Constructed Wetlands for Swine Wastewater Treatment

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Abstract. A prototype constructed wetland was evaluated for over 4 years to set the basis for an on farm constructed wetland system for 3,520-head finishing operation. The prototype wetland systems provided nitrogen and removal rates over 80% and the amount of land required for the full-scale system has been reduced by more than 50%. Several solid separators have been evaluated and a settling tank is being installed to provide additional removal for phosphorous and solids for better wetland performance and more agronomically balanced nitrogen and phosphorous final effluent that will require less land for terminal management.

Keywords. Constructed Wetlands, Solids Separation, Swine Waste Treatment, Nitrogen Removal and Phosphorous Removal.

Problems associated with swine wastewater treatment lagoons and land application has prompted an urgency to find alternative treatment systems that are technically feasible and economically viable. Swine wastewater typically contains high levels of nutrients (carbon, nitrogen, and phosphorus) but the liquid nature makes the cost of handling and transportation expensive. This requires that sufficient land be available in the vicinity of the swine facility to apply the wastewater at agronomic rates to cropland.

Constructed wetlands have received considerable attention as possible wastewater treatment system components, which could reduce the amount of land necessary for terminal land application. However, questions exist about the long-term efficiency of constructed wetlands for swine wastewater treatment. The primary questions include nitrogen loading rates, oxidative/reductive conditions, denitrification potential, phosphorus removal rates, and ammonia toxicity to wetland plants.

The prototype study was undertaken to investigate the capacity of constructed wetlands planted with either native wetland plants or water tolerant agronomic plants to treat swine wastewater. One of the initial goals was to determine if the constructed wetlands system could produce an effluent, which would meet stream discharge requirements for nutrient loading because cost sharing was being proposed for swine waste wetland systems that could discharge. Three sets of two, 3.5 x 33.5 m wetland cells were constructed adjacent to the existing lagoon in 1992.

During the first year, the nitrogen loading rate at 3kg/ha/day specified for advanced treatment for stream discharge was used, but effluent nitrogen and phosphorus concentrations would not consistently meet stream discharge requirements. The goal was then changed to determine the maximum possible removal of nitrogen and phosphorus.

The second year nitrogen-loading rate of 8 kg/ha/day resulted in about an 87% removal of nitrogen or about 1880 kg/ha/yr. The fourth year loading rate of 25 kg/ha/day resulted in about an 87 percent nitrogen removal or about 5870 kg/ha/yr. The nitrogen-loading rate for the fifth year was continued at 25 kg/ha/day to determine if the same removals could be achieved as during the previous year. Questions also arose concerning whether the nitrogen loss was due to denitrification or ammonia volatilization.

Mass removals are for 270 days of operation per year.

Conjunctive microcosm studies were conducted to determine the maximum nitrogen-loading rate possible and determine maximum nitrogen removal with sequencing nitrification and wetland treatment. Results show that with nitrification pretreatment, wetland has the potential to remove more than 10,000 kg N/ha for 270 days operation per year.

Table 1. Nitrogen loading rates and mass removal efficiencies for the constructed wetlands, Duplin Co., NC (June 1993-December 1998).

Nitrogen Loading	System	% Mass Removal	Average Annual N Removal	Average Effluent N Concentration
3 kg/ha/day	Rush/Bulrush	94	760 kg/ha/yr	8.2 mg/1
	Cattails/Burreed	94		
8 kg/ha/day	Rush/bulrush	88	1880 kg/ha/yr	24.2 mg/1
	Cattails/Burreed	86		
15 kg/ha/day	Rush/Bulrush	85	3360 kg/ha/yr	29.5 mg/1
	Cattail/Burreed	81		
25 kg/ha/day	Rush/Bulrush	90	5870 kg/ha/yr	46.0 mg/1
	Cattail/Burreed	84		

% Mass Removal = % mass reduction of N (NH_3-N+NO_3-N) in the effluent with respect to the nutrient mass inflow.

For 270 application days per year

The full-scale constructed wetland system has been in operation since late 2001 in southeastern North Carolina. Four houses for a 3520-head finishing operation with under floor wastewater storage pits are emptied once per week and cleaned with water recycled from the final storage pond. The wastewater removed from the house is pumped to the solids separator. Three different solids separators have been used, and a settling tank will be installed after Phase 1 of the project, which is to investigate a passive-low intensity system. This settling tank is sized to hold a daily flush volume so it will be operated on a daily batch basis. Utilization of chemicals and polymers for phosphorus removal will be evaluated. Sludge from this settling tank will go to the incline screen solids separator for further dewatering prior to alternative processes to produce a value-added byproduct that can be used off farm. This will result in reduced solids loading to the wetlands and the production of a more agronomically balanced nitrogen and phosphorus final effluent that will require less land for terminal land management.

Three solid separators have been investigated for use with the constructed wetland system. An incline, static screen with a 0.2-inch screen opening provided less than a 15% suspended solids removal efficiency and would clog frequently. The solids removed by the screen had greater than 98% moisture and thus were difficult to handle and caused problems with flies and odors when stored. The dissolved air flotation system yielded better-suspended solids removal but clogging of the pump and strainer was a maintenance problem, and the sludge from the unit was difficult to dewater and de-air. Currently, an incline drag conveyor with a 0.35-inch screen opening is in place that removes approximately 30% of the suspended solids from the incoming wastewater. The overall solids removal efficiency has been improved by retrofitting one of the original solids drying beds as a gravity-settling basin following the solids separator, which provides a 30-minute detention time.