Treatment of Nitrogen in Swine Wastewater by Marsh-Pond-Marsh Constructed Wetlands

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ABSTRACT

North Carolina is the second largest producer of hogs in the United States. The total hog population generates more than 19 million tons of waste per year. The traditional method of treatment has been to store the waste in an anaerobic lagoon and then to spray the waste onto the land. This method has come under scrutiny in recent years due to lagoon breaks, lagoon leaching, groundwater contamination and odor. Since 1998, North Carolina A&T State University has conducted research on the treatment of swine wastewater with six marsh-pond-marsh constructed wetland cells (10 m width x 40 m length) located at the university swine unit. The marsh sections were planted with cattail (Typha latifolia, L.) and bulrushes (Scirpus americanus). A range of loading rates (3 to 37 kg N ha^{-1} day^{-1}) has been studied to determine treatment efficiency of nitrogen. Three different scenarios were researched. The first scenario was to load the wetland cells at 16 and 32 kg N ha^{-1} day^{-1} with replications. The second scenario was to load the cells at 7,13,22,26,34 and 37 kg N ha^{-1} day^{-1} with equal hydraulic loading rates. The third scenario was to cycle the wetland cells from flood to drain stages at a loading rate of 20 kg N ha^{-1} day^{-1}. Nitrogen removal efficiency reduced with increasing nitrogen loading rates. Flood and drain cycles did not improve nitrogen removal efficiency. Approximately 5% of Nitrogen removal occurred through vegetation uptake in marshes.

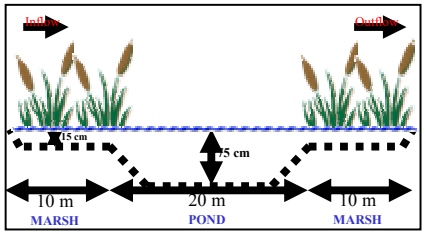
INTRODUCTION

As the hog population in North Carolina continues to grow more efficient methods of swine waste treatment have become a priority. The State government and the public are demanding a safe and effective alternative to the current practices. Constructed wetlands have shown promise as a possible alternative treatment method(Reddy et al., 2001; Payne et al., 1992; Hunt et al., 1995) . Constructed wetlands have low operational and maintenance costs making them applicable to small and medium sized farmers. Continued research is required to study the effects of higher nutrient loading rates on the efficiency of constructed wetlands.

METHODOLOGY

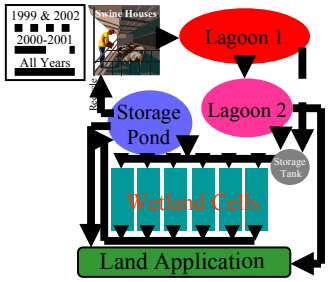
Site and Wetland Cells Description

Six wetland cells (10 m X 40 m) were constructed at the North Carolina A&T State University swine farm in 1995. Each cell has a 20 m middle pond section and 10 m marsh sections at the influent and effluent ends. Shallow sections with marshes at the influent and effluent ends and deep pond section had operating depths of 15 and 75 cm, respectively. The marsh sections were planted with cattail (Typha latifolia, L.) and bulrushes (Scirpus americanus) in 1996.



Wastewater Flow

The waste from the swine houses was flushed with recycled water (SP) into a two stage anaerobic lagoon (Primary Lagoon (L1) and Secondary Lagoon (L2)). In 1999 and 2002, Wastewater from L2 was pumped by a shallow well pump to an 8000 L storage tank. In 2000-2001, wastewater was pumped from L1 to the storage tank and water was pumped from SP to the wetland cells for dilution. The wastewater was discharged from the storage tank by gravity to the wetland cells. The effluent from the wetland cells was discharged to a storage pond(SP) for recycling and/or land application.



