National Program 214 Agricultural and Industrial Byproducts
National Program Annual Report: FY2013

Introduction

The U.S. Department of Agriculture's Agricultural Research Service (USDA-ARS) National Program for Agricultural and Industrial Byproducts (NP 214) had another productive and dynamic year in FY 2013. Scientists in NP 214 continue to make extraordinary impact in diverse areas of research that address management and use of manure nutrients and resources, manure pathogens and pharmaceutically active compounds (PACs), atmospheric ammonia and greenhouse gas emissions from agriculture, and developing beneficial uses of agricultural, industrial, and municipal byproducts .

The overarching goal of NP 214 is:

> *To effectively and safely manage and use manure and other agricultural and industrial byproducts in ways that maximizes their potential benefits while protecting the environment and human and animal health.*

The total amount of manure, biosolids, and industrial and municipal wastes generated annually in the U.S. exceeds 1 billion tons. Most animal manure and biosolids, along with significant amounts of other agriculture and industrial byproducts, are applied to agricultural land because of the benefits they can provide, including nutrients for crop production and organic matter to improve soil properties. However, improperly managed manure and other byproducts can be a source of pollution when their constituents move offsite, posing a threat to soil, water, and air quality, and to human and animal health.

Farm sales of meat and milk in the U.S. in 2012 were valued at more than $128 billion annually. For animal production, new technology and economies of scale have driven a structural shift from small to large animal feeding operations (AFOs). The development of AFOs has often separated animal production from crop production. Consequently, less land is available for on-farm recycling of manure-derived nutrients to crops, despite the U.S. having more than enough agricultural land to use all manure nutrients. Because transportation costs inhibit its distribution, most manure is land-applied locally around animal facilities, often exceeding local need and demand for use as fertilizer. AFOs are now typically subject to regulations designed to prevent negative environmental impacts of manure generation, storage, and use. There is thus an increasing challenge to using manure on agricultural lands while protecting the environment, and a great demand exists for scientific research and information about effective management of manure to guide management, policy, and regulation.

In addition to manure, millions of tons of industrial and municipal byproducts are produced annually in the U.S. They are often considered to have little value and are frequently disposed of in landfills or incinerated, at considerable expense. However, many of these byproducts are potentially useful on agricultural land or in horticulture either individually or through blending, mixing, or treating with other byproducts. Byproducts have many characteristics that may make them useful for direct land application, soil reclamation and remediation, as components of manufactured soils and composts, or as animal feedstuffs. Research and development is needed, however, to determine the composition and bioactivity of these products and to determine potential hazards and appropriate uses. At this time, state and federal regulatory agencies lack analytical tools to make reasonable policy decisions regarding the beneficial use of byproducts in agriculture or horticulture. Protocols and methodology standards are needed to enable regulatory authorities to examine and approve byproducts use. Treatment technologies and management practices to make these products usable will reduce potential environmental hazards, reduce disposal costs, and increase the cost-effectiveness of agriculture.

USDA-ARS recognizes the value of manure and other agriculture and industrial byproducts and established NP214 as a primary area of research and as a link between the research community, agriculture and industry stakeholders, and the broader public. During FY 2013, 58 full-time scientists working at 16 locations in 12 states across the U.S. actively engaged in 72 ARS-led and cooperative research projects. Research conducted under NP 214 occurs at locations and scales ranging from a laboratory bench top or growth chamber to 10,000-head dairies. The following ARS locations conducted research under NP 214: Ames, Iowa; Auburn, Alabama; Beltsville, Maryland; Bowling Green, Kentucky; Bushland, Texas; Clay Center, Nebraska; Fayetteville, Arkansas; Florence, South Carolina; Kimberly, Idaho; Lincoln, Nebraska; Madison, Wisconsin; Mississippi State, Mississippi; Peoria, Illinois; and Riverside, California.

Personnel in NP214

There were no new hires or retirements in NP214 in FY 2013.

The following scientists in NP 214 received prominent awards in FY 2013:

- Scott Bradford received the Excellence in Review Award from the Environmental Science & Technology journal, and was elected as Fellow to the Soil Science Society of America and the American Society of Agronomy.
- Dexter Watts received the 2013 Early Career Award in Agronomic Research from the Southern Regional Branch of the American Society of Agronomy.

The quality and impact of NP 214 research was further evidenced in FY 2013 by the following:

- Over 140 refereed journal articles
- Applications for 2 new patents
- 1 new cooperative research and development agreements with stakeholders
- 1 new scientific model developed, and
- Administration or development of 4 web sites for academia or stakeholders.

