



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 two-fold: 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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