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Agricultural Nutrient Management

Cutting Edge Technologies & Opportunities

What's Inside

Introduction

In the early 1980's, nutrients from animal waste and excess fertilization were identified as the number one source of nitrogen and phosphorus overenriching the waters of the Chesapeake Bay. As much as 38 percent of the nitrogen and 41 percent of the phosphorus is estimated to come from agricultural sources, including what flows off the land in surface runoff and what volatizes into the atmosphere as ammonia gas.

In response, the agricultural community embraced the challenge to reduce nutrients and precious topsoil that were leaving farms upstream of the Bay. "Nutrient management" went from a new buzzword that needed explaining to a widely accepted aspect of farm management.

Demonstration projects in the 1980's looked at biogas generators, manure and dead animal composting, soil tests for nitrogen, stream bank fencing and manure marketing. The adoption of new, successful techniques, however, depended on a number of factors including education, affordability, profitability, and market forces both within and outside of the agricultural economy.

Over the past twenty years, agriculture in the Bay watershed has changed significantly. The industrialization of agriculture has led to fewer farms that raise two to six times more chickens, eggs, and swine than forty years ago. These farms with concentrated numbers of animals are usually close to regions experiencing high population growth, a trend that raises its own set of social policy dilemmas.

While different stakeholders perceive the impacts of intensive livestock facilities as either good or bad, few can argue that an environmental consequence of agricultural industrialization is nutrient surpluses in particular regions or subwatersheds. In the Bay watershed, large amounts of feed are imported from the midwest to feed millions of chickens, cows, and hogs, and many of those feed nutrients end up in manure supplies. In strong agricultural pockets of land, there's often too little land to fully utilize the manure's nutrients.

Innovations to solve these nutrient management challenges run the gamut from high-tech, high-cost technologies to relatively low-tech, affordable techniques that can be readily adopted by many farmers. For individual farmers who operate under small profit margins, changes are driven by economics. "Sustainable agriculture" to some farmers simply means agriculture that pays for itself.

On the other hand, external forces, such as the push to support renewable energy, hold new opportunities for more complex technologies that are waiting for the right mix of good timing, public policy, and available resources. Increasingly, the growing surplus of animal manure is examined as part of a larger waste management stream, and opportunities exist to treat and use animal, human, and industrial waste jointly to produce marketable products that are good for the economy and the environment.

The following summaries describe some alternative technologies that hold promise for solving today's nutrient management challenges on the farm. The summaries were gleaned from a recent Nutrient and Sediment Technology Forum held in Pennsylvania, which tapped expertise in nutrient management from both within and outside the Chesapeake Bay watershed.

Chesapeake Bay Program Innovative Technology Clearinghouse

www.chesapeakebay.net/innovative.htm

The Bay Program invites technology developers and vendors to submit information about their innovative, environmentally beneficial technologies to the clearinghouse.This clearinghouse is intended to communicate potential technology solutions for Chesapeake Bay restoration and protection needs.Questions should be directed to Allison Wiedeman. (wiedeman.allison@epa.gov; 410-267-5733).

Animal Waste Handling & Processing

Alternative Manure Processing: BIOREK Technology

A technology currently used in Europe, the BIOREK technology takes the process of anaerobic digestion and biogas combustion one step further – it brings ultrafilters (common in wastewater treatment) to the manure marketplace that allows you to remove and concentrate nutrients. The ultrafiltration process separates nitrogen from phosphorus and leaves behind 75% clean water, 15% phosphorus-potassium concentrate, a liquid ammonia concentrate, and composted manure. The system combines industrial organic wastes (fat sludge from meat processing plants, fish waste, dewatered sludge, kitchen wastes, etc.) and animal manure. It also includes a co-generation component that produces enough power to run the plant (30%) and be sold to a power grid (70%). End products allow farmers to apply nitrogen separately from potassium and phosphorus in forms that are more readily available to plant roots. The company BIOSCAN is investigating a demonstration in the United States and possibly in Pennsylvania.