In 2013 NP 214 scientists participated in research collaborations with scientists in Australia, Denmark, Germany, South Korea, the Netherlands, Canada, and the United Kingdom, and New Zealand.

Accomplishments in FY 2013

This section summarizes significant and high impact research results that address specific components of the FY2009 – 2013 action plan for the NP 214. Many of the programs summarized for FY 2013 include significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for USDA-ARS research by rapidly disseminating technology, which enhances the impact of ARS research programs. Accomplishments address 4 categories of research:

1. Management and use of manure resources
2. Manure pathogens and pharmaceutical compounds
3. Atmospheric gas emissions
4. Beneficial use of byproducts

Component 1. Management, Enhancement and Utilization of Manure Nutrients and Resources

Problem Statement 1A: Improving the Usability of Manure Nutrients through More Effective Animal Nutrition and Management.

No significant results in 2013

Problem Statement 1B: Maximizing the Value of Manure through Improved Collection, Storage, and Treatment Options.

New technologies capture ammonia from broiler houses. Over half of the nitrogen excreted by broiler chickens is lost to the atmosphere as ammonia before manure is removed from the barn. This is a huge loss of a potential fertilizer nutrient resource, and further pollutes air and water. Scientists at Fayetteville, AR, developed the ARS Air Scrubber to reduce the ammonia, bacteria, dust, and odors from animal housing air exhaust, and found that potassium bisulfate was by far the best acid to use in the Scrubber. In related research, ARS scientists in Florence, SC, developed gas-permeable membranes as components of a new process that can capture 88 to 100% of the ammonium volatilized from poultry litter. The benefits of these technologies include cleaner air inside poultry houses, better bird growth and performance, reduced ventilation costs, and a concentrated liquid ammonium salt that can be used as a fertilizer for crop production. These technologies also significantly decrease the ammonia volatilization into the atmosphere, reducing pollution and decreasing the environmental impact of the poultry industry.

Is anaerobic manure digestion economical on smaller dairy farms? In the U.S., anaerobic digestion is an economically viable manure treatment for large dairies (>500 cows), but roughly 90% of U.S. dairies have less than 200 cows. ARS scientists in Beltsville, MD, performed an economic assessment of small-scale digesters using cost data from eight existing and theoretical 100 to 250-cow dairies. Total capital costs, capital costs per cow, and net costs per cow generally decreased with increasing herd size. Use of digested solids for bedding generated the highest revenue ($100 per cow per year), followed by biogas use for heating and/or electrical generation ($47 to $72 per cow per year) and CO_2 credits ($7 per cow per year). No farm had a positive cash flow under the assumed conditions (8% discount rate, 20 year term), but six farms had positive cash flows when 50% cost sharing was included. Results show that, with cost sharing, economically viable anaerobic manure digestions systems are possible on 250-cow dairies. Additional revenue streams, such as tipping fees for food waste, may reduce the minimum size to 100-cow dairies. These results will help the U.S. dairy industry increase on-farm renewable energy systems and decrease greenhouse gas emissions on dairy farms.

Problem Statement 1C: Utilizing Manure in Integrated Farming Systems to Improve Profitability and Protect Soil, Water, and Air Quality.

New model for cattle barnyards and feedlots helps reduce phosphorus abatement costs. Pollution of rivers, lakes, and bays by phosphorus from both urban and agricultural sources is an issue throughout the country. Government agencies are developing 'water quality trading' programs as a cost effective way to reduce phosphorus pollution. In these programs, urban facilities save money by paying local farmers to reduce pollution instead of paying for expensive new technologies, but they have to quantify how much less phosphorus is lost from farms. An ARS scientist in Madison, WI, developed and tested a user-friendly computer model that quantifies annual runoff, sediment loss, and phosphorus loss from barnyards and feedlots on cattle farms. The model can be used throughout the country, and is already being adapted by the Wisconsin Department of Natural Resources for its water quality trading program in areas with many dairy cattle barnyards, and the Madison Metropolitan Sewerage District estimates the trading program can save them as much as $65 million in its efforts to reduce phosphorus pollution.

