

INNOVATION IN MANURE MANAGEMENT TECHNOLOGIES – Efforts at North Carolina State University funded by the Attorney General Agreements with Smithfield Foods, Premium Standard Farms and Frontline Farmers

C.M. Williams* and F.J. Humenik**

*Animal and Poultry Waste Management Center, Campus Box 7608
North Carolina State University
Raleigh, NC 27695-7608
Mike_Williams@ncsu.edu

**College of Agriculture and Life Sciences Animal Waste Management Programs
Campus Box 7927
North Carolina State University
Raleigh, NC 27695-7927
Frank_Humenik@ncsu.edu

Introduction

The impact of animal agriculture on the environment attributed to the production of meat, eggs and milk are significant issues facing the livestock industry, intensive swine production in particular. In the United States and elsewhere, researchers are expending considerable efforts to develop innovative manure treatment technologies to address these issues. The attention that is directed to the development of new animal waste treatment technology involves academic institutions, government, and the private sector, including the animal production industry. Historically, research has arguably been more intensive in Western Europe because of limited land area resulting in more urban pressure on animal agriculture. In 1997, fifteen experienced researchers from eleven countries, mostly in Western Europe, published a book entitled MANURE MANAGEMENT, TREATMENT STRATEGIES FOR SUSTAINABLE AGRICULTURE.¹ These researchers basically defined the “state of the art” of animal manure management and concluded that a range of treatments are available that can address many of the identified environmental issues. Available treatments included aeration, anaerobic digestion including lagoons, solids separation, and composting. New processes that were identified as potentially effective included thermal treatments, purification by soil, use of chemical additives, and membrane processes. However, it was noted that if the use of manure is to be other than direct land application as a source of plant nutrients, there are economic challenges to developing commercially competitive organo-fertilizers or other alternative co-products.

Many stakeholders involved in animal waste treatment issues assume that there are readily available alternative management technologies that have been adequately developed and verified to the point that they can replace existing systems. However, while there are a number of different technologies and management systems available, the practicality of applying many of these alternative technologies is largely unproven at

¹ See MANURE MANAGEMENT – TREATMENT STRATEGIES FOR SUSTAINABLE AGRICULTURE (C.H. Burton ed., Silsoe Research Institute, Wrest Park, Silsoe, Bedford, UK, (1997).

the present time. For example, many promising alternative technologies generate solids but only limited viable markets have been identified or established for the end products; this limitation significantly impacts the economic feasibility of the technology. In addition, some candidate replacement systems have not performed well under performance verification testing or are cost-prohibitive. Other potential replacement technologies are still in field trials and need further evaluation before any definitive conclusions can be reached. The present level of research, development, and demonstration efforts, however, provides optimism that innovative alternatives may be developed and proven practical in the future.

North Carolina State University Research – The Attorney General Agreements²

The Attorney General of North Carolina entered into Agreements in July and September 2000 with Smithfield Foods and Premium Standard Farms (PSF), respectively, to develop “Environmentally Superior Technologies” (EST) for implementation onto farms located in North Carolina that are owned by these companies.³ In March 2002, the Attorney General also entered into an Agreement with Frontline Farmers in which its membership agreed to work cooperatively with the Attorney General and North Carolina State University (NCSU) to develop and implement EST.⁴ The Smithfield Foods Agreement provides \$15 million and, to date, the NC Attorney General has allocated \$2.3 million from the PSF Agreement for a total of \$17.3 million for the EST identification and development initiative.

The Agreements define EST as “any technology, or combination of technologies that (1) is permissible by the appropriate governmental authority; (2) is determined to be technically, operationally, and economically feasible for an identified category or categories of farms as described in the Agreements and (3) meets the following performance standards:

1. Eliminate the discharge of animal waste to surface waters and groundwater through direct discharge, seepage, or runoff,
2. Substantially eliminate atmospheric emissions of ammonia,
3. Substantially eliminate the emission of odor that is detectable beyond the boundaries of the parcel or tract of land on which the swine farm is located,
4. Substantially eliminate the release of disease-transmitting vectors and airborne pathogens, and
5. Substantially eliminate nutrient and heavy metal contamination of soil and groundwater.”

² Sections of the following text are published, in part, in *Proceedings North Carolina Animal Waste Management Workshop*. October 16-17, 2003, Research Triangle Park, NC. Edited by G.B. Havenstein, published by College of Agriculture and Life Sciences, NCSU. Pages 14-18 (2003).

³ See Agreements between Attorney General of North Carolina and Smithfield Foods and Premium Standard Farms (North Carolina Department of Justice, on file with Ryke Longest, 2000).

⁴ See Agreement between Attorney General of North Carolina and Frontline Farmers (North Carolina Department of Justice, on file with Ryke Longest, 2002).

