity to maintain this level for up to a year. Where sufficient storage space is available, dry manure can be maintained for several years before being removed.

Once removed, land application is generally made. When poultry litter is applied, it should be spread thinly to promote drying. If fly larvae are in the litter, then incorporating it

into the soil as quickly as possible will help break the fly development cycle.

Good housekeeping and management practices that keep manure and litter dry are a first line of defense against flies. A partial list of such practices includes the following:

- Water troughs or cups should be free of leaks, drips, and condensation. The water pressure should be properly adjusted (to prevent dripping) and an on/off cycle should be used (to control condensation).
- Adjust the floor/grade relationship if the water table is high or if outside water can penetrate the house.
- Provide abundant cross-ventilation and avoid excessively high temperatures.
- Prevent dysentery with antibiotics, if necessary, and avoid foods that have a known laxative effect.
- Avoid excessively high house temperatures that encourage abnormal water intake.
- Use absorbent litter materials.
- Consider combining deep pit manure storage with composting for layer operations.

Chemical Controls

Under certain conditions, insecticides may be used to control adult flies in barns and poultry houses. But these products should be reserved for critical times when the management system breaks down, because flies quickly develop resistance. Insecticide applications may be regulated in some states and should be handled carefully to minimize any harmful effects associated with toxic ingredients.

By increasing their focus on outcomes, rather than inputs, growers will find that they have many more tools than insecticides to help them control flies. Consider composting, for example. Undisturbed litter that is free of moisture will slowly begin to compost naturally, and it will support a large number of predators and parasites that feed on fly larvae. These predators include beetles, mites, and parasitic wasps. Scavenger insects help aerate the litter and make it less suitable for fly development. Take care, however, to leave the litter undisturbed; time is needed to encourage the buildup of the beneficial insects. Schedule complete cleanouts, therefore, in the off-fly seasons, and make only spot applications of insecticides in the meantime to reduce the potential for resistance to insecticides.

Integrated Pest Management

Among many reasons to include new waste management practices and beneficial insects in the battle against flies is the dawning recognition that flies are not going to be eradicated. Instead, an integrated and routine program to *control* them must be implemented and practiced throughout each year. Other reasons to integrate pest management measures involve changes in our understanding of and attitudes toward pesticides:

- the choice of effective pesticides that can be safely applied is limited;
- flies develop resistance to even the most potent pesticides,
- avoiding insecticide residues in animal tissues and other products is essential, and
- pesticides are included in a general concern for the effects of agricultural chemicals on the environment.

Pesticides should be used, therefore, as part of an integrated system and with proper attention to practices that will minimize these concerns. Thus, consider insecticides as supplemental to good housekeeping and waste management, and use space spray with no residue to gain immediate control.

Use sprayers made especially to form aerosols that will remain in the air long enough to catch the adult fly and make the application early in the morning before the flies fly up to ceilings and support posts. Using portable equipment may help the applicator reach some difficult areas around the house.

Fly baits in wet or dry form can also be used as supplements to other methods. Liquid baits must be prepared by the applicator and brushed or sprayed on fly resting areas. Larvicides can be applied to manure below the cages and around waterers, but treating manure

regularly (and throughout the facility) is not recommended. Such a practice is costly, the flies quickly develop resistance, and the treatment will also kill the beneficial insects.

Some growers may want to investigate other practices, for example, feed-through larvicides or the commercially available parasitic wasps, or soldier flies, which reduce the volume of waste and crowd out houseflies.

Sticky fly papers and spot cards can be used to monitor the presence of flies. Spot cards are plain white cards stapled so that each side is available for the flies to rest on. The resting flies leave brown regurgitation and fecal spots on the cards, which are then retrieved and the spots counted. Chemical treatments are advised if the grower finds 50 spots per card per week. (The cards also provide a handy record of conditions — and indicate the grower's use of controls — should such a record be needed.

Some type of regular "scouting" or inspection schedule should be used throughout the year to determine where and when the fly population is developing, and therefore where and when to use cultural practices or pesticides. It can also help the grower determine the effectiveness of the control program overall.

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CONSTRUCTED WETLANDS

Agricultural runoff is one of the nonpoint sources of pollution that threatens the water quality in rivers and lakes of the United States. Water that flows off the land after precipitation events picks up fertilizers and animal wastes that have been applied to the soil and deposits them in lakes and rivers.

