FY 2007 Annual Report
National Program 206-- Agricultural Waste and Byproduct Utilization

Introduction

Over one billion tons of agricultural, municipal, and industrial wastes with potential uses in agriculture are generated annually in the United States. Many of these materials are applied to agricultural land because of the benefits they provide. These benefits include: providing a nutrient source for crops; improving soil chemical, physical and biological properties; improving water storage and use; reducing movement of contaminants to water and air; and reducing production costs and energy use. However, improperly managed manure and other byproducts can pose a threat to soil, water and air quality, and to human and animal health.

The goal of the Agricultural Waste and Byproduct Utilization National Program is to develop and evaluate management practices and systems, control technologies, and decision tools to allow producers and their advisors to (1) use manure and other byproducts effectively and safely while protecting the environment and human and animal health and (2) provide policy-makers and regulators with information and tools to establish appropriate conservation program, environmental credit trading, and environmental protection decisions. To achieve this goal, the National Program is focused on four major areas of research: atmospheric emissions, nutrient management, pathogens and pharmaceutically active compounds, and municipal and industrial byproducts. Selective accomplishments from these four components are described in the following section.

Accomplishments

Atmospheric Emissions: Air emissions from animal production operations and land application of manure and other byproducts include particulate matter, ammonia, volatile organic compounds that cause odor or serve as precursors for ozone formation, hydrogen sulfide, greenhouse gases and pathogens. Research is being conducted to: (1) develop new methods and improve existing methods to measure particulate matter and gaseous emissions; (2) develop and determine the effectiveness and environmental benefits of management practices and control technologies to reduce emissions; (3) develop and test decision tools to predict emissions and their dispersion across a range of animal production systems, management practices, and environmental conditions. Tools and practices for measurement, control and prediction of emissions from animal production operations will help provide the scientific background for management, policy and regulatory decisions.

Loss of ammonia from livestock operations is a major problem. ARS scientists from Florence, South Carolina are developing a cost-effective, large-scale method of removing ammonia from livestock wastewater using an innovative bacterial process, anammox. The anammox process involves using anaerobic bacteria to convert nitrite and ammonia

to harmless dinitrogen gas. The scientists have isolated the bacteria, planctomycetes, used in the anammox process from livestock wastewater. They have demonstrated anammox's commercial potential to remove nitrogen from wastewater at higher rates and at a lower cost than conventional methods. This finding can be of significant importance in modern livestock production because excess ammonia is a global problem, and the use of conventional biological nitrogen removal methods is usually limited by operational cost, which can be lowered four-fold with the anammox process. This technique is currently being tested with cooperators in the United States and Brazil.

Although many mathematical models have been used to predict ammonia emissions from anaerobic treatment lagoons, there is still a need for more accurate predictions. Challenges for more accurate ammonia volatilization predictions include three major factors: lagoon water characteristics (ammonia concentration, solids content, and water temperature); bubble formation due to microbial activity; and weather conditions (wind speed and air temperature). An improved model that incorporates the impacts of bubble formation and varying wind speed on the ammonia volatilization process was developed by scientists from Florence, South Carolina. The new model was tested against ammonia emissions data generated over a one-year period in three swine lagoons with distinctly different manure management and water quality characteristics: traditional lagoon, partially treated lagoon that received liquid manure after liquid-solid separation, and treated lagoon that received liquid manure after separation of solids and removal of nitrogen and phosphorus. Internal bubbling of the non-treated lagoon increased ammonia volatilization rate during the warm season. The new model accurately predicted the measured ammonia emissions in the three lagoons. Based on model theory and field measurements, ammonia emission from swine lagoons would be significantly under-estimated if either bubbling-enhanced mass transport or variable wind speed are not taken into account. The new process model for ammonia emissions not only provides more accurate predictions, but also uses input factors that can be conveniently constructed from readily available data.