Manure Digestion & Methane Generation

Dick Waybright of Mason Dixon Farms has been perfecting the use of methane digesters on his dairy farm in Adams County, Pennsylvania, since 1979. He currently uses three digesters to treat the waste from his 4,500 head of cows. He's had success running five, 150-kilowatt generators that he considers low maintenance because he keeps the temperature constant to avoid cold starts and runs them at lower RPMs than the maximum. The 30-day digestion process leaves liquid manure, which he will either spread as liquid manure or further dewater to allow for composting in large concrete bins. The composted manure is used as bedding material in his free stalls. Methane generated from the digestion process is used to generate electricity to heat and light his buildings; 17% percent of the electricity is sold to the local power company. His philosophy and advice to others is to keep it simple and limit your cost of investment. Only when he made it a profitable part of the farm did he keep building upon it.

Composting Facilities & Opportunities

Potential Compost Feedstocks

- Leaves & yard waste
- Manure & crop residues
- Spent Mushroom Substrate
- Animal Mortalities
- Paper/Cardboard
- Wood processing residues
- Construction & demolition wastes
- Food processing wastes
- Food preparation wastes
- Post consumer food wastes
- Exotics (explosives, contaminated soils)
- Biosolids (sludge)
- Municipal Solid Wastes

A wide variety of organic materials can be processed using the composting process, and compost mixes are constantly being rediscovered to meet different needs. Forces that make farming on the urban fringe a challenge can also offer opportunities for creative coexistence. Cooperative ventures are potential win-win situations that involve the composting of animal manures, crop residues, municipal leaf and yard waste, and various food wastes. Most farms have sufficient equipment to at least begin composting to see if the process will work for them. Additional investment in equipment and a more permanent site can be a shared proposition if the pilot project is successful. Likewise, the farm may serve as a collecting area and initial treatment area for materials that will be moved to a larger facility for further processing and marketing.

Penn State University's University Campus is a microcosm of this farm/urban interface where a high population of students share space with livestock and crop farming. Since 1997, the Organic Materials Processing and Education Center has composted food waste, manure, soybean fodder, and leaves and other landscape debris. Runoff from the compost pad is diverted to a vegetative filter that absorbs nutrients from the runoff to prevent water contamination. The finished compost is incorporated into landscape and research projects throught campus. For more information, contact Professor Robert E. Graves, Agricultural and Biological Engineering Department, Penn State University.

Worm Digestion

Ross Orner of Orner Farms, Clearfield County, Pennsylvania, began composting manure from his dairy beds about four years ago using red worms. The end products include a vermiculture compost and compost "tea" that are sold to greenhouses. It's been a profitable niche market for a by-product of excess dairy manure – compost tea sells for two to three times the price of milk.

Orner adds composted bedded pack manure to indoor bins every day. His 300,000 employees (red worms) work the top nine inches of compost, ridding the compost of weed seeds and producing a 95% worm-free material that is harvested from the bottom of the bins. The final product, Worm Wonder, contains beneficial soil bacteria and fungi and is sold commercially in 8-pound bags. A secondary product is compost tea, a highly concentrated microbial solution produced by extracting beneficial microbes from vermicompost. When applied to the soil, microbes in the tea jump start biological activity and stimulate the use of available nitrogen in the soil. Potato growers in the midwest have cut nitrogen fertilization by 60% using compost tea on their fields. For more information, call 814-583-7418 or www.ornerfarms.com.

Thermal Processing System for Farm Animal Waste

Donald Noll of Sun Combustion, Inc. admits his company's ideas may appear to be overkill for the treatment of animal waste, but he encourages the agricultural community to keep an open mind in considering thermal processes that have been used to treat other industrial waste products. Thermal processing systems are modular, allowing various components to be mixed, matched and sized to fit any need. Essentially, thermal reactors and oxidizers are employed to convert waste slurry into heat, gaseous and liquid products that are ultimately processed until the final products are clean and inert. Small farms could pool farm wastes for processing in a portable system.

