한국대기환경학회 2004 추계학술대회 논문집
Proceeding of the 38th Meeting of KOSAE(2004)
Korean Society for Atmospheric Environment

2C5) 대규모 양돈농장에서 발생하는 암모니아 배출량

Ammonia Emissions from Concentrated Animal Feeding Operations (CAFOs): Swine Waste Agricultural Operations

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1. Introduction

The need for developing sustainable solutions for managing the animal waste problem is vital for shaping the future of animal farms. As part of that process, the North Carolina Attorney General has concluded that the public interest will be served by the development, implementation, and evaluation of environmentally superior swine waste management technologies (ESTs) appropriate to each category of hog farms in North Carolina. The EST should meet the following performance standards:

- Eliminates the discharge of animal waste to surface waters and groundwater through direct discharge, seepage, or runoff;
- Substantially eliminates atmospheric emission of ammonia;
- Substantially eliminates the emission of odor that is detectable beyond the boundaries of the parcel or tract of land on which the swine farm is located;
- Substantially eliminates the release of disease-transmitting vectors and airborne pathogens; and
- Substantially eliminates nutrient and heavy metal contamination of soil and groundwater.

During the past year and a half, project OPEN (Odor, Pathogens, and Emissions of Nitrogen) funded by A&PWMC, has demonstrated the effectiveness of a new paradigm for policy-relevant environmental research to address animal waste management in North Carolina. This new paradigm is based on a commitment to improve the scientific understanding associated with all aspects of environmental issues (air, water, soil, odor and odorants, and disease-transmitting vector and airborne pathogens) associated with ESTs and, as part of a comprehensive strategy, to facilitate in the development, testing and evaluation of potential ESTs for the management of swine waste. This report will show that targeted emissions of ammonia were reduced under some of the environmental conditions studied for the candidate technologies.

2. Research Farms and Methods

Four research swine farms that have been evaluated are provided with applied technologies as follows: Barham farm (In-ground ambient temperature anaerobic digester/energy recovery/greenhouse vegetable production system), Corbett #2 farm (RECIP: Solids separation/reciprocating water technology system), Grinnell's laboratory (Belt manure removal and gasification system), and Howard farm (Solids Separation/Constructed Wetlands System. More detailed information including site plans, design schematics and projected operational characteristics can be found in the Three-Year Progress Report recently released by the Air & Poultry Waste Management Center, NCSU, Raleigh, NC (A&PWMC, 2003). Ammonia emissions from the major source compartments of the EST farms (i.e. waste storage unit-mostly lagoon, housing unit, and spray field) were measured by dynamic flow-through flux chamber system and Open-Path

Fourier Transfer Infrared (OP-FTIR) system, and ambient ammonia concentrations were also measured at the farm boundaries of upwind and downwind by denuder technology during the two different seasons (warm and cold). On-site measurement period for each season was limited to two weeks at the EST site. During the experimental periods, ammonia emissions from storage lagoon and spray fields were measured continuously by the flux chamber technology, and the emissions from hog houses were measured by OP-FTIR system. The same measurement technologies were used at two conventional hog farms with anaerobic lagoon and spray system; these are also called baseline farms. The data from the EST farm measurements were compared and contrasted with data from baseline farms for the evaluation of the technologies.

3. Results and Discussion

Ammonia fluxes from the lagoon at Barham, Corbett #2 (ReCip), and Howard farms during the each measurement periods are illustrated in Fig. 1, 2 and 3. The levels of the NH_3 flux from the lagoon at the EST farms varied from 200 to 3500 g-N m^{-2} min^{-1} during the measurement periods (April 2002-March 2003). In general, seasonal variability was found in the most cases, in which higher NH_3 fluxes were recorded in warm season; and more clear diurnal variations were shown during warm season at all EST farms. However, during cold season the variability of the NH_3 flux during a day was significantly small, and the levels of flux were likely to stay below ~ 500 g-N m^{-2} min^{-1} for the experimental days. Typical diurnal variation showed that low NH_3 fluxes during the morning start increasing as the lagoon temperature increase after sun rise during a day, and decreasing in late afternoon around 17:00-18:00; and staying low level during nighttime. This diurnal trend seems to be

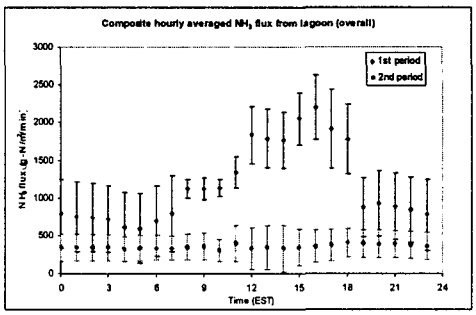

Fig. 1. Diurnal variation of overall storage pond NH_3 flux during April and November, 2002 measurement periods at Barham farm.

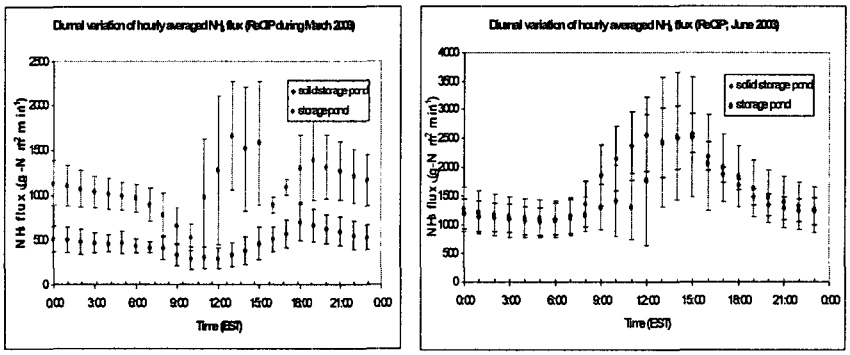

Fig. 2. Diurnal variations of hourly averaged NH_3 flux from solid storage pond and storage pond at Corbett #2 farm (ReCiP) during (a) March 10-25, 2003, and (b) June 2-13, 2003. Error bar indicates 1 standard deviation.