If the runoff is uncontrolled, it causes soil erosion and increases the presence of suspended solids, which can contain nutrients, pesticides, herbicides, and metals, in the water. Flooding and the degradation of rivers, streams, and lakes are possible consequences. Nonpoint source pollution can also threaten groundwater quality as the same pollutants leach through the soil.

Runoff can be controlled. Best Management Practices (BMPs) can be adopted as part of the poultry grower's operating procedure. For example, stormwater can be diverted from poultry houses and manure storage areas, and land applications can be made when no storms are predicted. In addition, the arsenal of BMPs now includes the use of constructed wetlands for treating runoff and wastewater.

Functions of Constructed Wetlands

Constructed wetlands are not considered to be waters of the United States; but components of a wastewater treatment system. Therefore, if there is a discharge from a constructed wetlands, a federal or state discharge permit may be required.

A constructed wetlands is a designed structure, or set of structures, that attempts to replicate the functions of a natural wetlands. As with natural wetlands, they support water tolerant or aquatic plants and their soils are saturated (waterlogged) or covered with shallow water for some part of the year. However, since constructed wetlands are designed to treat wastewater efficiently and effectively, they generally do not fulfill all the functions provided by a natural wetlands (e.g., they do not recharge groundwater or contribute to the creation of hydric soils).

The constructed wetland is the heart of the treatment system. It cleans wastewater by filtering and settling solids, decomposing organics, and adsorbing/absorbing other pollutants such as phosphorus and trace metals. The dissolved organic pollutants are removed by a complex group of microbes (bacteria, fungi, algae, and protozoa) that live in the wastewater and on plant and sediment surfaces. Since waste materials are food for most of these microbes, pollutants are gradually converted through complex food cycles into environmentally less damaging by-products (gases that escape to the air and inert solids that stay in the system).

The primary purpose of wetland plants is to provide a place for these microbes to attach and grow. Generally, treatment effectiveness increases with plant density, which allows a larger quantity of attached microbes to exist within the system. The density of plants also affects flow hydraulics. Uniform flow is enhanced by uniform plant densities, but variable densities create short-circuiting which reduces the retention time and treatment effectiveness of the wetland. In addition, plants make the system attractive and provide food and shelter for wildlife.

The system remains effective during winter because the microbes are still present on the dead stalks, stems, and roots of the vegetation. Because the biological processes slow down during winter, wetland systems are typically sized to meet treatment objectives during cold weather.

Designing Constructed Wetlands

Constructed wetlands can effectively treat poultry industry wastewaters, including stormwater runoff. These wetlands are designed by engineers and built to restore, enhance, or replace the physical, chemical, and biological processes in natural wetlands. They are typically used as polishing cells following conventional primary treatment facilities such as lagoons, settling basins, or septic tanks. The integrated treatment system provides a higher quality wastewater that may be recycled or discharged to a receiving stream if appropriate permits are obtained.

In addition, the volume of treatable wastewater may be substantially reduced during the growing season because of evapotranspiration by the plants. For example, a poultry producer currently having difficulty with overflowing lagoons during wet weather now has the option of adding constructed wetlands, which can be used to treat a portion of the lagoon wastewater during the growing season. Typically the wastewater in the wetlands will be evapotranspired, but any effluent can also be recycled as process waste or as irrigation water.

Constructed wetlands consist of one or more "cells" of wetland plants in series or parallel. Construction can be easily accomplished. Excavate the area to shape the bottom of the wetlands and build small dikes around it. Line the bottom and sides of the excavated areas with clay or a synthetic material. Use PVC pipe to distribute and collect wastewater and to control water levels in the wetland. Water levels are normally shallow — about 3 to 12 inches. Uncontaminated runoff can be diverted from the system by berms or other buffers or grading.

A lagoon, detention basin, or other type of solids trap is used in front of the constructed wetlands to remove heavy or coarse solids. Some contaminated runoff contains high sediment loads and decomposing organic matter that may settle in bottom deposits. Because these deposits can adversely affect the hydrology and life forms in the wetland, the solids trap is particularly important.

Most wetland systems for treating agricultural related wastewaters will not be larger than one or two acres. In general, they should not be located in areas with steep topography, shallow topsoil, or limited space. They must be properly constructed to ensure groundwater protection. Federal, state, or local cost-share funds may be available for constructed wetlands.