New technology automatically monitors feedlot runoff pond pollution. Holding ponds are used to store runoff and prevent pollution from animal feedlots, but leakage from ponds can contaminate underlying soil and groundwater. Working with the Nebraska Cattlemen's Association, Nebraska Department of Environmental Quality and AgraTek LLC, ARS scientists at Clay Center, NE, developed a technology using resistivity arrays that detect small changes in sub-surface soil and water quality as impacted by pond leakage. A controller was also developed to automate the monitoring, communicate information through a cell phone modem to a central data base, and alert personnel of potential environmental risks. Scientists also developed geophysical tools that assess sub-surface soil and water quality and can be integrated with the automated system. These tools provide better information to understand subsurface contamination, assess site historic contamination, and delineate contaminant movement.

Enhanced-efficiency nitrogen fertilizers do not improve crop nitrogen use. Nitrogen is one of the most important and costly inputs for crop production. Farmers are looking for better management practices to enhance nitrogen use and crop production while reducing environmental impacts. ARS scientists in Bowling Green, KY an part of an ARS multi-locations collaborative study evaluated several inorganic nitrogen fertilizers, commercially available Enhanced-Efficiency Nitrogen Fertilizers (EENF), and poultry litter under no-till corn production. The work demonstrated all nitrogen sources increased corn grain yield over control (no nitrogen applied). But environmental benefits of EENF were mixed among locations. This research gives farmers scientifically-based information for determining where these EENF might be most effective, thereby optimizing nutrient use for yield and environmental benefits.

New methods improve phosphorus indexes. The phosphorus index (PI) is a simple tool used by most states to evaluate the risk of phosphorus loss from agricultural fields, which can be a major source of pollution for local water bodies. While the PI is commonly used, most state PIs have not been rigorously evaluated against diverse and accurately measured P loss data to determine how well the PI predicts P loss risk across varying environmental conditions. ARS scientists from Bowling Green, KY, developed a method to evaluate a PI by using output from a more complex P loss model. The scientists identified several weaknesses in how many current PIs are calculated and developed methods to fix those weaknesses. These methods provide an approach states can use to meet the requirements of NRCS 590 nutrient management standards for PI evaluation, and have already been adopted in Kentucky, Maryland, Oregon, and Washington.

Poultry litter applied in subsurface bands provides more soil fertility. Unlike inorganic nitrogen fertilizers, poultry litter and other manures provide crop nutrients in soil beyond the year of application. ARS scientists in Mississippi State, MS found that how poultry litter is applied affects how long nutrients are available after application. Cotton planted in soil that received poultry litter in subsurface bands two years prior produced more lint (yield) than cotton planted in soil that received the same amount of litter by surface broadcast. Scientists also developed a new method for taking soil samples that measures soil fertility more accurately than traditional sampling when litter is applied in subsurface bands. Combined, subsurface banding and accurate fertility measures can increase profit and reduce fertilizer costs for cotton and other row crops in the southern and southeastern U.S.

Years to restore surface mine soil determined. The time required to restore the quality of degraded coal mine land to its pre-mined condition is unclear. The sustainability and functionality of an agro-ecosystem in a reclaimed coal mine soil can be assessed by measuring how soil quality indicators change and improve over time after reclamation. ARS scientists in Starkville, MS, evaluated the effects of time on restoration quality of degraded coal mine soil under different land use and landscape positions and found the current reclamation practices used in the southeastern U.S. improved major soil quality indicators to levels similar to those of pre-mined soil in 7-12 years. The improvement was greater under grass than under forest vegetations, indicating soil carbon and nitrogen are restored faster under grass than under forest ecosystem. The information will help the mining industry, reclamation planners, regulators, and landowners accelerate establishment of healthy and sustainable post-mining ecosystems.

Component 2. Manure Pathogens and Pharmaceutically Active Compounds (PACs)

Problem Statement 2A: Identifying Factors that Control the Fate and Transport of Pathogens from Animal Agriculture.

Antibiotic resistance can spread rapidly on a poultry farm. Antibiotic resistant bacteria in broiler and other animal feeding operations are influenced by antibiotic use, transfer from outside the operation, and vertical carriage through hatching and birthing procedures. Once present in a new poultry operation, antibiotic resistance can spread rapidly within a house and between houses and affect thousands of birds. ARS scientists in Starkville, MS, traced the colonization of antibiotic resistant *Salmonell*a in two new broiler houses and found that *Salmonella* established and colonized within the first 3 weeks of operation. *Salmonella* genotypes within the new houses were relatively few and uniform at the start of operation, but expanded, becoming more diverse with successive flocks, and stabilized by the third flock. Concurrently, antibiotic resistance continued to increase to include greater numbers of antibiotics, as the *Salmonella* population began to stabilize. This research demonstrates that a pathogen such as *Salmonella* can quickly colonize a new poultry operation from older houses on a farm and through the hatching process. Likewise, the presence of antibiotic resistance, despite no perceived use of antibiotics, can increase rapidly as a dominant population of *Salmonella* establishes itself.

