FY-2006 Annual Report Manure and Byproduct Utilization National Program 206

Introduction

Over one billion tons of agricultural (e.g., manure), municipal (e.g., biosolids), and industrial (e.g., coal combustion products) wastes with potential uses in agriculture are generated annually in the United States. Many of these materials are spread, sprayed or otherwise 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 Manure and Byproduct Utilization National Program is to develop and evaluate management practices and systems, control technologies, and decision tools to (1) allow producers and their advisors to effectively and safely use manure and other byproducts while protecting the environment and human and animal health and (2) provide policy-makers and regulators with information and tools to make 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: (1) atmospheric emissions, (2) nutrient management, (3) pathogens and pharmaceutically active compounds, and (4) 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 for measurement, control and prediction of emissions from animal production operations will help provide the scientific background for management, policy and regulatory decisions.

Ammonia emitted from beef cattle feedlots represents a loss of manure nitrogen fertilizer value and can negatively impact the environment locally and regionally. ARS scientists from Bushland, TX and Watkinsville, GA along with cooperators from Texas A&M University, West Texas A&M University, and the University of Alberta used four micrometeorology and nutrient balance methods to measure ammonia emissions from a 50,000 head feedlot. All four methods resulted in similar ammonia emissions of 44 to

60% of fed nitrogen during the summer and 15 to 40% of fed nitrogen during the winter. On an annual basis, ammonia emissions from the feedlot averaged 31.7 pounds per head capacity, with 48% of fed nitrogen lost as ammonia. This multi-year study provides the most comprehensive measurement of ammonia emissions from a beef cattle feedlot currently available to guide policy and regulatory decisions. Data generated in this experiment will contribute to the development of an ammonia emissions process model that will contribute to improved ammonia management at animal production operations.

Substantial greenhouse gas (GHG) emission reductions in confined swine operations can result when anaerobic swine lagoons are replaced with advanced technologies that use aerobic treatment. A recently approved swine wastewater treatment technology developed by ARS scientists from Florence, SC and industry cooperators reduces or eliminates ammonia emissions, nutrient losses, odor and pathogens. In addition, this system is more effective than anaerobic lagoons and anaerobic digesters in reduction of GHG emissions. Replacement of an anaerobic lagoon at a 4,360 head swine operation with the new aerobic treatment technology reduced GHG emissions from 4,972 tons of carbon dioxide equivalents per year to 50 tons of carbon dioxide equivalents per year. This GHG reduction translates into a direct economic benefit to the producer of approximately $4.50 per pig capacity per year at a Chicago Climate Exchange trading value of $4 per ton of carbon dioxide equivalent emissions reduction. GHG emission reduction credits can compensate for the higher installation cost of new aerobic treatment systems and help facilitate producer adoption of environmentally superior technologies to replace anaerobic lagoons.

Particulate matter (PM) emissions from animal feeding operations (AFOs) may contribute to overall PM levels that exceed air quality limits and pose a threat to human health. Methods are needed to measure PM emissions, particle size distribution, and dispersion of PM from AFOs. ARS scientists from Ames, Iowa worked with cooperators from the Space Dynamics Lab in Logan, Utah and the University of Iowa to determine the feasibility of using light detection and ranging (LiDAR) equipment to evaluate PM emissions from AFOs. Field tests conducted at a swine production facility in Iowa showed that the LiDAR system could generate a 2-dimensional image of the PM plume dispersion and transport across the landscape. Coupling of LiDAR measurements with micrometeorological data allowed determination of PM emission rates. A LiDAR system with three lasers allowed PM particle size distribution to be calculated. Data generated by the LiDAR system also could be used to identify other source(s) of PM emissions in the vicinity of the AFO and to document the effectiveness of management practices and control technologies for PM emissions reduction.

Nutrient Management: Utilization of nutrients in manure is an environmentally sustainable manner is one of the critical management issues facing the U.S. livestock industry. 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, public health and animal health.

Rapid methods to determine phosphorus in manure are needed by producers and their advisors to determine appropriate manure application rates. ARS scientists from Beltsville, MD have developed a robust x-ray fluorescence method to measure phosphorus non-destructively in cattle manure, poultry litter and feed samples that vary in physical state and composition. The x-ray fluorescence method can detect the effects of different handling and storage conditions on the composition of manure and the subsequent mineralization and release of phosphorus. This spectrometric method will eventually be transportable to the field for on-site analysis of phosphorus and other minerals in manures. On-farm phosphorus analysis will greatly improve nutrient management by allowing producers and their advisors to determine application rates based on the actual composition of the manure.