Management

Wetland plants include mixtures of cattails, reeds, bulrushes, sedges, and grasses that are normally native to the area. The plants provide the right conditions for the microorganisms that live in the wetlands and break down the pollutants.

Pond and wetland systems are particularly effective because ponds can be designed to catch the stormwater and slowly release it to the wetlands following the storm. This technique keeps the wetlands wet for longer time periods, which can be especially important during dry seasons.

The systems need little routine maintenance but should be inspected periodically to detect any loss of plants, leakage through the dikes, clogging of the pipes, mosquitoes, or short-circuiting of the flow. These problems and others are usually easily corrected.

Properly managed constructed wetlands are cost effective, energy efficient, and simple to operate. They accept varying pollutant loads, attract a variety of wildlife, and add diversity to the farm landscape. Above all, constructed wetlands can help achieve clean water.

Information on the design and construction of wetlands for managing wastewater is available from USDA Natural Resources Conservation Service local offices, and the U.S. Environmental Protection Agency.

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Using Litter to Generate Heat and Electricity

Incineration of on-farm poultry mortalities increases in popularity as new technologies add affordability to perceived environmental and health advantages that incineration can offer over other methods of dead bird disposal. Now, engineering and technological developments are occurring to determine if burning litter is a feasible alternative or complementary to other methods of poultry litter management.

Examples of two loosely related, developing alternatives are presented here: the first burns air-dried litter to produce energy for regional distribution; the second, collects litter in a fluidized-bed combustion system and uses it to heat the poultry house. Applying these methods to poultry litter management requires considerable research and development because they have so far been too expensive to use in small systems.

Using Air-dried Litter as an Alternative Fuel

The first in a new breed of commercial electricity generating stations fueled by poultry litter was introduced in the United Kingdom in 1992. Today, the plant, which cost $30 million has a gross output of 14.2 megawatts.

The plant is fired on about 143,300 tons of litter per year (roughly the same energy as would be derived from 66,139 tons of coal). Special road vehicles deliver the material to the plant's storage bunker. The area of production is within a 31-mile radius of the plant.

Environmentally, this technology has a lot to offer:

- it creates demand for the product that effectively prevents the excessive application of litter on agricultural fields, thereby protecting water resources and restoring nutrient balance;
- gases produced in the process are low in major pollutants and after treatment in a three-stage electrostatic precipitator are suitable for discharge to the atmosphere;
- it is low in cost and continuously available; and
- the ash by-product is high in potash and can be removed from the plant in bulk and used as a component of manufactured agricultural fertilizers.

Fluidized-bed Combustion

Fluidized, or bubbling, bed combustion has been used, worldwide, in industry, for more than 20 years. Now some agricultural and government researchers and others in the poultry and waste management industries are probing the usefulness of burning poultry litter in a fluidized bed combustion system.

The objectives of modifying or otherwise developing this technology are twofold: first, to determine whether this method can dispose of litter efficiently and cleanly; and second, whether this biomass is a suitable raw material for energy production.

Recent claims suggest that the technology has many applications:

- the generation of hot gases for heating and drying;
- the generation of electrical power;
- the generation of steam and pressurized systems to suit process inlet requirements.

If so adapted, it would have several advantages:

- modular designs that are inexpensive and easy to install;
- reduced power consumption to save operating costs;
- adaptable to a variety of waste streams should conditions change; and — of most importance to some poultry growers —
- ability to burn waste materials having an extremely high moisture content.

If these and other technologies for converting litter to energy are successful, they will help expand potential uses for litter, increase environmental well-being, and contribute to economic sustainability.

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Alternative Bedding — Select Materials May Have Hidden Values

In the Near East (Morocco), straw is the conventional poultry litter. Recent drought conditions, however, have depleted supplies, forcing growers to pay more and settle for less — or find alternatives. This story is repeated in many regions: the conventional bedding materials and the cause of the shortage may vary, but the race is on for finding suitable alternatives.

A further impetus to trials involving litter materials is the challenge growers face each day: the perception, whether imagined or real, that they must do more to help meet state and regionally mandated reductions in the total volume of wastes stemming from human activities (rural and urban). These "goals" are generally 25 to 40 percent of the total volume produced at the time the goal was set. Particular goals depend on the overall status of resources in the watershed.

