Long Term Data for Constructed Wetlands for Swine Wastewater

J.M. Rice, A.A. Szogi, F. J. Humenik and P.G. Hunt

Problems associated with swine wastewater treatment lagoons and land application have 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.

This 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. Three sets of two, 3.5 x 33.5 m wetland cells were constructed adjacent to the existing lagoon in 1992 (Figure 1).

One set of two cells (two cells end-to-end) contained (*Juncus effusus*) and bulrushes (*Scirpus americanus, Scirpus cyperinus* and *Scirpus validus*), and another set of two cells contained bur-reed (*Sparganium americanum*) and cattails (*Typha angustifolia* and *Typha latifolia*). The third set of cells contained agronomic plants. One cell contained soybean (*Glycine max*) grown in saturated soil culture and on one-meter-wide beds that were flanked by ditches of approximately 10-cm depth. The other agronomic cell contained flooded rice (*Oryza sativa* cv. Maybelle).

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 1,880 kg/ha/yr. The third year nitrogen-loading rate of 15 kg/ha/day resulted in about 83% nitrogen removal or about 3,360 kg/ha/yr. The fourth year nitrogen-loading rate of 25 kg/ha/day resulted in about an 87% nitrogen removal or about 5,870 kg/ha/yr. Mass removals are for 270 days of operation per year. 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.

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, wetlands have 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 [1]	Average Effluent N Concentration
3 kg/ha/day	Rush/bulrush	94	260 kg/ha/yr	8.2 mg/l
	Cattails/bur-reed	94		
8 kg/ha/day	Rush/bulrush	88	1880 kg/ha/yr	24.2 mg/l
	Cattails/bur-reed	86		
15 kg/ha/day	Rush/Bulrush	85	3360 kg/ha/yr	29.5 mg/l
	Cattail/Bur-reed	81		
25 kg/ha/day	Rush/Bulrush	90	5870 kg/ha/yr	46.0 mg/l
	Cattail/Bur-reed	84		

% Mass Removal = % mass reduction of N (NH_3-N + NO_3-N) in the effluent with respect to the nutrient mass inflow.
[1] For 270 application days per year

Conclusions

The overall conclusions are that wetlands by themselves cannot remove sufficient nitrogen and phosphorus to meet stream discharge requirements but do show promise for high rates of nitrogen mass removal. Sequencing a nitrification pre-treatment component prior to the wetlands can increase the nitrogen removal efficiency of the wetlands. Added work needs to be conducted to determine whether nitrogen removal is due to denitrification or ammonia volatilization at high nitrogen loading rate.
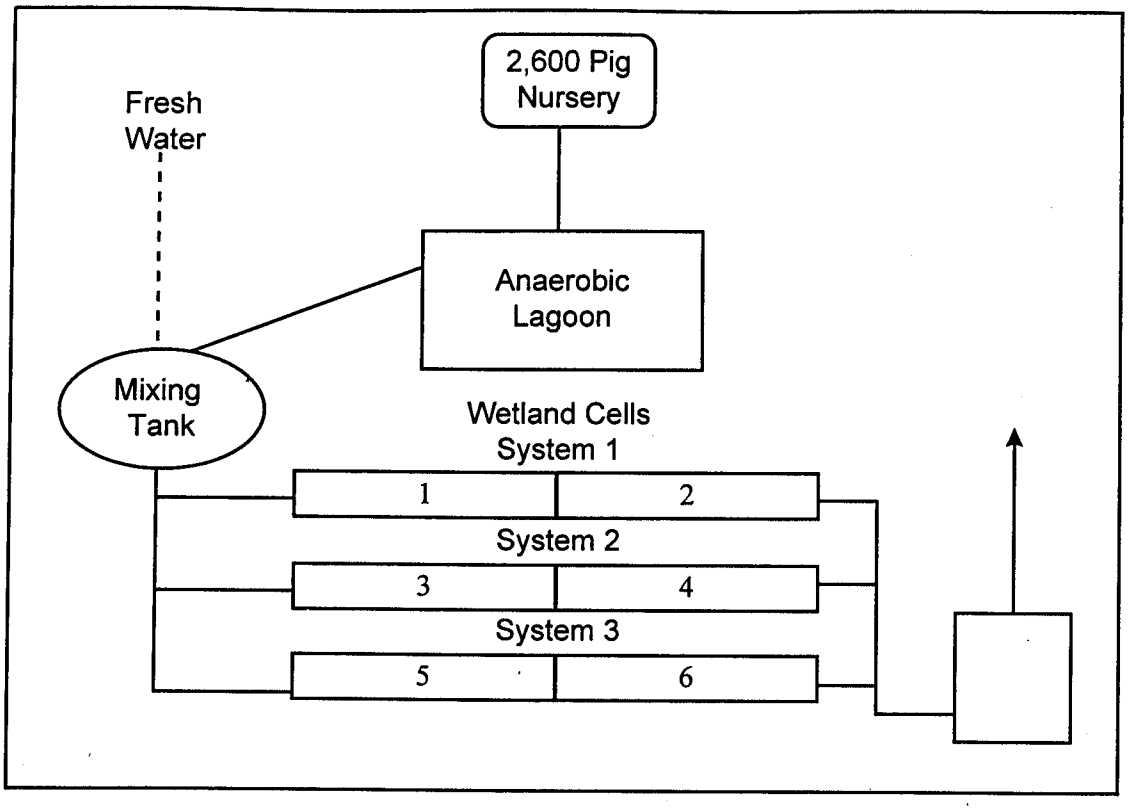
Figure 1. Schematic diagram of the constructed wetland site.