Manure Transport of Poultry Litter

Penn Ag Products, a division of Tyson Foods, has capitalized on the synergy between the broiler and mushroom industries in southeastern Pennsylvania. The company currently buys poultry litter from fifty poultry houses at $5 - $7/ton. Tthe litter is mixed with hay, gypsum, cottonseed meal, horse manure, and crushed corn cobs and composted into a final product sold to mushroom growers at $12-$16/ton. Other custom uses for the compost include bedding, feed supplement, and soil amendment. The company aims to move as much broiler litter out of Lancaster County as possible. Of the 160,000 tons of broiler litter produced annually in the county, 26,000 tons are hauled away as compost.

Emerging Alternatives to Land Application of Broiler Chicken Litter

EnviroGro's Bio-Digester 201 is a 10x40 foot vessel capable of keeping up with a 500-head dairy operation, processing a batch every 4-5 days.

On the Delmarva Peninsula, at least eight projects are underway or being planned to demonstrate alternatives to the land application of broiler chicken litter. Bill Satterfield, Demarva Poultry Industry, Inc., reports that existing and planned faciltiies have the potential to process more than 879,000 tons of poultry manure; 600,000 to 800,000 tons of manure are produced annually on Delmarva.

Some examples include:

- Manure-to-pellet plant in Sussex County, DE by Perdue Farms-Agricycle, LLC . The end product is marketed as a starter ferilizer.
- Burning manure plant in Salisbury, MD by Eastern Shore Products, Inc. End products include cubes sold as slow release fertilizer, cattle feed, and fuel.
- Chicken manure composting facility in Dorchester, MD, by New Earth Service, Inc. Compost sold to golf courses, landscapers, retail bulk and retail bags.
- On-farm composting in rotating drums by EnviroGro Solutions, Inc. Bulk or bagged compost sold to redistribute nutrients.
- Large-scale manure burning plant proposed for Dorchester, Md, by FibroShore. Electricity to be sold to highest bidder.
- $50 million/20 megawatt power plant planned for Caroline County, MD, with hydroponic greenhouses and aquaculture facilities as part of plan.

Crops and Land Management

Permanent Cover Cropping System

For more information, two videos are available that cover the basics of sustainable no-till vegetable production and how Cedar Meadow Farm handled hurricane Floyd, which dumped over 8 inches of rain in 12 hours. To order, call (717) 284-5152; email: sgroff@epix.net; www.cedarmeadowfarm.com

Soil is meant to be covered! That's the message of Steve Groff, manager of Cedar Meadow Farm of Holtwood, Pennsylvania, which grows 15 different crops including no-till tomatoes. A combination of no-till, cover crops (crops planted to cover the soil between cropping cycles), and crop rotation has virtually eliminated soil erosion that was once as high as 14 tons per acre per year. Since phosphorus readily attaches to soil particles, it too stays in place rather than getting washed away during heavy rainfalls. The combination of cover crops and no tilling also improves soil tilth, increases organic matter levels, and enhances water infiltration and lessens pest problems. Yields have increased 10 percent over the last several years. Total pesticide usage on the whole farm has decreased 50 percent and beneficial insects have increased.

Grass Based Dairy Production

American Farmland Trust operates Cove Mountain Farm in Franklin County, Pennsylvania, to demonstrate the workings of a grass-based dairy system as an economic alternative to a housed livestock operation. The system is seasonal, meaning all 153 cows are milked between March and early January. Based on the primary system used in New Zealand for handling dairy manure, the 16-unit milking parlor milks one hundred plus cows per hour. The parlor sits next to a manure pit that holds 60 to 90 days of wastewater and manure; year-round storage is not necessary since the cows are kept outside all year. Small but powerful motors pump manure effluent back onto pastures using a traveling irrigator. During their dry months, the cows take advantage of the farm's topographic diversity and find comfortable spots during cold weather. The operation is not looking to breed high-yield milkers but thrifty cows that produce well on a primarily grass-fed diet. Net income totals approximately $1,000 per cow annually, and the system costs only $20 to 25 thousand for a 300-cow operation. The farm is currently a USDA research site. For more information, check out www.grassfarmer.com.

