한국대기환경학회 2004 춘계학술대회 논문집
Proceeding of the 37th Meeting of KOSAE(2004)
Korean Society for Atmospheric Environment

1B1) An Integrated Study of the Emissions of Ammonia, Odor and Odorants, and Pathogens and Related Contaminants from Potential Environmentally Superior Technologies for Swine Facilities Program OPEN (Odor, Pathogens, and Emissions of Nitrogen)

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Abstract

The need for developing sustainable solutions for managing the animal waste is vital for the future of the animal industry in North Carolina. As part of that process, the North Carolina Attorney General has concluded that the public interest will be served by the development and implementation of environmentally superior swine waste management technologies appropriate to each category of hog farms. To facilitate in the development, testing, and evaluation of potential technologies it is necessary that all aspects of environmental issues (air, water, soil, odor and odorants, and disease-transmitting vectors and airborne pathogens) be addressed as part of a comprehensive strategy. Program OPEN (Odor, Pathogens, and Emissions of Nitrogen) is comprehensively addressing these issues.

Keywords ammonia, odor, pathogen, emissions, hog waste

Introduction

The current technology used in North Carolina to manage the hog waste is known as the Lagoon and Spray System, which consists of an exposed waste lagoon to store the waste (~98% liquid) and mechanisms through which the digested manure is periodically sprayed onto the crops as a nutrient source.

The technology can be subdivided into four processes (Aneja et al, 2001a) which release NH_3, odor, and pathogens to the atmosphere: Production houses; Waste Storage and Treatment Systems (Aneja et al., 2000; 2001b; 2001c); Land application i.e. spraying; and Biogenic Emissions from Soil and Crops. Current estimates of NH_3 emissions in North Carolina from hogs alone, utilizing an emission factor (20.3 lbs of NH_3 hog^{-1} $year^{-1}$) determined (Battye et al., 1994), are: 1994~195 tons of NH_3 day^{-1}; 1996~258 tons of NH_3 day^{-1}; 1999~264 tons of NH_3 day^{-1}(Aneja et al., 2001a).

The primary objective of this study is to provide an assessment of the emissions of ammonia, odor and odorants, and pathogens (including potential disease-transmitting vectors) from 18 proposed Environmentally Superior Technologies (EST) for swine production in North

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This objective will be achieved through the use of state-of-the-art methodologies for measuring the respective emissions at different seasons of the year, followed by an integrated assessment of the potential environmental and health consequences these emissions represent for each of the evaluated ESTs (Figure 1).

NH_3 emissions measurements

Sources of ammonia emissions associated with ESTs include animal housing units, water holding structures, and specific mechanical/structural units that comprise the major portion of the ESTs.

Ammonia emission measurements are being made with

1. Dynamic chamber system interfaced to a mobile laboratory (which houses the spectroscopic analytical system and the data acquisition system),
2. Open-path FTIR system coupled with wind flow field measurements,
3. NH_3 denuder coupled with dispersion diffusion models,
4. Nitrogen mass balance.

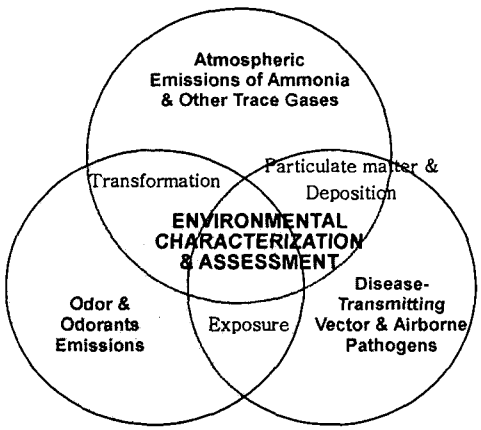

Fig. 1. Integrated approach of environmental characterization and assessment for swine facilities.