The search for alternative litter supplies has environmental consequences on both counts. First, used litter constitutes a large part of the material that each grower must land apply, compost, convert to energy, or otherwise dispose of or recycle. Second, the choice of litter materials may have unexpected benefits: some producers have found that using shredded paper as a litter material reduces odor and provides a nearby market for the town's newspaper recycling program.

Straw

The Moroccan study tested alternative litter materials on cockerel performance and litter quality. The materials investigated included soft wheat straw (whole or ground), rice straw (ground) wood shavings and rice hulls, alone and in combination. The birds' performance, water consumption, and leg injuries or defects were measured; and the various litters were compared for moisture content, pH, temperature, overall cleanliness scores, and buildups of dust and ammonia.

Differences were noted in the litters, but they were inconclusive. However, straw-based litters had the highest moisture content, pH values, and temperatures, and they received the lowest scores when subjectively rated. Notwithstanding this finding, all materials tested, including straw, were deemed suitable bedding materials, singly or in combination with other materials.

Evaluating Alternative Materials

Fine-textured particleboard residue, a by-product of the wood manufacturing industry that usually ends up in landfills, has been proposed as a way for poultry growers to compensate for the increasing scarcity of hardwood or pine shavings in Indiana. In this case, the shortfall in conventional bedding materials may be driving the search for alternatives but the alternatives themselves — for example, sand, particleboard, newspaper, rice and peanut hulls, ground corn cobs, cereals, and grasses — are turning up some surprising trade-offs.

Previous investigations of litter sources correlated the type of bedding with significant differences in bird performance and carcass and litter quality. Thus, the quantitative and qualitative properties in each kind of litter should be taken into consideration before litter is purchased and placed in chicken houses.

Evaluating the performance of the litter generally involves a comparison of two or

more types of litter and a litter prepared from the same ingredients but combined to study the effects of using both at one time. Other management and environmental practices, for example, dietary arrangements, types of feeders and waterers, and litter removal or replacement must be handled the same way throughout the trial in all pens included in the experiment.

Parameters chosen to measure the effects, if any, of the litter on the birds' condition and on the quality of the bedding include the birds' weight gain, feed conversion, mortality, and water consumption; and the degree of caking, pH, ammonia nitrogen, temperature, dust, and moisture conditions in the litter. In the Moroccan trials, for example, each of the materials included in the experiment tested as "suitable" for litter, though straw got lower index values for cleanliness. No statistical differences could be found in the way these materials acted, and no correlation was observed between increased litter moisture levels and leg abnormalities.

Investigators concluded therefore, that even litter materials that may warrant minor complaints, for example, straw, can be used as needed. They could be used as a base, for example, and top-dressed with less available but more preferred materials, such as sawdust or wood shavings. Future studies may profitably assess the litter microbiological parameters and carcass side-effects.

Litter Alternatives Tested in Indiana

Fine and coarsely textured particleboard litter trials carried out on male turkey farms in Indiana yielded good results; the particleboard, containing less moisture to begin with produced a cleaner, drier product initially. It was drier and had less bacteria and mold on day zero.

The birds raised on fine particleboard had several advantages over the pine shavings and coarse particleboard, including fewer breast buttons and leg abnormalities and a 0.22 kg gain in muscle deposition, which off-set a 0.16 kg reduction in market body weight (as compared to birds grown on the traditional litter).

Coarse particleboard, on the other hand, has jagged edges. The birds suffered some foot-pad dermatitis, but not to a level to cause concern. Therefore, coarse particleboard is also an acceptable litter material for use on male turkeys.

Sand

Sand is another material that shows continuing potential as an alternative bedding material. In recent trials, chicks were randomly assigned to litter treatments of either sand or pine shavings. The birds' health and performance were compared at 50 days of age; carcass grade and yield and foot pad lesions were examined by processing 10 male and 10 female birds per pen; and bacterial counts were determined at the end of the trial by analyzing pooled litter samples taken from each pen.

No differences were found in body weights, mortality, or feed conversion in the birds; and no significant differences were found in their carcass grade or yield or foot pad lesions. Likewise, no differences were found for litter moisture or litter temperatures. Abdominal fat yields, however, were significantly lower for the birds grown on sand litter, and the sand pens also had significantly lower E. coli and aerobic plate counts than the pine shavings pens (6.09 and 7.25 CFUs/g, respectively). The trials continue; however, sand is already an acceptable alternative.

