

*A FINAL REPORT ON RESEARCH RESULTS*

*TO*

**NORTH CAROLINA PORK COUNCIL**

**PROJECT TITLE:**

**COVERED LAGOONS FOR THE REDUCTION OF ODOR AND  
AMMONIA VOLATILIZATION AND CONSERVATION AND  
PROCESSING OF NITROGEN TO A VALUE ADDED PRODUCT**

Submitted by

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**Abstract:**

A floating permeable cover was installed on a well-established anaerobic lagoon serving a building with a total capacity of 1224 feeder to finished pigs in Onslow County, North Carolina in August 2000. The cover has survived several severe storms and allowed even intense rainfall to pass through without causing cover inundation.

The overall project objective was to take advantage of a permeable lagoon cover that has been in place for 8 years to confirm its capability to control odor and reduce ammonia emissions and to serve as a covered unit process that can conserve nitrogen for processing to a value added product by answering the following questions:

1. Are odor emissions still consistently low in concentration and near neutral relative to quality?
2. Are ammonia emissions continuing to decrease beyond the 80% measured after cover installation and how do they compare to a similar uncovered lagoon nearby?

3. Can the nitrogen that has built up in the lagoon liquid be recovered in a form that is feasible transport off farm for further processing or utilization?
4. What are the economics of the evaluated covered lagoon-value-added products system compared to an uncovered lagoon-spray field system?

## AREAS OF RESEARCH EMPHASIS WITH RESULTS

The permeable 5cm thick polyethylene foam cover is manufactured from recycled polyethylene chips and topped with a geotextile layer containing zeolite particles. The bio-cover component added a gas absorption and selective cation exchange capacity. It is highly air and water permeable and suitable for support of active populations of aerobic microorganisms such as might be found in a trickling filter. Microbiological examination of the cover after 4 months of use showed an active population of aerobic bacteria and protozoa with analyses showing that nitrifying, sulfide oxidizing and methanotrophic bacteria were likely trophic components of the microbial populations observed (Miner et. al, 2003).

### **Odor Emissions**

Results of odor emissions measurements taken twice during one month after cover installation with cotton fabric swatches evaluated by a trained odor panel were that odor and irritation concentrations were very low for emissions from the covered lagoon and follow-up observations confirmed the continued odor control effectiveness of the cover (Miner et. al, 2003).

During visits to the farm in November 2006 and again in June 2008 an informal odor evaluation was conducted around the perimeter of both the covered lagoon as well as the control lagoon. These informal surveys confirmed that the cover has continued to reduce the odor emissions from surface of the lagoon.

### **Ammonia Emissions**

Measurements taken before cover installation and one week after cover installation and three months after cover installation showed a reduction in ammonia emissions by about 80% (Miner et. al, 2003) and at 232 days after cover installation ammonia emissions continued to decrease (Shores et. al. 2005).

The ammonia concentration in the covered lagoon has increased significantly from a pre-cover average nitrogen concentration of about 525 mg/l, (n=2) to a post-cover average of nearly 950 mg/l, (n=17). During the same time period the average nitrogen concentration of a second, uncovered lagoon (control lagoon) has declined slightly from approximately 500 mg/l to an average of about 409 mg/l since August 2000 when the cover was installed on the other lagoon (Figure 1).

