Constructed Wetlands For Animal Waste Treatment

Managing Animal Wastes

Managing the waste produced by confined animal feeding operations is a major agricultural and environmental challenge. Confined animal feeding operations continually generate huge amounts of animal waste and must have waste management systems adequate to handle these large amounts of waste. In addition, waste management systems for different animal operations must process various types of waste. For dairy and swine farms the animal waste system must process both liquid and solid waste; for poultry layer farms, primarily liquid waste; for poultry broiler farms, mostly solid waste.

Finally, most confined animal feeding operations apply both solid and liquid waste to nearby fields. Applying liquid animal waste to land has unique problems, including odor, high solids content, high nutrient concentrations, and limited pumping distances. In addition to these technical problems, other factors such as new regulations, more and closer residential neighbors, and increased animal numbers often cause existing land treatment sites to become rapidly inadequate.

Livestock producers constantly search for animal waste treatment systems that are more efficient or less labor intensive or that require less land.

Constructions Wetlands

Constructed wetlands have received considerable attention for the last 5 or 6 years as a new method for treating animal waste. For many years constructed wetlands have been used successfully to treat lower strength municipal wastewaters. Characteristics of these municipal constructed wetland systems that appeal to livestock producers include:

- Low construction cost.
- High waste treatment efficiency.
- Small land area requirement.
- Low energy requirement.
- Little or no maintenance.
- Good odor control.
- Natural waste degradation.

Properly applied to animal waste treatment, constructed wetlands can be a very important part of a total animal waste treatment plan. When combined with grass filter strips of cattails and bulrushes, constructed wetlands have demonstrated over 95 percent removal of nitrogen at a loading rate of slightly over 15 pounds of nitrogen per acre per day.

Types Of Constructed Wetlands

Two basic types of constructed wetlands are (1) surface flow in layer and (2) subsurface flow. The surface flow system is the one most applicable to treatment of animal waste.

Surface flow constructed wetlands are flat, pond-type structures holding very shallow water—2 to 10 inches of water depth is typical—and supporting growth of bulrushes, cattails, and other aquatic plants. Wastewater is piped into one end of the constructed wetland. It travels slowly through the plant stand and eventually flows out of the wetlands.

How Wastewater Treatment Works

Wastewater treatment in constructed wetlands occurs by several mechanisms:

- Dilution with rainfall.
- Chemical reactions.
- Biological activity that transforms and filters the wastewater.

Wastewater "strength" is generally measured by how much oxygen is required to reduce wastewater contents to chemical compounds that are stable or nearly stable in the environment. Oxygen is necessary for most of the chemical and biological processes that "treat" or reduce animal wastewater biochemical oxygen demand (BOD) and nutrient content to more desirable levels.

Wetland plants transport oxygen from leaves through stems to roots and thus into the wastewater solution. This routing of oxygen helps satisfy the high BOD of the wastewater introduced into the pond. Therefore, the selection of appropriate plants for constructed wetlands is critical. The Natural Resources Conservation Service (formerly
Soil Conservation Service) has conducted extensive work on appropriate plant material and recommends the use of emergent plants—those that grow above the water line.

The most commonly used emergent plants in constructed wetlands for animal waste treatment are the reeds, bulrushes, and cattails (Scirpus, Typha, and Juncus). Saturation culture soybean and flooded rice also successfully treat swine wastewater. The roots of the plants play an important role in the treatment process, providing surfaces for bacterial growth, filtration of solids, nutrient uptake, and oxygen to promote the processes of nitrification and denitrification.

Most animal wastewater has such a high BOD demand that it must be either diluted with fresh water or pretreated in some manner to reduce the oxygen demand on the wetland system. During different seasons, weather conditions, and times of day the oxygen concentration in wetlands will vary. The cooler the water temperature, the lower the oxygen demand. These daily and seasonal changes affect the biological processes which remove carbon, nitrogen, and phosphorus along with reducing the high BOD demand in animal wastewater.

**Limitations Of Constructed Wetlands**

Constructed wetlands have limitations for treating animal waste. Some potential problems that can limit the success of this treatment method are:

- High nutrient levels in wastewater.
- High ammonia levels that can kill aquatic plants on which the wetlands depend.
- Reduced treatment efficiency during the winter.
- High flows during heavy spring rainfalls.
- Plant residue buildup in the wetlands which can contribute to the establishment of a potential nutrient sink.
- Zero discharge requirements for animal waste systems.
- Potential for muskrats and mosquitos.

**Planning Constructed Wetlands**

Several elements must be considered in designing constructed wetlands:

- Type of wastewater, which is influenced by the number and type of animals, lot runoff, rainfall collection, and stack pad drained-liquid.
- Wastewater content including BOD, total suspended solids, nitrogen, and phosphorus.
- Hydraulic flow through the system, which affects BOD reduction, fluid transport rate, and odor.
- Seepage, evaporation, and transportation losses.
- Suitable posttreatment of the outflow.
- Total land area needed for all components of the entire treatment system.