The dynamic-chamber technique is being used to measure ammonia emissions from water-holding structures (storage lagoon) and soils receiving effluent. Associated measurements include site meteorology, and water chemistry (i.e. TKN, NO_3-N and NH_4-N).

The following parameters are recorded on 15 minutes average bases into Campbell 21X data Logger during the experimental periods; NH_3 concentration from the flux chamber, ambient NH_3 concentration at 10 meter height, site meteorological data-air temperature, relative humidity, solar radiation, wind speed and wind direction, and lagoon water temperature (soil temperature), lagoon pH.

Open-path FTIR spectroscopy is being used to measure the concentration of ammonia in air adjacent to and expelled from animal housing units. This information combined with the appropriate models, technical information and meteorological data will yield estimates of ammonia flux.

Annular denuder technology is being used to provide integrated measures of the upwind/downwind ambient atmospheric chemistry (NH_3, HNO_3, SO_2, and ammonium aerosols) at each EST site. This information may also be combined with specific models and meteorological information to assess emissions.

Figure 2 shows diurnal variations of lagoon NH_3 flux from swine farms that measured by dynamic chamber system, wind speed and lagoon temperature during April and June, 2002. It shows NH_3 flux from lagoon increases as lagoon temperature increases during the measurement period.

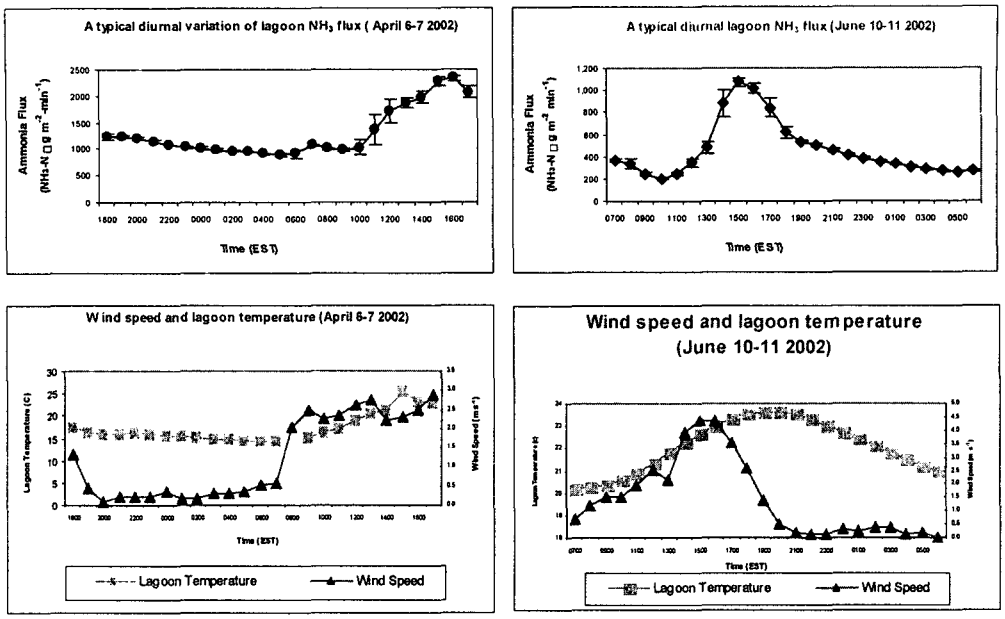

Fig. 2. Diurnal variations of lagoon NH_3 flux measured by dynamic chamber system, lagoon temperature and wind speed during experimental period at experimental swine farms.

Odor Measurement

Both odor and potential components of odor (such as H_2S, VOCs, NH_3 and particulates) are being measured at hog production facilities with and without EST. A combination of field and laboratory techniques are being used by employing a trained odor panel and direct measurement by analytical instrumentation.