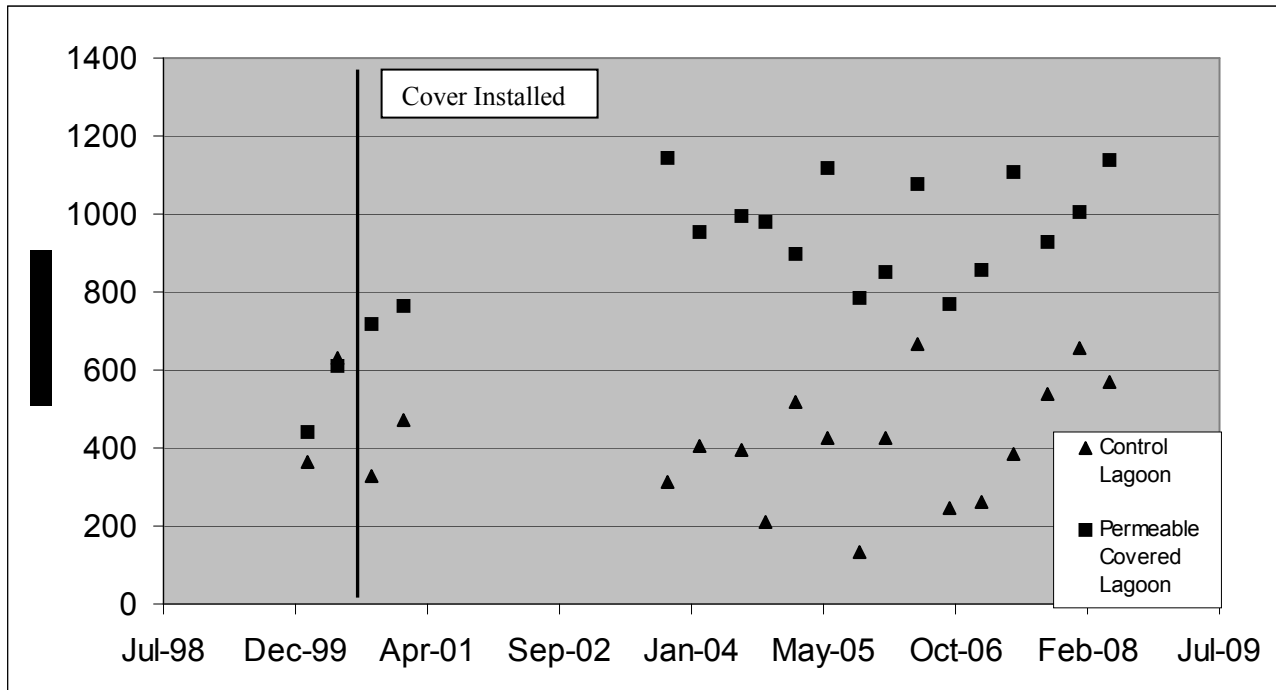


Figure 1. Nitrogen concentration in the permeable-covered lagoon and the uncovered control lagoon.

The ammonia emission from the covered lagoon and a similar nearby uncovered lagoon were measured with a hand-held Draeger Sensor XS NH<sub>3</sub> which is an electrochemical sensor that measures ammonia concentration in a range of 0-50 parts per million (ppm) (the 'minimum' full scale). When ammonia gas is absorbed on the electrode, the resulting oxidation reaction changes the resistance which is proportional to the ammonia concentration. This change in resistance is then interpreted in terms of an electrical current (mA). The sensor has a resolution of 1 ppm and accuracy of  $\pm 3\%$  of maximum full scale (0-200 ppm). Pac III monitor is the unit that carries the above sensor. It has the circuitry to convert the mA reading generated by the sensor into gas ppm and also display it on its LCD screen.

The PACIII monitor was used to take 25 ammonia concentration measurements around the perimeter of each lagoon and the results recorded. An average ammonia concentration was then calculated for each lagoon using the 25 measurements. The ammonia concentrations around the perimeter of the lagoon never exceeded 5 ppm and the average of the 25 readings for the cover and uncovered lagoons were 1ppm and 2ppm respectively. While the measured ammonia concentrations were near the lower end of the sensors capability, the results suggest a lower ammonia concentration in the vicinity of the covered lagoon.

### Nitrogen Recovery

Since the installation of the permeable cover the nitrogen concentration in the lagoon has increased nearly two fold. Prior to the cover installation the nitrogen concentration averaged less than 525 mg/l while the average nitrogen concentration in the 8 years since the cover has been in place has averaged approximately 950 mg/l.

Dekker Technologies, Inc. built a prototype ammonia-scrubbing unit and evaluated its performance at a livestock facility in Indiana prior to transporting it to North Carolina. Due to the poor performance of the prototype unit, Dekker Technologies suspended their research and development of their vacuum assisted system prior to shipping the unit to North Carolina.