**Pretreatment**

Animal waste is generally high in solids. Some form of waste treatment for solids removal is necessary prior to water entering the wetlands. Mechanical solids separation, stack pads with drained-liquid collection for storage of animal waste, or collection of the total animal waste stream in lagoons for solids settling and treatment is necessary. Solids removal ensures that the wetlands are not so heavily loaded with carbon that they are totally anaerobic and incapable of supporting the interactive functioning of aerobic and anaerobic processes that are necessary for successful operation of the wetlands. Solids removal prior to wetland entry is essential for the long-term operation of this system. In animal operations where solid waste must also be treated, wetlands should be considered as only a component of the total animal wastewater treatment system.

**Posttreatment**

Because direct discharge of animal wastewater into streams is not allowed, wetland effluent must be reused or applied to land. Wastewaters are usually irrigated either directly to surrounding land or through vegetated filter strips to croplands and woodlands. Wetland effluent must be further treated in receiving ponds or lagoons before being discharged, reused as flush water in animal housing, or recycled to the wetland. The amount of land available for land application of wastewater will determine whether constructed wetlands are appropriate at a particular site.

Problems with ammonium nitrogen concentration and potential toxins to wetland plants can be reduced by proper management of rain water and lot runoff as well as by dilution with freshwater recycle effluent.

**Review Of Dairy Wastewater Treatment Studies**

Studies on constructed wetland treatment of dairy wastewater in LaGrange County, Indiana, at Oregon State University, and in DeSoto County, Mississippi, indicate that nutrient reduction can
Nitrate nitrogen removal can vary from 54 to 90 percent. Total phosphorus removal can range from 58 to 74 percent, and BOD reduction can vary from 58 to 75 percent.

The LaGrange County, Indiana, study area had problems with excessive solids loading. A 4-inch layer of solids accumulated in the initial third of each wetland cell during the first year of operation. This highlights the importance of a solids removal operation prior to wetland treatment.

The Oregon State University dairy farm used a recycle flushing system, and the wetlands discharge was left in the storage pond and returned to a storage tank that fed the wetlands system. Efficiency was somewhat lower than in the Indiana study.

The DeSoto County, Mississippi, dairy farm used three cells, 20 feet by 80 feet, operating in parallel. These cells received wastewater from a primary lagoon which was 135 feet by 170 feet. After start-up, nitrate nitrogen removal was around 90 percent in the Mississippi study.

Although individual dairy conditions determine reduction levels, these studies show that using constructed wetlands for waste management can effectively reduce waste nutrients.

Review Of Swine Wastewater Treatment Studies

Recent studies on swine wastewater treatment in Mississippi, Alabama, and North Carolina suggest that constructed wetlands can do an excellent job of mass removal of nitrogen and phosphorus. However, at the high loading rates necessary to get these large nutrient mass removals, constructed wetlands still do not produce water acceptable for discharge. This means application to croplands, vegetation strips, or woodlands is a necessary part of the complete waste treatment system.

Recent swine wastewater studies in Mississippi used a marsh/pond/marsh constructed wetland system for treatment of wastewater that entered from a lagoon which treated primarily wastewater from the farrowing house. This wetland system emptied through a vegetated strip where the testing of BOD, ammonia nitrogen, phosphorus, and suspended solids showed more than 95 percent mass reduction for each of these. This removal rate for nitrogen is about ten times greater than what would be expected by land application on forage grasses.

In studies at the Sand Mountain Experiment Station in Alabama, wastewater from a two-cell five-hundred head swine lagoon was diluted by ratio of 2.7 to 1 before wetland system treatment. These studies produced 89 percent and 79 percent mass removals of nitrogen and phosphorus at the highest loading rate investigated. These results generally agreed with those from Mississippi.

Research in North Carolina on wetland treatment efficiency of swine wastewater indicated mass removal of 90 percent for nitrogen and 80 percent for phosphorus.

Results of these studies indicate that constructed wetlands are very effective in removing contaminants and pretreating swine wastewater for irrigation to cropland.

Conclusion

Animal waste treatment is a major agricultural and environmental concern. As the number of confined animal facilities grows in specific watersheds and river basins, the proper treatment of animal wastewater becomes more critical. Because constructed wetlands have been very successful in treating municipal wastewater, they hold great promise as part of a complete system for animal waste treatment.

In municipal wastewater treatment, wetland systems are operated to meet extreme discharge requirements. To ensure safety, the strict monitoring of discharge water is required. At this time, the Environmental Protection Agency does not allow discharge of animal waste effluent to the waters of the United States. Therefore, the main goal of animal wastewater treatment with wetlands is reduction of contaminant mass. Constructed wetlands can transform and assimilate large quantities of carbon, nitrogen, and phosphorus from wastewater and dramatically reduce required land application area.
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