Equipment:

" Jerome 631-X Hydrogen Sulfide Analyzer (Arizona Instrument)

" ppbRAE VOC Monitor PGM-7240 (RAE Systems, CA)

" HAZ-DUST EPAM-5000 (Environmental Particulate Air Monitor)

Table 1. Relationship between odor intensity and measurements from equipment

Perceived odor intensity range		Low (1-4)	Medium (4.5-6)	High (6.5-7)
VOC's (ppb) with ppbRAE	average	3.8	15.3	38.0
	maximum	8.8	66.0	116.0
H_2S (ppb) with Jerome meter	average	5.9	16.5	51.7
	maximum	7.3	42.5	79.7
particulates (mg/m3) with EPAM	average	0.030	0.017	0.040
	maximum	0.071	0.028	0.073

Pathogen Measurement

The levels of pathogens, indicators of pathogens, and related microbial contaminants of

health concern of swine manure origin are being analyzed on farms with alternative ESTs. Particular emphasis is on quantifying the extent to which alternative treatment systems reduce pathogens and related microbes of swine manure origin, the transport, survival and fates of these pathogens and other microbes on the farm, and the extent, if any, to which these pathogens and related microbes travel off the farms to contaminate air, water and land. Figure 3 shows that microbial indicator concentrations for experimental farms.

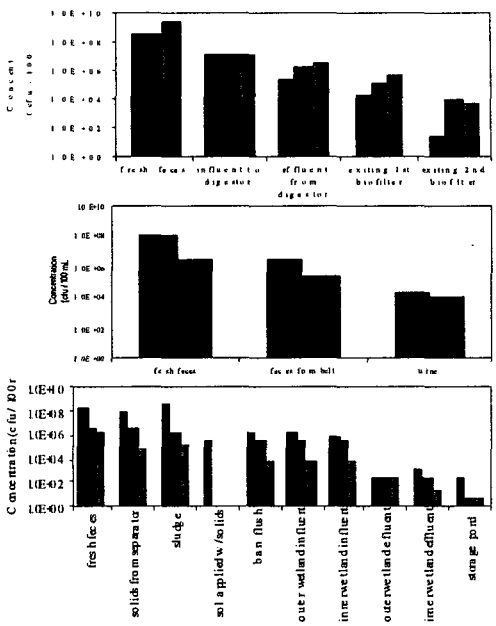

Fig. 3. Microbial indicator concentrations for experimental farms.

Evaluations Conducted to Date

Collectively, eighteen different EST candidates are undergoing performance verification and economic analysis. Among the ESTs, three technologies have been measured so far. These three technologies are; In-ground ambient temperature anaerobic digester/energy recovery/greenhouse vegetable production system Soils separation/constructed wetlands system Belt manure removal and gasification system (liquid fuel recovery)

Baseline Measurements

Two farm sites employing conventional technology (i.e. lagoon and soil spray system) have been selected based on relative size and type of management as compared to the range in farm sites that will be fitted with a proposed EST for baseline measurements. The same measurement technologies for NH_3, odor and pathogens will be used at these baseline sites. The results from these baseline measurements are being utilized as reference values to compare the results from eighteen different EST.

Summary

Modern large-scale animal production facilities represent multiple sources of potential emissions of ammonia, odors and pathogens that can negatively impact environmental and human health. This project employs state-oftheart scientific techniques in a coordinated effort to assess emissions from proposed alternative Environmentally Superior Technologies (EST) for swine production in North Carolina. This coordinated effort will fulfill the promise of producing an integrated assessment for each EST, while also affording the opportunity to further our understanding of previously unrecognized interactions among the many variables that influence emissions from large-scale animal production facilities.

Acknowledgements

This research is funded by Animal Waste Management Center (APWMC), Raleigh, NC, USA. We sincerely acknowledge technology PIs and Cavanaugh & Associates for their cooperation. We thank L. W-Davis, M. Barnes, C. Stokes, and P. Moore. We also thank NC Division of Air Quality for their support. Financial support does not constitute an endorsement by APWMC of the views expressed in the article/report, nor does mention of trade names of commercial or noncommercial products constitute endorsement or recommendation for use.

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