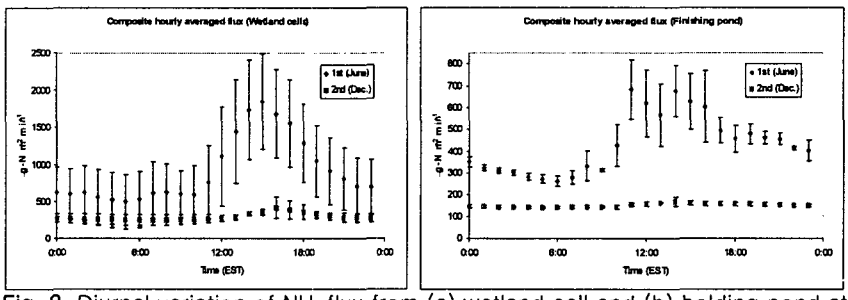

Fig. 3. Diurnal variation of NH_3 flux from (a) wetland cell and (b) holding pond at Howard farm during June and December, 2002 measurement period. Error bar indicates 1 standard deviation.

followed diurnal variation of lagoon temperature during the experimental periods; and it suggests that lagoon temperature is the one of most important parameter to control NH_3 flux from lagoon. There was no measurement of lagoon NH_3 flux at Grinnell's laboratory because the belt manure system consisted of only swine housing unit with a ventilating fan. The NH_3 concentrations were monitored at the center of ventilating flow from the fan, and used to calculate the NH_3 emission from the housing unit with known of flow rate of the fan during the experimental periods.

The NH_3 emissions from the hog houses at EST farms were estimated based on the NH_3 concentration measured by FTIR system, and were then normalized by the total live weight of the hogs in the houses at the time of the sampling. The barn houses at Barham farm, Grinnell's laboratory, and Howard farm were ventilated by fans, and the houses at Corbett #2 farm were naturally ventilated. Higher emissions from the barns were experienced during the warm periods at EST farms, but not at Barham farm. Relatively lower emission from the houses at Corbett #2 farm was found during the experimental periods. Table 1 provides the total NH_3-N emissions (kg-N/1000 kg-live weight/yr), and their relative emissions (% of E) to the estimated nitrogen excretion (E) at each EST farm, respectively. From the summary of total NH_3-N emissions expressed in kg-N/1000 kg-*lw*/yr, as well as relative emissions expressed as % of N-excretion, we can draw some inferences about the performance of each EST relative to the baseline farms.

Table 1. Average overall NH_3 emission (Kg-N/Yr/1000 Kg-live weight) from the barns at EST farms (OP-FTIR measurements).

Farm Informations	Sampling period	Baseline farm emissions				EST farm emission			
		Lagoons	Barns	Total	% of E	Lagoons	Barns	Total	% of E
Barham farm	Apr. 2002	20.7	54.5	75.2	40.76	16.1	17.6	33.7	39.35
	Nov. 2002	16.1	46.2	62.3	37.08	3.6	25.7	29.3	31.81
Corbett #2 farm	Mar. 2003	14.5	12.7	27.2	16.20	18.0	6.3	24.3	14.67
	June 2003	40.4	3.5	43.9	23.8	42.1	25.7	67.8	28.97
† Grinnell's laboratory	Apr. 2002	n/a	54.5	54.5	23.86	† 0.0	67.0	67.0	38.09
	Nov. 2002	n/a	46.2	46.2	22.78	† 0.0	27.3	27.3	10.10
Howard farm	Jun. 2002	62.2	73.8	96.2	52.15	62.2	73.8	136.0	70.09
	Dec. 2002	13.0	44.1	52.7	31.35	13.0	44.1	57.1	43.26

†*Grinnell's laboratory has no lagoon treatment system.*

4. Summary

The estimated emissions from proposed four ESTs for each measurement period were compared with the estimated emissions from baseline farms, after the later are adjusted for the average environmental parameters (lagoon temperature and air temperature) observed at the EST sites. The ESTs at Barham Farm and Grinnell's Laboratory were more effective in reducing the ammonia emission during one of the two sampling periods. However, based on the current research results and analysis, and available information in the scientific literature, the evaluated alternative technologies may require additional technical modifications to be qualified as Environmentally Superior as defined by the NC Attorney General Agreements.

Acknowledgements

We sincerely acknowledge the help and support provided by Ms. Lynn Worley-Davis. We thank the technology PIs, farm owners, Cavanaugh & Associates, and Mr. Bundy Lane, C. Stokes, and P. Moore for their cooperation. We acknowledge the discussions and gracious help provided by Drs. W. Robarge, P. Arya and M. Williams of North Carolina State University. We thank Mark Barnes,

Guillermo Rameriz, and Rachael Huie. Thanks to Dr. Bruce Gay, US EPA; and Dr. Joette Steger, for their review of Project OPEN. Financial Support does not constitute an endorsement by the A&PWMC of the views expressed in the report, nor does mention of trade names of commercial or noncommercial products constitute endorsement or recommendation for use.

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