New or Recycled Paper

Broiler growers in the Northwest tested virgin and recycled paper-mill waste as an alternative to fir shavings and rye grass. The results showed no difference in the birds' four- or seven-week body weights, feed conversion rates, or mortality. However, the houses containing the short fiber pulp and paper waste litter produced less caking.

In northern Georgia, the Chestatee-Chattahoochie Resource Conservation and Development Council, in cooperation with the North Georgia Waste Management Authority and local poultry integrators, evaluated various recycled paper products as poultry bedding. The recycled paper proved to be equal to or better than the traditional wood shavings, sawdust or rice hulls.

Coffee Bean Hulls, Straw, Wood, and Paper

Kentucky tested coffee bean hulls, wheat straw, wood shavings and two kinds of paper ("mixed paper and recycled hardback books" and "mostly hardbacks") The birds showed no

significant differences in body weight, feed consumption and efficiency, breast blisters, or leg abnormalities. However, the caking effect and temperature were highest in wood shavings. The litter temperature in all cases was higher than the ambient temperature.

An Interesting Corollary

Pending additional study, growers can use a variety of materials to substitute for or to replace conventional bedding materials, and therefore some measure of control over failing supplies or rising prices, and other factors than supply and demand can influence this choice.

So what about the use of products (e.g., recycled paper, plant residues, or sawdust and chips generated in wood product manufacturing) that nobody else wants? Can we really use paper diverted from landfills, such as newspaper and old phone books?

Those who have tried it think we can. In their view, bedding made from recycled paper is cleaner than some other bedding materials. It is higher in density and absorbency, provides additional pest control, and helps control odor. In the house, its proponents suggest, it lets chicks grow in less stress; and in the field, it decomposes quickly.

At the present time, paper makes up about 38 percent of the waste stream. Using it as a bedding material presents an interesting possibility.

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Phytase Supplements — A Feed Additive that is Good for the Environment

Recent studies of nutrient enriched waters suggest that land applications of poultry litter and manure and mortality compost based on nutrient management planning are helping to protect the environment. But nutrient management plans also have an anomaly: namely, they are too often based on nitrogen alone. The practice has inadvertently contributed to a build up of phosphorus in soils that far exceeds plant needs and is easily released to the environment. The problem is compounded because phosphorus is an important dietary nutrient for poultry, and high levels of phosphorus are found in poultry waste.

The solution, it now appears, must be twofold: we must stop applying so much phosphorus to the land — in some regions, no phosphorus at all — and, if possible, we must find ways to limit the available phosphorus in poultry waste. Phytase, an enzyme that increases the availability of naturally occurring phosphorus in poultry diets while decreasing the level of phosphorus found in poultry waste, may be part of the solution.

Adequate dietary phosphorus is a requirement for healthy birds, and inorganic supplements of calcium and phosphorus are normally included in their diet — sometimes at extremely high levels — to guard against leg weakness, improve bone density and egg quality, and enhance weight gains. However, when phytase is used as a dietary supplement, both calcium and phosphorus supplements can be greatly reduced.

Phytase has a positive effect on bird growth: according to trials performed at the University of Minnesota, which linked the use of phytase supplements to profitability (i.e., to the bird's market value). Tests described by BASF Animal Nutrition, the U.S. marketer of phytase under the brand name Natuphos, indicate that turkeys fed 73 percent of recommended inorganic phosphorus supplements, 100 percent of the recommended calcium, and 500 units of phytase per kilogram of feed resulted in 20 percent higher net returns than for turkeys fed the conventional way. A positive net return was also noted for birds fed 52 percent of the recommended phosphorus supplements and 200 units of phytase per kilogram of feed. Birds fed inadequate levels of phosphorus without phytase performed poorly and resulted in negative net returns.

Other Studies

Other projects to evaluate phytase have demonstrated similar results.

- Research funded by the Georgia-based U.S. Poultry and Egg Association in 1996 showed that feeding phytase and a vitamin D3 derivative to broilers reduced the birds' need for dietary phosphorus.
- Phytase supplements have also been shown to improve calcium and phosphorus use in commercial layers as determined by egg shell quality, feed consumption, egg production, and egg weight.
- Other benefits of phytase supplements that have been demonstrated indicate that they can correct the adverse effects of egg production associated with low dietary phosphorus and significantly reduce the impact of low dietary calcium on bird health.