Bench scale testing was conducted to determine the feasibility of stripping ammonia for N recovery from covered lagoon liquids. Previous studies of ammonia stripping from traditional swine lagoons (i.e. uncovered) gave mixed results and left questions on the feasibility of stripping ammonia for nitrogen recovery. The higher concentration in the covered lagoon liquid stream could improve the potential for recovery of ammonia. Actual nitrogen recovery will require a second step to convert the air stream ammonia from the stripping process to a useable form.

In an initial study, the covered lagoon liquid was characterized and evaluated for suitability of ammonia stripping as the first step in a nutrient recovery system. Bench-scale experiments, using a countercurrent stripping tower, were conducted on this liquid at high temperature (55-64°C) to evaluate the effect of different pH conditions on ammonia stripping in relation to the characteristics of the liquid waste stream, and to determine if high temperature could replace pH adjustment while maintaining efficient operation.

A simple model of a stripper column was developed based on the relationship of the percent TAN removal per pass through the column as a function of the  $\alpha_1$  (ionization fraction) value. The model results were used to predict behavior of a full-scale column.

Swine waste lagoons typically have a fairly high alkalinity (reported average 2350 mg/L as CaCO<sub>3</sub>). The liquid from the covered lagoon used for stripping tests contained even higher levels of alkalinity (4850 mg/L as CaCO<sub>3</sub>). The stripping column was operated using liquid collected from the covered lagoon and stored for up to three weeks.

Because the liquid waste stream from the covered lagoon has very high alkalinity (i.e., buffer capacity), a large amount of base is needed to raise the pH to a level recommended for ammonia stripping. In the tests conducted on the covered lagoon liquid, 2.5 g/L (21 lb/1000 gal) of lye were required to raise the pH to approximately 9.0, and 5.0 g/L (42 lb/1000 gal) were required to raise the pH to approximately 10.0.

Covered lagoon liquid was tested at temperatures of 55 – 64°C and pH of 7.6 – 10.2. Nitrogen removals were calculated, and percent removal was plotted against the ionization fraction ( $\alpha_1$ ) of NH<sub>3</sub> (Figure 1). The percent removal after one pass through the bench-scale column (1.2 m height) ranged from 6% to 31%. A consistent relationship was observed with the fraction of NH<sub>3</sub>. Since these parameters are independent of operating characteristics, this relationship can be used for a wide variety of conditions.

Some of the options for getting better removal are to use more base (higher pH and therefore higher  $\alpha_1$ ), use more passes through the column, or use a taller column with larger air flow (G). A simple simulation model was developed to provide a basis for determining the tradeoffs among these options. Percent removals of TAN with a one-pass system were calculated for a range of  $\alpha_1$  values of 0.15 to 0.98 (Figure 2). With greater air flow rate (larger G:L, or gas to liquid ratio), greater ammonia removal at a given  $\alpha_1$  value was predicted. The model indicated that removal of at least 70% could be achieved with the covered lagoon liquid using a G:L of 800 with no pH adjustment. This finding is consistent with findings of other researchers.

Table 1. Average Liquid Characteristics

Source	TKN (mg N/L)	TAN (mg N/L)	TS (mg/L)	SS (mg/L)	Alkalinity (mg/L as CaCO <sub>3</sub> )	pH
Covered Lagoon Liquid (August 2005)	1,290	990	3,550	748	4,850	7.1
Similar Uncovered Lagoon Liquid (average 2004-2006)	397					7.5