Phosphorus-Based Nutrient Management Planning

When applying manure on crops as a fertilizer, basing this application on the nitrogen needs of a crop can lead to an overloading of phosphorus and potash to the soil. Because it is now known that phosphorus can leach into surface and groundwater where soils are saturated, phosphorus-based nutrient management is now being required on some farms in the Bay watershed. Researchers at Penn State University are refining a phosphorus-based management scheme that considers critical source areas, or areas that have the highest potential for phosphorus pollution. A phosphorus index assigns low to high ratings to zones on a farm for their potential to deliver phosphorus to surface or groundwater sources. The nutrient management plan, based on nitrogen balances, is then adjusted to change the way phosphorus is either applied or managed in these target zones. For more information, contact Dr. Douglas Beegle, Department of Crop and Soil Science, The Pennsylvania State University;telephone 814-863-1016.

Smart P Fertilizer

Smart P fertilizer is a solid-phase buffered fertilizer that binds phosphorus to aluminum, releasing only that phosphorus needed by plants after watering. The low solution phosphorus levels result in less leaching, better root growth, improved plant growth and quality, and stronger drought tolerance. Though commercially available in Europe, Smart P fertilizer is currently undergoing field testing in the United States in the horticultural industry. The potential exists for agricultural crop applications to reduce leaching in soils that are saturated with phosphorus. For more information, contact Dr. Jonathan Lynch, Associate Professor of Plant Nutrition, Department of Horticulture, The Pennsylvania State University.

Animal Feeds / Alternative Agricultural Systems

Poultry Rations

A great deal of research and development is being invested in the formulation of poultry and cattle feeds to reduce the amount of phosphorus at the front end of the animal. Most publicized is the addition of phytase to poultry diets. Phytase is an enzyme that releases phosphorus from phytic acid and makes it available to the bird for digestion. The more efficiently a bird can digest phosphorus, the less phosphorus excreted in the bird's waste. Research continues on the most effective application of phytase in poultry diets in combination with the ingredient 250HD3 and optimal amounts of phosphorus to be added to poultry rations. University of Maryland researchers estimate that in Delmarva, where 602 million broilers are produced each year, the amount of phosphorus in poultry manure can be reduced by 5000 tons/year (and at a savings of $.13/ton of feed). For more information, contact Roselina Angel, PhD, Department of Animal and Avian Sciences, University of Maryland.

Dairy Rations

New Bolton Center, Pennsylvania, is researching the effects of forage quality and cattle grouping on nitrogen losses to the environment. Urea excreted by cows is the most volatile form of nitrogen, quickly breaking down and being lost to the atmosphere as ammonia. The goal of the research is to minimize this urinary urea loss by optimizing the use of nitrogen and protein in the cow's digestive system. For example, researchers know that the higher the proportion of legume haylage in a ration, the more nitrogen is lost as ammonia. They estimate that ration formulation can reduce nitrogen losses by up to 30% on dairy farms by reducing over-feeding of haylage and enhancing fiber digestion of alfalfa fed as hay. Supplying appropriate rations to cows based on their production can also help reduce nitrogen losses. For more information, contact James D. Ferguson, Associate Professor of Clinical Studies at the New Bolton Center.

Feeding Strategies

Animal manure, and the nutrients lost in the waste, is a function of the digestibility and composition of animal feed. Cutting down on the nutrients excreted by animals must be a multi-phase approach that 1) reduces feed wastage, 2) improves feed efficiency, and 3) balances an animal's specific water needs.Wenger Feeds continues to research nutritional strategies that can help reduce nutrient exretion. These include matching the nutrient requirements of animals to the nutrient content of feeds and improving the digestibility of feed nutrients through such actions as the addition of enzymesand proper sizing of feed particles. Effects of an animal's age and sex also need to be carefully evaluated to match nutrients and digestive capabilities.