Pathogens responsible for Johne's disease and gastroenteritis are resistant to ensiling. Dairy and beef production relies heavily on silage as feed during winter. The low pH and high acid concentrations during ensiling generate a well-preserved, highly nutritious feed, but acid tolerant organisms that survive ensiling can be a concern for food and animal safety when fed to livestock. ARS researchers in Bowling Green, KY, demonstrated that two acid-tolerant pathogens that cause Johne's disease in cattle (*Mycobacterium paratuberculosis*) and human gastrointestinal illness (*Salmonella typhimurium*) would survive the ensiling process and be capable of causing subsequent infection. While the *Salmonella* sometimes survived ensiling, the *Mycobacterium* was especially resistant, surviving longer and in higher concentrations. These results suggest that when present in manure and applied to forage grasses that are subsequently ensiled, the *Mycobacterium* may survive ensiling and be a potential route of infection if ingested by a susceptible animal.

Problem Statement 2B: Minimizing the Release of Veterinary Pharmaceuticals and Hormones.

No significant results in 2013

Problem Statement 2C: Reducing Antibiotic Resistant Bacteria in Agricultural Manures and Wastes.

Antibiotic resistance genes and pathogens measured in land applied manure. Animal manure contains pathogenic microorganisms that can cause illness and death in humans. Land applied manure can be a source of pathogens in the environment. ARS scientists in Bowling Green, KY, applied poultry litter and dairy manure to forage grasses under conventional and no till management. They found that even when pathogens like *Campylobacter* and *Salmonella* were initially present in manures at high concentrations, they were rarely detectable following land application. Indicator organisms like *Enterococcus* were measurable but the common indicator *Escherichia coli* (*E. coli*) was not. Scientists also found that antibiotic resistance (AR) genes were very high in poultry litter before application and remained high following land application. However, detection of AR genes, pathogens and indicators following manure application was irregular, suggesting that factors such as moisture and temperature influence survival. This information will inform risk assessment models as well as producers and the public about the risks of AR genes and potential pathogens in livestock manures that are land applied to forage grasses.

Problem Statement 2D: Minimizing Risk with Best Management Practices and Treatment Technologies.

No significant results in 2013

Component 3. Atmospheric Emissions

Problem Statement 3A: Quantifying the Extent of Agricultural Emissions of Air Pollutants.

A new system estimates enteric methane production from feedlot cattle. Ruminant cattle can be an important source of methane emissions to the atmosphere and climate change. Current models to estimate cattle enteric methane emissions were developed using animals fed high-forage diets, and can greatly overestimate emissions from cattle fed high-concentrate finishing diets. An ARS scientist in Bushland, TX, developed an improved model to estimate enteric methane production from feedlot cattle based on their feed intake, dietary fat levels, grain processing method, and dietary grain concentration. The new model more accurately estimates methane emission than existing models and allows producers to estimate dietary effects on emissions. This model has been integrated into the USDA-Office of Chief Economist's tool for producers and regulators to use in estimating greenhouse gas emissions from agriculture, and provides the feedlot industry with an improved tool to help decrease the environmental footprint of the beef industry.

Integrated research updates cattle gas emission factors. Ammonia and greenhouse gas emissions from cattle operations are a concern for human health and climate change. Implementation of air quality regulations and development of national gas emission inventories demand accurate on-farm determination of emission rates. ARS Scientists in Bushland, TX integrating research under the USDA-funded Federal Air Quality Initiative project documented that for feedyards where beef cattle are fed optimum crude protein diets recommended by National Research Council guidelines, ammonia emissions were 40 kg/animal/year. Methane loss as a fraction of cattle gross energy intake (called Ym), was 3.2% in summer, and was close to the 3.0% value used by the Intergovernmental Panel on Climate Change. In related research, ARS scientists in Kimberly, ID, determined commercial dairy emission rates from the open-freestall and wastewater pond areas of 0.20 kg ammonia and 0.75 kg methane per cow per day. These data will be used to develop reliable gas emission models and inventories, which in turn will be used to guide cattle management policy and practices. For example, the Bushland scientists used their field data to determine that Manure-DNDC (DeNitrification-DeComposition), a newly developed process-based biogeochemical model, can reliably predict ammonia emission from cattle feedyards, and can be used by feedyard managers to effectively reduce ammonia loss, decreasing the environmental footprint of the beef industry.