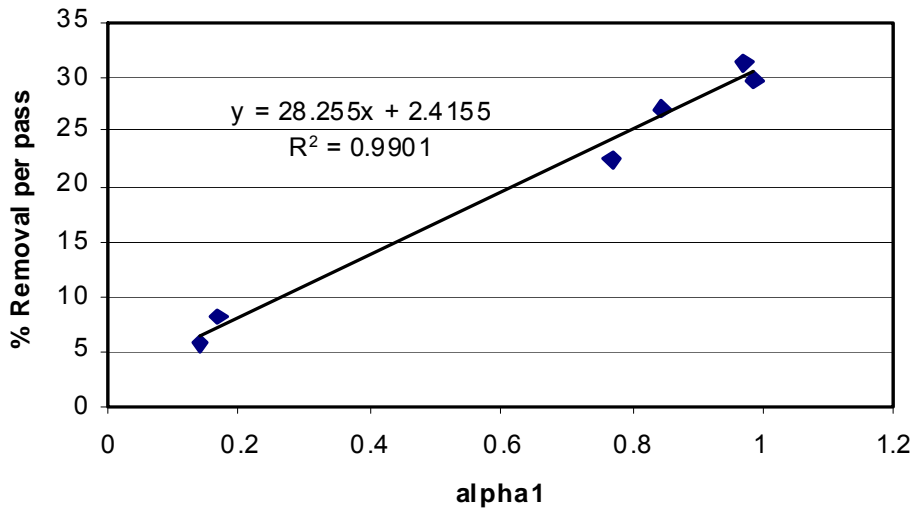


Figure 1. TAN percent removed in one pass through the column at various pH, operated at 55-64°C and G:L of 80.

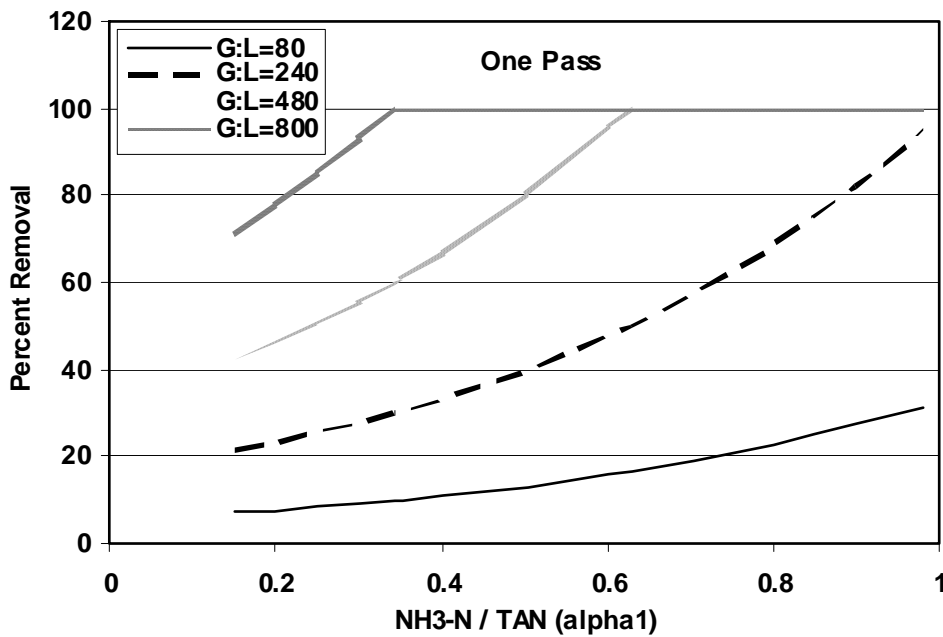


Figure 2. Predicted percent removal of TAN after one pass through the stripping column at 60°C with different pH and G:L ratios.

Based on the model results, ammonia stripping may be effective for the covered swine lagoon wastewater even at only moderately high pH. Based on the promising results of the model unit, a full-scale column (6 m height) was constructed to test model results and determine trade-offs between pH adjustment and air flow rates. The full-scale system was not operational until June and thus the results could not be included in this report. Once the data analysis has been completed an addendum to this report will be submitted.

### **Technology Transfer**

Study results have been and will continue to be included in North Carolina Extension Service programming for re-certification of animal waste system operators. The results from the permeable cover are also being included in comparison with results from impermeable cover installations being implemented as part of a Natural Resources Conservation Service, Conservation Innovation Grant to reduce methane emissions from animal waste treatment system.

A paper entitled *Ammonia Stripping for Nitrogen Harvesting from Swine Waste Management Systems*, by S.K. Liehr, J.M. Rice, and C.L. Baird has been submitted for presentation at the conference "Nutrient Recovery from Wastewater Streams" , May 10-13, 2009.

### **REFERENCES:**

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