Methods are needed to control emissions from livestock production operations. Decreasing ammonia losses from the surface of beef cattle feedlots would improve air quality and increase the value of manure collected from the pens. ARS scientists from Bushland, Texas evaluated a number of materials for their ability to decrease ammonia emissions from a mixture of beef cattle feces and urine. Several of the materials including alum, zeolite, urease inhibitor and corn oil decreased ammonia emissions by 50 percent or more. In a related investigation, ARS scientists from Clay Center, Nebraska added antimicrobial plant oils (thymol, carvacol and eugenol) to cattle and swine manure. These oils inhibited essentially all microbial metabolism in manure slurries resulting in no production of volatile fatty acids or other gaseous products. Results from the eugenol addition to cattle and swine manure were unique because eugenol stopped production of volatile fatty acids associated with odor, yet allowed lactate accumulation. This effect rapidly lowered pH, thereby reducing ammonia emissions. Development of commercial uses of these natural plant oils in livestock production systems is currently being undertaken by an industry partner since these materials can be used to control both pathogens and emissions.

Nutrient Management: Utilization of nutrients in manure in an environmentally sustainable manner is one of the critical management issues facing livestock producers. Movement of nutrients in excess amounts from manure and other byproducts to soil, water and air can cause significant environmental problems. Nitrogen and phosphorus from manure and other sources have been associated with algal blooms, accelerated eutrophication of lakes and streams, and development of hypoxic zones in the Gulf of Mexico. ARS scientists are conducting research to develop management practices, control technologies, and decision tools for effective agricultural use of nutrients from manure and other byproducts, while protecting environmental quality and public health.

Managing manure is difficult because of its highly variable composition. A portable near-infrared spectrometer was developed by scientists at Beltsville, Maryland to determine moisture, total nitrogen, organic nitrogen, and ammonium nitrogen in poultry litter and dairy manure. The instrument is based on wavelength filters that selectively target the manure nitrogen constituent of interest. Testing has demonstrated that the instrument is capable of providing accurate estimates of nitrogen forms in poultry litter and dairy manure. This portable manure analyzer will be commercially available and should be valuable to producers, consultants, Natural Resources Conservation Service staff and Extension agents as they design nutrient management plans for livestock production operations.

New legislation in North Carolina promotes replacement of old lagoon technology with new Environmentally Superior Technology. ARS scientists from Florence, South Carolina, along with industry cooperators, have designed and demonstrated a second generation system for swine wastewater treatment that is cost-effective and meets Environmentally Superior Technology criteria. The system, installed at a 5,150 head swine finishing operation, removed 97.7% of total suspended solids, 99.6% of biological oxygen demand, 96.1% of total nitrogen, 97.4% of ammonia, 94.0% of total phosphorus, 99.9% of odor causing compounds, and 99.9% of pathogen indicators. Animal health and productivity were improved compared to traditional lagoon management; mortality decreased 57%, daily weight gain increased 11% and feed conversion improved by 5.4%. The system is currently in operation at swine and dairy facilities in North Carolina.

Nitrogen management on Northeast dairy farms is a challenge because of the range of farm-grown feeds, the wide array of manure management systems, and the diversity of field crops and soils. Cooperation among ARS scientists from Beltsville, Maryland and university scientists has resulted in the development of an online nitrogen management tool describing best management practices for dairy farms that utilize a whole-farm perspective. The web site, www.DairyN.cornell.edu, contains components covering: nitrogen losses, crop and soil nitrogen management practices, feed storage practices, dairy herd nutrition and precision feed management, manure storage practices, and integrating the components into a whole-farm system. The web site is an important resource for Extension agents, Natural Resources Conservation Service staff and consultants as they write nutrient management plans for dairies in the northeastern United States.

Pathogens and Pharmaceutically Active Compounds: Pathogens and pharmaceutically active compounds in manure, biosolids, and other byproducts can be transmitted to animals and humans through food supplies, water and possibly air. Livestock and poultry can also be re-infected not only via water and air, but from other vectors such as birds, rodents and insects. The most significant of the manure-borne zoonotic pathogens are the protozoan parasites *Cryptosporidium parvum* and *Giardia duodenalis*, and the bacterial pathogens *Salmonella*, *Campylobacter*, *Escherichia coli*, and *Listeria monocytogenes*. Pharmaceutically active compounds such as hormones and antibiotics also may be present in animal waste and disseminated in the environment. The potential for serious health effects both on and off the farm; the lack of knowledge about pathogen survival in manure during collection, storage, treatment and application; and uncertainty about fate and transport of pathogens in soil, water and air from the animal production site or manure application area, clearly point to the need for research on these issues.