- Broilers and hens on corn-soybean diets supplemented with phytase also showed significant linear responses to increasing levels of phytase. The study concluded that phytase increased the use of dietary phosphorus.

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RESOURCE INFORMATION 1

POULTRY WATER QUALITY CONSORTIUM

The poultry industry and three government agencies have joined together to form the Poultry Water Quality Consortium to promote better environmental management by the rapidly growing poultry industry.

The Consortium encourages the use of poultry by-products as a resource rather than letting them become a pollution source. As the industry grows, protecting natural resources is becoming a major priority, demanding new technologies in poultry by-product development, storage, utilization, and land application.

The Consortium is responding to this environmental challenge by promoting cooperation and the exchange of information between the poultry industry and government agencies on water quality and by-product utilization issues. Focusing on pollution prevention, the Consortium will facilitate the development and transfer of new technologies designed to protect water quality and promote a clean environment.

Members of the Consortium

- U.S. Poultry & Egg Association
- Tennessee Valley Authority
- U.S. Environmental Protection Agency
- U.S. Department of Agriculture – Natural Resources Conservation Service

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U.S. Poultry and Egg Association

Founded in 1947, the U.S. Poultry & Egg Association is the largest and most active poultry organization of its kind. Known as the "All-Feather Organization," the association addresses the changing needs of those involved in producing and processing poultry and eggs.

The U.S. Poultry & Egg Association is dedicated to the growth and development of the poultry industry and represents the entire industry — from the producers of eggs, broilers, and turkeys to the processors of poultry and egg products and the many allied companies serving the industry.

U.S. Poultry & Egg has a long-standing commitment to promoting continuous improvement in environmental management by the poultry industry.

Services Available to Poultry Growers

U.S. Poultry is best known for its annual International Poultry Exposition, held in January in Atlanta, Georgia. The Expo features the world's largest display of technology, equipment, and supplies used to produce and process poultry and egg products.

Continuing education is a high priority. The association's seminar program has expanded into a comprehensive schedule of workshops and clinics to keep the poultry industry informed. Twelve seminars are held each year.

Through its government relations program, U.S. Poultry and Egg keeps Congress and federal agencies aware of industry needs, and informs members of government actions.

The association's research program returns millions of dollars to the industry. Research grants are used to find better ways of producing poultry and egg products. Members are kept aware of industry developments through the distribution of newsletters, reports, and memos.

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USDA Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS), an agency within the U.S. Department of Agriculture (USDA), administers national soil and water conservation programs with the cooperation of landowners and operators in local soil conservation districts and other government agencies. It has traditionally provided technical and financial assistance to the U.S. agricultural community to help individuals plan, design, and implement waste management systems and other conservation projects. In addition, NRCS offers education, research, and database development.

The NRCS focuses on nonpoint source pollution and its effects on soil, water, air, plants, animals, and people. Potential agricultural contaminants include pesticide residues, nutrients, salts, trace minerals, and sediment. To help the agricultural community treat or prevent water quality problems, NRCS promotes economically feasible and practical measures, such as the environmentally safe management of dead birds, litter, and manure; the development of nutrient management plans; and the construction of litter storage facilities.

NRCS also encourages voluntary approaches to solving resource problems as it works to insure a continuing exchange of information.

Services Available to Poultry Growers

Through its conservation practices, the NRCS provides planning, design, and construction assistance on waste treatment lagoons, manure and litter dry-stacking facilities, poultry mortality facilities, management, and nutrient management plans based on soils, crops, and equipment availability. It also serves as technical representative for USDA cost-share programs to implement nutrient and poultry mortality management systems and, in some cases, provides financial as well as technical assistance in special project areas. The NRCS works closely with state regulatory agencies in waste management.

Contact

For more information about NRCS programs and assistance, call or visit the NRCS office listed in your local telephone directory under U.S. Department of Agriculture.

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TENNESSEE VALLEY AUTHORITY

The Tennessee Valley Authority (TVA) is committed to develop and implement programs and activities that will assist agriculture and agribusiness to protect the environment. Protecting water quality is a major concern of TVA, as illustrated by its ongoing projects related to nonpoint source protection.