Selection of EST candidates to undergo performance verification and economic analysis involved a request for proposals that was issued nationwide to research institutions and industry. Selections were based on terms and conditions of the Agreements and competitive review (outside *ad hoc* review) as well as review by an Advisory Panel appointed per the Agreements and comprised of individuals that represent government, environmental and community interests, the companies (Smithfield, PSF and Frontline Farmers) and individuals with expertise in animal waste management, environmental science and public health, economics and business management. Collectively, this process yielded the following EST candidates:

1. In-ground ambient temperature anaerobic digester / energy recovery / greenhouse vegetable production system,
2. High temperature thermophilic anaerobic digester (TAnD) energy recovery system,
3. Solids separation / constructed wetlands system,
4. Sequencing batch reactor (SBR) system,
5. Upflow biofiltration system,
6. Solids separation / nitrification-denitrification / soluble phosphorus removal /solids processing system,
7. Belt manure removal and gasification system to thermally convert dry manure to a combustible gas stream for liquid fuel recovery,
8. Ultrasonic plasma resonator system,
9. Manure solids conversion to insect biomass (black soldier fly larvae) for value-added processing into animal feed protein meal and oil system,
10. Solids separation / reciprocating water technology system,
11. Micro-turbine co-generation system for energy recovery,
12. Belt system for manure removal,
13. High-rate second generation totally enclosed Bion system for manure slurry treatment and biosolids recovery,
14. Combined in-ground ambient digester with permeable cover / aerobic blanket - BioKinetic aeration process for nitrification-denitrification / in-ground mesophilic anaerobic digester system (this project represents 3 farm sites),
15. Dewatering / drying / desalinization system,
16. Solids separation / gasification for energy and ash recovery centralized system (this project represents 3 farm sites),
17. High solids high temperature anaerobic digester system, and
18. Solids separation / mesophilic anaerobic digestion / membrane filtration – reverse osmosis system.

EST Process Analysis

Performance verification and economic feasibility analysis for candidate EST located on commercial farm sites involves a 15-step systematic process: 1) EST candidate selection through a request for proposals and competitive review process, 2) selection of appropriate commercial farm or university research site for the technology study, 3) execution of farm owner agreement, 4) execution of technology design agreement, 5) development of technology design documents, 6) submittal, review and approval of

design documents by NC Department of Environment and Natural Resources (NCDENR) for permitting purposes, 7) execution of technology construction agreement, 8) on-site construction, 9) execution of agreements for technology operation and post-evaluation decommission (if necessary), 10) construction closure approval, 11) establishment of functional operation of technology (e.g. steady state waste treatment conditions), 12) procurement of environmental performance data and economic feasibility data by third party research teams, 13) analysis of data and results reporting to the Advisory Panel, Designee, and public, 14) input and review process by the advisory panels, and 15) EST technology determinations per terms and conditions of Agreements. A progress report describing the detail of the activities related to each of these steps between the dates of July 25, 2000 and July 25, 2002 was previously published.⁵

Current Construction, Operational and Performance Data Procurement Status

In addition to the progress made during the past year relative to constructing and bringing the technologies to operational conditions, environmental performance data procurement and economic assessment has occurred for the following technologies:

(Project 1) Ambient Digester / Greenhouse tomato production,
(Project 3) Constructed wetlands,
(Project 5) Upflow biofilter,
(Project 10) Reciprocating wetland,
(Project 6) Super Soil Systems,
(Project 7) Belt Manure / Gasification System (belt component only),
(Projects 9 & 12) Belt Manure System / Manure Conversion to Insect Biomass,
(Project 16) Solids Separation / Ash Recovery,
(Project 11) Microturbine Co-Generation, and
(Project 14) Mesophilic Digester / Permeable cover.

Full progress reports by project investigators for many of these projects have been published in July 2003.⁶

Status of Emission Analysis

Emissions of odor, pathogens and nitrogen were conducted for several project sites during this reporting period. Investigators for this component of the performance verification process, Project OPEN (Odor, Pathogens, and Emissions of Nitrogen)

⁵ Development of Environmentally Superior Technologies: Two-Year Progress Report for Technology Determinations per Agreements Between the Attorney General of North Carolina and Smithfield Foods and Premium Standard Farms, and Frontline Farmers (North Carolina State University Animal and Poultry Waste Management Center, on file with C.M. Williams; also available at www.cals.ncsu.edu/waste_mgt/).

⁶ See Development of Environmentally Superior Technologies: Year 3 Progress Report for Technology Determinations per Agreements Between the Attorney General of North Carolina and Smithfield Foods and Premium Standard Farms, and Frontline Farmers. Reporting Period July 26, 2002-July 25, 2003. (North Carolina State University Animal and Poultry Waste Management Center, on file with C.M. Williams; also available at www.cals.ncsu.edu/waste_mgt/).