Reducing the survival of bacterial enteric pathogens in manure and hence their ability to disseminate in water and air was evaluated. Scientists from Beltsville, Maryland prepared and inoculated a series of manure stacks with two important pathogenic bacteria, *E. coli O157:H7* and *Salmonella typhimurium*, contained in specially designed tubes. These sample tubes were assayed for viable pathogens during composting. With very minor additions of on-farm materials like straw and careful attention to the construction and geometric shape of manure piles, the pathogenic bacteria were reduced to undetectable concentrations within a matter of weeks. In another experiment, nearly complete pathogen destruction was obtained by composting solids and multi-stage treatment of liquids separated in a swine wastewater treatment system developed at Florence, South Carolina. These results provide producers with tools to reduce the number of pathogenic bacteria in manure rapidly and thoroughly to levels that will minimize the risk of off-site pathogen transport during manure handling and land application.

Generic *E. coli* are used as indicators of water quality, but it is not clear if they are appropriate indicators of public health risk. Scientists from Beltsville, Maryland measured generic *E. coli* and virulence markers associated with pathogenic *E. coli* in a stream flowing through a watershed with substantial livestock grazing. Both generic *E. coli* and virulence markers for pathogenic *E. coli* decreased dramatically from summer to winter. Several sites had very high *E. coli* levels in sediment, which likely contributed to downstream contamination. No correlation was observed between concentrations of generic *E. coli* and virulence markers for pathogenic *E. coli*. In a study at Watkinsville, Georgia the investigators detected substantial fluxes of the pathogen Salmonella in surface water even though the indicator bacterium *E. coli* was not found. These results suggest that generic *E. coli* may be useful as indicators of fecal contamination, but they may not be suitable to directly predict public health risks.

Byproducts: Each year millions of tons of agricultural, municipal and industrial byproducts are generated in the United States. These materials are frequently considered to be wastes and are often disposed in landfills. However, many of these materials have

characteristics that make them potentially useful to improve soil properties for enhanced crop production, to prevent movement of contaminants to critical bodies of water, and to lower energy inputs in agricultural systems. Research is being conducted to determine benefits and risks of the materials, to develop and evaluate the effectiveness and economic benefits of byproduct-based management practices and control technologies, to document the environmental benefits of using these materials, and to develop guidelines for specific uses of byproducts.

Degraded soils result in reduced crop yields, require higher inputs of fertilizer, water and energy, and pose a greater threat to the environment than high quality soils. Many agricultural, industrial and municipal wastes are generated each year and may be appropriate soil amendments to improve degraded soils. ARS scientists from several locations (West Lafayette, Indiana; Oxford, Mississippi; Tifton, Georgia; and University Park, Pennsylvania) have demonstrated that flue gas desulfurization (FGD) gypsum, generated by removal of sulfur dioxide from the flue gases of coal-fired power plants, can improve soil chemical and physical properties and reduce contaminant movement to surface water. Their research has shown that application of FGD gypsum to soil improves soil structure, resulting in greater infiltration and storage of rainwater. Since water moves into the soil, more is available for subsequent use by crops and less water runs over the soil surface, reducing erosion and movement of sediment, nutrients and trace elements to surface water. More efficient infiltration and storage of rainfall is critical to crop production in areas that have recently experienced severe drought, such as the southeastern United States. These results show that a low-cost material like FGD gypsum can allow farmers to increase crop production while improving soil and water quality. The southeastern United States alone has approximately 20 million acres of crop and pasture land that could benefit from application of FGD gypsum.

Each year foundries in the United States landfill several million tons of waste sand that can no longer be used to make metal-casting molds and cores. These waste foundry sands are potentially useful as soil amendments and ingredients in manufactured soils, but benefits and risks of these materials need to be determined. Scientists at Beltsville, Maryland along with university cooperators conducted a national study to characterize toxic organics and trace metals in ferrous and non-ferrous waste foundry sands. Total levels of trace metals, polycyclic aromatic hydrocarbons, and phenolics were determined, along with trace metal leaching potential. The research demonstrated that the majority of waste sands from iron, aluminum, and steel foundries contain low levels of organics, and trace metal levels comparable to those found in native soils. The data is currently being used by ARS and the U.S. Environmental Protection Agency (EPA) to assess the risk of using waste foundry sands in agricultural and horticultural applications. This research has significantly advanced the EPA Office of Solid Waste (OSW) goal of promoting recycling and beneficial uses of foundry sand. The ARS scientists and their university cooperators have recently received the EPA Friend of OSW Award for their research on beneficial uses of foundry sand.