Problem Statement 3B: Characterize the Physical, Chemical, and Biological Processes Essential for the Development and Evaluation of Emissions Models.

Steam-flaked corn reduces the carbon footprint of fed beef cattle. Most cattle fed in the southern Great Plains are fed diets based on steam-flaked corn. Steam flaking uses additional natural gas that is not required when cattle are fed diets based on dry-rolled corn. ARS scientists in Bushland, TX, compiled data from their own beef feeding experiments to determine the effects of steam flaking on the carbon footprint of cattle fed high-concentrate finishing diets. Steam flaking required additional fossil fuel compared to dry rolling corn, but, cattle fed steam-flaked produced less enteric methane, excreted less manure and associated methane, and had better feed efficiency, thus decreasing the quantity of corn required for finishing. Overall, steam flaking decreased the carbon footprint of cattle feeding by 8 to 18% compared to feeding dry-rolled corn. These results are important in developing accurate Life Cycle Analysis of cattle feeding and in improving economic and environmental sustainability of cattle production..

Problem Statement 3C: Develop and Test Technologies and Improved Management Practices to Reduce Emissions.

Ammonia losses from poultry houses greater near watering lines. Ammonia loss to atmosphere from poultry houses represents a loss of a fertilizer nutrient resource, and pollutes air and water. ARS scientists in Starkville, MS, discovered the critical litter moisture content where ammonia generation is maximized and found that ammonia loss in broiler houses can be reduced by 38 to 77% if litter near watering lines is managed similar to litter near feeders and sidewalls. Management practices were developed and distributed in popular articles to show producers how to measure litter moisture and barn ammonia concentration in order to know if improved litter management is needed. Easily adaptable practices to reduce ammonia loss included appropriate attention to watering line management, and treatment of litter in zones of greatest moisture while birds are in the house. Farmers can immediately implement this information to produce healthier birds, reduce environmental concerns due to ammonia release, and improve profits.

Microbial-based inoculants reduce nitrous oxide emissions from nitrogen fertilizer. Excessive applications of nitrogen fertilizers can increases nitrous oxide (N_2O) emissions from agricultural soils and contribute to climate change. Microbial-based inoculants, known to promote root growth and nutrient uptake, may be able to reduce emission of N_2O in the presence of nitrogen fertilizers. ARS scientists in Auburn, AL, conducted experiments with three microbial-based treatments: SoilBuilder (SB), a metabolite extract of SoilBuilder (SBF), and a mixture of four strains of plant growth-promoting *Bacillus* spp; and two N fertilizers: urea, and urea ammonium nitrate (UAN). After 29 days of incubation, cumulative emissions of N_2O from UAN were reduced 80% by SoilBuilder and 44% by SoilBuilder metabolite. *Bacillus* significantly reduced N_2O at one and two days of incubation with UAN. N_2O emissions were not reduced at all from urea. Results will provide producers with scientifically-based information on the use of inoculants to improve fertilizer N use and reduce N_2O emissions.

Corn processing method and distillers grains do not increase methane emission from cattle. Dry rolled corn (DRC), high moisture corn (HMC), and wet distillers grains with solubles (WDGS) are all common feed ingredients for feedlot cattle in the Upper Midwest, but there is little information on how combinations of these ingredients impact cattle nutrient use and enteric methane emissions. ARS scientists at Clay Center, NE, conducted a nutrient balance feeding study with diets containing either DRC or HMC with either a low (25%) or high (45%) inclusion rate of WDGS. Corn processing method did not affect nitrogen or energy balance, and when higher rates of WDGS were added to the diet, cattle retained a higher percentage of diet N and produced less enteric methane. These results demonstrate that beef producers can use either DRC or HMC in their feedlot diets without negatively affecting the environment; and that feeding WDGS at inclusion rates up to 45% of the diet dry matter will not increase methane emissions, but will improve cattle nitrogen digestibility.

Component 4. Developing Beneficial Uses of Agricultural, Industrial, and Municipal Byproducts

Problem Statement 4A: Enhance the Value of Agricultural, Industrial, and Municipal Byproducts by Developing Beneficial Uses.