Nutrient Loading

1999:

Four wetland cells were loaded from June 1999 to January 2000. Two cells received 16 kg N ha^{-1} day^{-1} with 6 m^3 day^{-1} and a 21 day theoretical retention time and two cells received 32 kg N ha^{-1} day^{-1} with 12 m^3 day^{-1} and a 10.5 day theoretical retention time.

2000-2001:

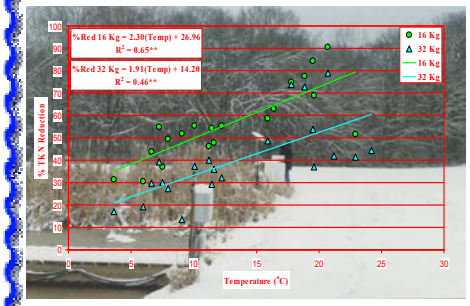
Six wetland cells were loaded from September 2000 to September 2001. The wetland cells received 7,13,22,26,34 and 37 kg N ha^{-1} day^{-1}, respectively, with 9 m^3 day^{-1} and a 16.5 day theoretical retention time.

2002:

Four wetland cells were loaded from June 2002 to October 2002. The cells were loaded at 20 kg N ha^{-1} day^{-1}. The wetland cells received cyclic loading of 4 to 1, 3 to 1, and 2 to 1 weeks (flood to drain) along with a constant flood wetland cell as control treatment.

RESULTS

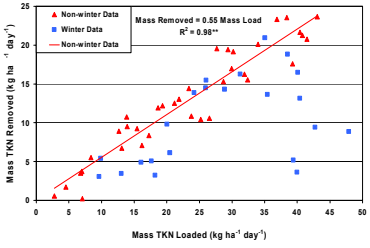
1999



The TKN and NH_4 removal rates were 51 and 60% for the 16 kg N ha^{-1} day^{-1} loading rate and 37 and 43% for the 32 kg N ha^{-1} day^{-1} loading rate, respectively.

Seasonal differences were evident for the N removal with higher removal rates during the warmer months. A linear relationship was found between the percent TKN reduction and the weekly mean air temperature.

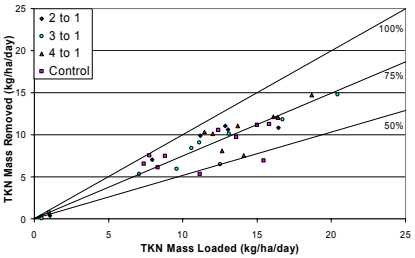
2000-2001



The TKN removal rate was 9 to 56% for winter (Nov-Feb) and 44 to 65% for non-winter with loading rates ranging from 7 to 37 kg N ha^{-1} day^{-1}. Similar results were obtained for NH_4 removal efficiencies.

A linear relationship was found between the TKN loaded (kg ha^{-1} day^{-1}) and the TKN removed (kg ha^{-1} day^{-1}) for the non-winter data.

2002



The TKN and NH_4 removal rate for the four treatments was 65 to 68% and 67 to 75%, respectively. Results indicate minimal variation among the four treatments. Similar results were obtained for removal efficiencies at similar loading rates in prior studies.

Nitrogen Removal by Macrophytes

		N-uptake (kg ha^{-1})		
Macrophytes		1999	2000-2001	2002
Cattails & Bulrushes	Inflow Marsh	3.15	3.54	1.05
	Outflow Marsh	3.4	4.17	1.28
Duckweed		0.66	1.33	-------

CONCLUSIONS

Low Nitrogen loading rates yielded higher percent removal of Nitrogen. Non-winter data showed higher Nitrogen mass removal than winter data irrespective of Nitrogen loading rates. Alternate flood and drain cycles did not influence Nitrogen removal efficiency. Vegetation has an affect upon the Nitrogen dynamics in wetlands.

Constructed wetlands are a cost effective and feasible alternative technology for swine wastewater treatment however, increasing the efficiency of wetland treatment systems needs to be further investigated.

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