TVA has established close ties with federal and state agencies, universities, and private organizations concerned with water resources management and nonpoint source control and, therefore, is in an excellent position to identify, demonstrate, and transfer poultry by-product resources technology to potential users.

Services Available to Poultry Growers

TVA's programs and projects primarily deal with helping prevent or reduce impacts of the poultry industry on the environment. This service is accomplished through educational workshops and demonstrations in cooperation with other federal and state agencies.

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U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) is dedicated to improving and preserving the quality of the environment and reducing risks to human health and the environment. Point and nonpoint sources of pollution are addressed under the Clean Water Act.

Certain poultry production, processing and rendering plants are regulated as point sources and may be required to obtain a permit. However, many of EPA's efforts to prevent or reduce water pollution associated with poultry by-products involve nonpoint source pollution. EPA helps states develop their nonpoint source assessments and management programs and provides assistance to implement nonpoint source control practices.

EPA believes the Poultry Water Quality Consortium will lead to greater cooperation between the poultry industry and government agencies on water quality and by-product utilization, thus reducing environmental and health risks and benefiting agriculture and the larger community.

Services Available to Poultry Growers

EPA administers a variety of nonpoint source control programs to address animal waste problems associated with smaller operations.

Currently, funds are provided to states under section 319(h) of the Clean Water Act to help them implement nonpoint source management programs including, for example, demonstrations of poultry composting facilities or development of educational manuals or regulations to address poultry by-products. EPA provides assistance to states to implement nonpoint source controls under other programs such as the Chesapeake Bay Program, the Gulf of Mexico Program, and the Clean Lakes Program.

Contacts

The U.S. Environmental Protection Agency, headquartered in Washington, DC, operates 10 regional offices.

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DIRECTORY OF POULTRY ASSOCIATIONS

STATE, REGIONAL, AND NATIONAL

The following state, regional, and national organizations are listed in alphabetical order. The organizations in most states are therefore listed together; however, if you are looking for a particular association, please consult the entire list. The Wilkes Area Poultry Association, for example, is listed under W, not under North Carolina. We hope that we have not inadvertently omitted or incorrectly identified any organization or its address. This material will be updated from time to time.

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Other pages in this handbook contain more detailed information on these subjects. Permission is hereby granted to producers, growers, and associations serving the poultry industry to reproduce this material for further distribution. The Poultry Water Quality Consortium is a cooperative effort of industry and government to identify and adopt prudent uses of poultry by-products that will preserve the quality of water for everyone.

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Other Supporting USDA Agencies

Farm Service Agency

The USDA's Farm Service Agency supports the U.S. agricultural community through commodity programs, farmer operating and emergency loans, conservation, domestic and overseas food assistance and disaster programs that improve the economic stability of agriculture and the environment. These programs help farmers produce an adequate food supply, compete for export sales, and keep consumer prices reasonable while caring for the environment and natural resources.

The Farm Service Agency's mandate is to assure a continuous supply of food and fiber for all Americans, and to promote sound resource management systems. As part of this mandate, it works with poultry producers to share the costs of solving erosion and water quality problems that result from nonpoint source pollution.

Services Available to Growers

The Farm Service Agency administers low-cost loans and cost-share programs. Under the latter, it is authorized to share with producers up to 60 percent of the cost of some conservation practices, including the building waste storage facilities such as lagoons, dry-stacks, and composting units.

Contact

For more information about cost-share programs, call or visit the FSA office listed in your telephone directory.

Cooperative State Research, Education, and Extension Service

The Cooperative State Research, Education and Extension Service (CSREES) links the research and education programs of the USDA and works with land-grant institutions to advance a global system of research, extension, and higher education in the food and agricultural sciences. Its overall mission emphasizes partnerships with the public and private sectors to maximize effectiveness and to improve economic, environmental, and social conditions in the United States.

Services Available to Growers

Educational programs to protect natural resources and the environment, to manage waste efficiently, and to deal with water quality are included in the national priority initiatives of the State Cooperative Research, Education, and Extension System. The Service (which is probably better known simply as Cooperative Extension) is internationally known as a leader in providing community access to research and education. Its publications are widely available and many of them are on the Internet.

Contact

For more information about the Cooperative State Research, Education, and Extension Service, call or visit the CSREES office listed in your telephone directory under local government.

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