demonstrated the effectiveness of a new paradigm for policy-relevant environmental research. This new paradigm is based on a commitment to improve scientific understanding associated with all aspects of environmental issues (air, water, soil, odor and odorants, and disease-transmitting vector and airborne pathogens) and, as part of a comprehensive strategy, to facilitate in the development, testing and evaluation of potential Environmentally Superior Technologies for the management of swine waste. The OPEN team, comprised of scientists and engineers from three universities (North Carolina State University, University of North Carolina at Chapel Hill, and Duke University), one national laboratory (National Exposure Research Laboratory, U.S. Environmental Protection Agency), one State of North Carolina Department (Division of Air Quality, and Division of Water Quality, NC Department of Environment and Natural Resources), and one private research organization (MCNC- North Carolina Supercomputing Center), developed a monitoring model based on 2 weeks intensive field sampling during both a warm and cool season for each of the operational technology sites. In addition the model includes comparative monitoring of conventional lagoon and spray-field sites (2 total). During this reporting period, four candidate EST sites (Project 1, in-ground ambient temperature anaerobic digester/energy recovery/greenhouse vegetable production system; Project 10, solid separation/ reciprocating water technology; Project 7, belt system; and Project 3, solid separation/ constructed wetlands) were evaluated during two seasons (cold and warm), and the results compared and contrasted with current lagoon and spray technologies at the 2 conventional swine farms. Data recently published shows that targeted emissions (odor, pathogens, and ammonia) were reduced under some of the environmental conditions studied for the candidate technologies.⁷

Status of Economic Feasibility Analysis

The economic feasibility analysis of candidate EST involves determining the consequences of adopting the new technologies on the economic welfare of North Carolina citizens. Toward that end, the investigators (RTI International and NCSU Department of Agricultural and Resource Economics) are assessing the following general research objectives for this initiative:

1. Quantify the costs to farmers of adopting an identified set of alternatives to the current lagoon and spray field system.
2. Identify, assess, and describe financial and other logistical factors that will affect the technology adoption decision.
3. Estimate the effect of alternative technologies on the position of North Carolina hog and pork producers relative to competing producers in regional, national, and global commodity markets.
4. Identify and quantify the pathways by which the adoption of new waste management technologies changes pollutant emissions to air and water and affects environmental quality.

⁷ *Id.*

5. Estimate the monetized benefits to North Carolina households of the changes in environmental quality achieved by implementing alternative waste management technologies.

During the past year, construction and operation costs data were procured for:

(Project 1) Ambient Digester / Greenhouse tomato production,
(Project 3) Constructed wetlands,
(Project 5) Upflow biofilter,
(Project 10) Reciprocating wetland,
(Project 6) Super Soil Systems,
(Project 7) Belt Manure / Gasification System (belt component only),
(Projects 9 & 12) Belt Manure System / Manure Conversion to Insect Biomass,
(Project 16) Solids Separation / Ash Recovery,
(Project 11) Microturbine Co-Generation, and
(Project 14) Mesophilic Digester / Permeable cover.

Preliminary cost data for Projects 1, 3, 5, and 10 was published in the referenced Year 3 progress report.⁸

RTI made substantive progress during the past year towards completing the development, testing, and evaluation of preliminary results of component models for measuring environmental impacts and assessing economic benefits. Specifically, a protocol and structure for integrating the different components of the environmental modeling and benefit assessment tasks into an integrated benefits assessment tool was developed. This involved completion and testing of an ammonia dispersion and deposition model as well as a surface water model; analysis of groundwater data to explore the observed relationship between nitrate levels and local nitrogen loadings from hog farms; and development of a methodology for extending the ammonia dispersion model to estimate the impacts of ammonia emissions on regional ambient levels of particulate matter (PM). In addition, RTI completed the development and testing of the benefit transfer model (based on an existing hedonic property value study) for assessing benefits of odor reductions; continued the adaptation and re-estimation of the recreation demand model for assessing the benefits of improved surface water quality, and adapted an existing EPA benefit transfer model to assess the health-related benefits associated with reductions in ambient PM levels. RTI also made significant progress in designing and programming an integrated benefits assessment tool (IBAT), which combines the modeling components described above into a single integrated software system. IBAT is designed to include a user interface that will allow the user to define scenarios (i.e., reductions in releases from hog farms) and generate summary benefits assessment results. And finally, during the past year, RTI conducted a survey of North Carolina swine farmers to evaluate their perceptions on alternatives to the current lagoon and spray-field system. The completed survey and a comprehensive description of the benefits modeling activities described above are presented in the referenced Year 3 progress report.⁹

⁸ *Id.*

⁹ *Id.*

Summary

The sustainability of animal production agriculture will likely depend upon the development and implementation of manure management technologies that are capable of addressing environmental concerns associated with emissions from concentrated animal feeding operations. Technologies that range from simple to complex are under development in North Carolina and elsewhere that may address the concerns noted. In North Carolina, a major initiative funded by resources from Agreements between the NC Attorney General and Smithfield Foods, Premium Standard Farms, and Frontline Farmers is in progress to determine the technical, operational, and economic feasibility for approximately 18 candidate technologies. It is anticipated that such determinations will be completed for approximately half of the candidate technologies by mid 2004 and the remaining ones completed by end of 2005.