Industrial and agricultural byproducts mixture is a fertilizer for peanut production. Two available byproducts in the U.S. are flue gas desulfurization (FGD) gypsum from power plants and ash generated from burning poultry litter to generate electricity. Developing uses for these byproducts prevents their disposal in landfills; and because they are rich in phosphorus, calcium, magnesium and potassium, they are potential fertilizers for peanut production, which requires large amounts of soluble calcium and phosphorus. ARS scientists in Beltsville, MD, demonstrated that broiler litter ash and FGD gypsum were as effective for peanut production as super phosphate fertilizer and FGD-gypsum. Peanut kernel arsenic, cadmium, copper, manganese and zinc concentrations were within the recommended levels for human and animal consumption. Use of these two byproducts for peanut production could save farmers over $1 million per year in commercial phosphorus fertilizer and mined gypsum, and electrical power companies over $8 million per year in landfill cost. Use of these byproducts as soil amendments also helps protect the environment by keeping them from potentially leaching out of landfills.

Compost and gypsum help revegetate barren superfund site. Wind and water erosion at a 300-acre abandoned asbestos-mining Superfund site in Vermont represents a continuing risk to nearby populations. Without a comprehensive vegetative cover, the site will continue to erode asbestos and be a health threat to human populations in the area. The current conditions at this site severely limit plant growth, and many areas are completely barren of vegetation due to infertility and soil contamination issues. ARS scientists in Beltsville, MD conducted a 3-year study in which they evaluated applications of a manure compost plus a gypsum byproduct and fertilizers to obtain an effective vegetative cover of the soil. Results showed the surface-applied amendments produced extensive vegetative cover of clover and grasses while control plots receiving simple fertilization remained barren. Protocols are now being developed to reclaim this site as well as other similar sites around the U.S. The U.S. Environmental Protection Agency (EPA) has estimated that revegetation by adding two feet of topsoil over the existing soil on the site would cost $220 million. Revitalizing the existing contaminated soil using these soil amendments would cost only $25 million, resulting in great savings to the public.

Manure-based biochars provide a robust soil amendment. Biochar is a charcoal that is created by pyrolysis of organic biomass, which involves heating in the absence of oxygen. Plant or wood-based biochars are valuable soil amendments that increase soil organic matter and water retention, but they typically do not provide sufficient soil nutrients. Conversely, much of the manure biochar applied to low organic matter, Southeastern Coastal Plain soils can lead to excessive soil phosphorus as well as significant changes in soil pH. Finding a single biochar to suit all soil issues is difficult. ARS Scientists in Florence, SC, developed a novel concept to design biochars for specific soil types to increase organic matter, nutrients, and water retention. Extensive studies showed that specific feedstocks, their blends, and pyrolysis conditions can be manipulated to produce biochars with custom properties. Scientists developed guidelines to manufacture designer biochars tailored to improve specific soil issues. For manure biochars, it is recommended to blend manures with plant or wood materials, pelletize, and then pyrolyze at lower temperatures. This technique creates a biochar suitable for soils with higher levels of nutrients. Using these guidelines should allow farmers and the public to make more effective use of biochar as a soil amendment while also improving crop productivity and limiting production costs.

Compost and biochar prevent accumulation of DDT and DDE in earthworms. Soils in old fruit orchards may contain excessive residues of DDT and DDE from historic pesticide sprays. This increases the risk of DDT and DDE accumulation in earthworms and earthworm-consuming birds and mammals. ARS scientists in Beltsville, MD, conducted growth chamber and field experiments and found that amending soils with different manure composts and biochar significantly reduced the availability of DDT and DDE residues and their bioaccumulation in earthworms during a 45-day exposure period. A full field test of this approach was initiated using fresh and aged manure composts. Scientists also found that complementary soil tests of DDT and DDE residues could predict earthworm bioaccumulation. This research shows that compost and biochar amendments can sufficiently reduce earthworm bioaccumulation to achieve substantial cost savings in remediation of DDT- and DDE- contaminated soils.

Industrial by-products reduce environmental impact of poultry manure. Ammonia volatilization and nutrient loss are major forms of environmental pollution associated with land application of poultry manures as fertilizer. Both of these problems might be reduced by adding a byproduct that can reduce nutrient mobility. ARS scientists Starkville, MS, found that amending manure with FGD- gypsum reduced the leaching potential of water soluble nitrogen by 83%, carbon by 71%, and phosphorus by 53%. When gypsum-amended manure was applied to soils, phosphorus, copper, and zinc loss in subsurface leachate was reduced 51%, with the same or increased crop productivity. Scientists also found that adding zeolite to poultry manure reduced ammonia emissions by 30%. In related research, ARS scientists in Auburn AL, found that applying FGD-gypsum to soils amended with poultry manure decreased phosphorus in runoff by 51%. These results provide scientifically-based information on how industrial byproducts can significantly reduce nutrient loss from soils amended with poultry manure.