Alternative Agricultural Systems

If you consider the water quality impacts of current cropping systems and confined animal production coupled with their small profit margins, then it may be an opportune time to evaluate lower impact agricultural systems that can protect the environment and raise farm profits. Tom Simpson, Coordinator of Maryland's Chesapeake Bay Program, proposes that it it a logical time to find ways to make less polluting crops profitable for farmers. Alternative farming systems include the "working lands" concept, which would provide payments to farmers to implement conservation plans far more comprehensive than currently devised;landscapes would be managed for multiple societal benefits including food, open space, biodiverse habitats, and water quality. Another option is energy-based crops, such as warm season grasses. Farmers could sell biomass for energy production and sell or bank carbon credits to offset carbon emissions in the fight against global warming. A third alternative is the "yield reserve program," an insurance-based concept that would pay farmers a per-acre incentive to apply only 75-85% of the nitrogen recommended in nutrient management plans. For more information on proposed pilot projects in these areas, contact Tom Simpson, University of Maryland; 301-405-5696.

Helpful References & Links

- **Agricultural Conservation Innovation Center**
  www.Agcons.com
  The Agricultural Conservation Innovation Center develops economically practical solutions to agricultural-environmental problems and makes these rapidly available to farmers and ranchers. A project of American Farmland Trust, ACIC believes that a program of economic signals and widely available incentives in support of conservation is long overdue. Traditional conservation tools (information, inspiration and cost sharing) cannot reach all farmers or provide adequate levels of protection to the vast agricultural landscape. ACIC hopes to correct this situation with our practical, environmentally sound proposals for change.

- **Maryland Nutrient Resources Network**
  Manure Net -- www.inform.umd.edu/ManureNet/
  These pages are provided by the University of Maryland to help farmers, scientists, teachers, students, policy makers and other citizens understand methods for reducing nutrient losses to water resources from animal production systems by improving animal and farm management.

- **Virginia Cooperative Extension Service**
  www.ext.vt.edu/
  Virginia Cooperative Extension Service offers educational programs and resources on a wide variety of nutrient management issues. Extension bulletins, fact sheets, and newsletters that address new technologies and best management practices are available for dissemination to waste managers, composters, farmers, consultants, and others involved in waste recycling and nutrient management.

- **National Center for Manure and Animal Waste Management**
  www.cals.ncsu.edu/waste_mgt/natlcenter/activities.htm
  The National Center for Manure and Animal Waste Management consists of 16 universities and a Policy Advisory Committee. The Center is supported for a 4-year period under the USDA Cooperative State Research, Education and Extension Service Fund for Rural America Program. Center efforts emphasize the development and dissemination of knowledge and technology that support sustainable, profitable and internationally competitive animal production and also protect community interests and environmental quality. Working with producers, agribusiness and policy makers, the Center will fuse interdisciplinary research, extension and education activities. White papers have been developed on a range of waste management topics. These papers describe the state of knowledge about each topic and list research and knowledge needs related to the topic.

- **Missouri Alternatives Center**
  www.agebb.missouri.edu/mac
  The Missouri Alternatives Center sorts through the masses of information and points users in the right direction. The Center works to improve profitablity and maintain the agricultural base needed to sustain rural communities. While it serves as a communications center for Missouri farmers, it shares material from all over the country and is a resource for all farmers, Extension staff, government personnel and people who want to begin farming, diversify their current operation, or find ways to profit from small amounts of acreage.

- **Penn State Nutrient Management Education Project**
  Penn State has a contract with the Pennsylvania State Conservation Commission to provide a wide range of education programs on nutrient management. For information on this project, contact: Jerry Martin, Nutrient Management Program,
  Room 100, 2301 North Cameron Street, Harrisburg, PA 717-783-9704; Email: jmartin@psu.edu