Improved field equipment is needed to make optimum use of nutrient-rich broiler litter while minimizing environmental degradation. ARS scientists from Auburn, Alabama have developed a one-row, tractor-drawn, broiler litter applicator for applying broiler litter in row crop canopies and in shallow trenches in pastures. Field trials conducted in cooperation with ARS scientists from Mississippi State, Mississippi and Bowling Green, Kentucky showed that cotton and forage yields were improved and nutrient losses to water and air where reduced when broiler litter was incorporated with the new applicator compared to surface application of litter. A farm scale, eight-row broiler litter applicator is currently under development and testing. This new equipment will allow producers to make more effective use of nutrients in broiler litter and will result in lower inputs of nitrogen and phosphorus to surface waters in naturally drained soils.

Pathogens and Pharmaceutically Active Compounds: Pathogens and pharmaceutically active compounds in manure, biosolids, and other byproducts can be transmitted to other animals and humans through food supplies, water and possibly air. Animals on the farm or at AFOs also can 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*, C*ampylobacter, 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 after land application, clearly point to the need for research on these issues.

Water and food-borne pathogens can pose a significant threat to human health as illustrated by the recent problems associated with *E. coli* O157:H7 contamination of spinach. Methods are needed to detect *E. coli* O157:H7 in a variety of matrices and to minimize its survival and transport in the environment. ARS scientists from Riverside, CA have developed a methodology that allows them to quantify *E. coli* O157:H7 at levels

less than 100 cells per gram of soil, manure or water. This method was used to demonstrate that *E. coli* O157:H7 can survive at least 45 days in soil even if the moisture content is as low as 3%. This information suggests that aggressive methods will be needed to control pathogens in the environment. Scientists from Mississippi State, MS have identified and collected viruses called bacteriophages from swine lagoons. These bacteriophages kill *Salmonella*, a pathogen that can infect humans and animals. Additional research is needed to refine this approach to help control or eliminate movement of pathogenic bacteria from animal production operations.

Natural and synthetic hormones are given to and generated by livestock and poultry. Scientists, policy-makers and producers require information to determine if hormones pose environmental and human health risks when manures are applied to agricultural land. Scientists from Watkinsville, GA tracked leaching of estradiol and testosterone, two natural hormones produced by poultry, through the soil. They found 27% of estradiol and 42% of testosterone leached through soil, probably as a result of water movement through worm holes, large interconnected soil pores and cracks in the soil column. Since hormones appear to be mobile, methods are needed to degrade these compounds. One promising line of research has been initiated by ARS scientists from Fargo, ND and Florence, SC. They found that "green catalysts" known as TAML activators (iron tetra-amido macrocyclic ligand) were very effective destroying hormones. Further work will be needed to determine if these catalysts can destroy hormones in a variety of environmental matrices.

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 crop production, to reclaim and remediate degraded soils, to produce manufactured soils and composts, to promote clean air and water resources, and to lower energy inputs in agricultural systems. Research must be conducted to determine benefits and risks of the materials, to develop and demonstrate byproduct uses, to develop guidelines for appropriate uses of byproducts, and to provide information to regulatory and advisory agencies to allow agricultural and horticultural uses of the materials.

Soils degraded by human activities and natural processes cannot effectively support crop production or vegetative cover, require greater inputs to establish and maintain plant production, and pose a threat to the environment. The U.S. Army has significant land areas that require remediation due to physical, chemical and biological soil constraints resulting from military training activities. ARS scientists from Auburn, AL are working with the U.S. Army Corp of Engineers to remediate degraded sites at Fort Campbell, KY and Fort Benning, GA using an "aggregate cellulose pulp" made from solid waste generated at military bases. The pulp byproduct has improved soil conditions and resulted in enhanced plant growth. Beneficial use of this material will reduce disposal costs at Army bases by $100 M per year and will provide environmental benefits through remediation of military lands.

ARS has formed partnerships with other organizations to promote beneficial agricultural uses of industrial byproducts. ARS is now a member of the Coal Combustion Products Partnership with the U.S. Environmental Protection Agency, the Department of Energy, the Department of Transportation and the electric power industry. One of the promising products for agricultural uses is the synthetic gypsum produced when sulfur dioxide is scrubbed from the exhaust gases released from coal-fired power plants. ARS scientists from West Lafayette, Indiana and Oxford, Mississippi have demonstrated that synthetic gypsum can be used to improve soil physical properties thus reducing soil crusting, reducing soil erosion and improving movement of air and water into soil. When soil conditions are improved by synthetic gypsum, less tillage is required, carbon storage in soil is increased and greenhouse gas emissions are reduced. Soil conditions on millions of acres of land in the United States could be improved through application of a low-cost material such as synthetic gypsum.