Emerging Technologies for Nutrient Management

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High rate of Manure P in the Shenandoah Valley

Map 5: Estimated Manure Phosphorus Production from Confined Livestock

Pounds Per County In Thousands
- Less than 100
- 100 to 500
- 500 to 1,000
- 1,000 to 2,000
- 2,000 or greater

Livestock populations (18 types) per farm were adjusted to reflect the number held in confined or using manure systems based on general practices in each state. Phosphorus losses were estimated by multiplying the average manure phosphorus pool by the average amount of manure produced by each type of livestock, which was then multiplied times an estimate of the average phosphorus content of the manure for each type of livestock. An additional adjustment was made for typical losses of phosphorus during storage and treatment.

Data Sources: Census of Agriculture, 1992.
This analysis has only been run for the contiguous 48 states. Alaska, Hawaii, Puerto Rico, U.S. Virgin Islands, and Insular Areas data were not incorporated in the study.

U.S. Department of Agriculture
Natural Resources Conservation Service
Resources Assessment and Planning Division
Washington, D.C. November 1997  Map 5  34201

USDA
Total Manure Nitrogen in Chesapeake Bay Watershed Counties

Source: EPA Chesapeake Bay Program
General Approaches

- Feed management
  - Precision feeding
- Manure treatment
  - P removal
- Manure utilization
  - Energy, fertilizer and other products
Feed Management
Does diet matter?
Precision Phosphorus Feeding for Virginia Dairy Farms

Objective:
Reduce P pollution of VA waterways and the Chesapeake Bay
- Implementation of incentives for precision feeding
- Demonstration of intensive dietary nutrient strategies
Precision Feeding Project

- Benefits of participation
  - Free feed testing (reduce overfeeding)
  - Free ration consultation
  - Earn money for meeting P levels
Components

- Feed sampling, analysis, bimonthly, for 3 years
- Calculate P requirements, P intake
- Incentive payments based on (intake/requirement)
  - $12 / $6 / $3 per cow per year
  - Payment capped at 400 cows
- No penalty for overfeeding
Program Accomplishments

- 215 herds signed up (35% of VA cows)
- 129 completed first year; 66 earned incentive
- Across all farms, P feeding down by 5–15%
  - Annual reduction of 20 tons less P by participants
  - For all Dairy Cows in VA: 105 tons reduction in P/yr

Successful herds (n=66) at each incentive payment level:
- $12: 25 herds
- $6: 32 herds
- $3: 9 herds
The first ~70 herds enrolled in Virginia P incentive payment study. Req’t ≈ 0.33% P
The Distiller’s Grain Challenge
What is needed?

- Develop and implement Quality Assurance/Quality Control procedures on dairy farms
  - Training of farm workers
- Research to characterize and quantify the nutrient content of byproduct feeds
  - Distiller’s grain
  - Could P be removed from the byproducts before feeding?
General Approaches

- Feed management
  - Precision feeding
- Manure treatment
  - P removal
- Manure utilization
  - Energy and fertilizer
Manure Treatment Objectives

- Stabilize manure
- Odor reduction
- Nutrient management
- Energy recovery
- Pathogen reduction
- Reduce gaseous emissions
Manure Treatment Options and By-Products

- **Manure**
  - Aerobic Processes
  - Anaerobic Digestion
  - Direct Combustion
  - Gasification Pyrolysis
  - Physical & Chemical Technologies
  - Fertilizer
  - Energy
  - Chemicals
Manure Treatment: **Struvite**

**Physical and Chemical Treatment**

- **Strait reactor**
  - Recovers phosphate, ammonia and magnesium in liquid manure
  - Remove P of the manure by 50% of P as struvite
  - If applied to all dairy farms in Rockingham Co. about 345 tons of P would be removed each year

- Currently demonstrating struvite recovery at D&D farm in Dayton VA
Other Uses of Struvite

- Fertilizer
- Raw material for:
  - cleaning products
  - fire resistant panels
  - binding material in cement
Manure Treatment: Biogas

- Anaerobic digestion process
- Biogas composition
  - ~ 65% Methane
  - ~ 35% Carbon dioxide and other trace gases (e.g. hydrogen sulfide; water vapor)
- Biogas energy content ~ 65% BTUs of natural gas
- Decompose manure in controlled environment to recover methane

The Methane Molecule

900 cows + organic wastes, 130 kW
Up to 225,000 ft³/d, solids separated

RCM Digesters.com
AD: Byproducts and Utilization

**Anaerobic Digester**

- **Animal Manure**
- **Effluent**

**Biogas**

- **Energy**
  - Electricity
  - Heat

**Solid-liquid Separation**

- **Liquids**
- **Solids**

**USE**

- Fertilizer
- Other
Challenges for AD Systems in VA

- Only ONE Anaerobic Digester unit in VA
- **VA Dairy Size:** 721 Dairies in VA, average herd size of ~139. Tend to be on farms with 300+ animals
- **Capital Cost:** On-farm systems can cost well over $100k+
- **Logistics:** Centralized AD – may be expensive to transport dairy manure long distances
- **Green Energy:** Challenge for VA farmers to generate electricity and sell green power to the grid
  - complex insurance requirements, expensive interconnect fees, limited kWh output due to farm size, etc.
AD Systems are growing in the US

- Improved digester designs and demonstrated biogas production and engine-generator set reliability
- Concerns about odor and other environmental impacts of manure management practice
- Increased governmental cost share programs
- Increased interest in renewable energy portfolio and green energy programs
- Potential for sale of carbon credits to generate income
Potential for Commingling Waste Streams to Enhance Biogas

Concept depends on a variety of factors (business model, tipping fees, etc.)

Need to first determine if this is technically feasible
Mixing dairy manure (DM) with poultry processing wastewater (PW) increases the gas production compared to DM alone.
More methane produced using comingled feedstock
Designer Manure!

- Combined aerobic and anaerobic digestion
- Enhanced biological phosphorus removal
  - Produce specific N&P content in the manure
  - Research in its infancy
  - Economic analysis needs to be done
Potential Hurdles to Implementation of Biogas Systems

- Permitting
  Facilities processing multiple waste streams will likely have to secure multiple permits?

- Ownership Issues
  Poultry processing plant or dairy farmer?
General Approaches

- Feed management
  - Precision feeding

- Manure treatment
  - P removal

- Manure utilization
  - Energy and fertilizer
Pyrolysis Conversion of Poultry Litter to Value-Added Products
What is pyrolysis?

- Thermal conversion of organic materials in the absence of oxidizing agents such as oxygen.
- Always occurs before any combustion process.
- Leads to thermochemical decomposition of organic materials into a complex mixture of compounds:
  - Pyrolysis temperature $400 \leq T \leq 600 \, ^\circ\text{C}$
  - Products—liquid, solid, gases
  - Liquid yield: 60 to 70 wt%; Gas yield 10 to 20%; Solid yield 10 to 40%
Poultry Litter Bio-oil
Potential Applications of Bio-oil

- Extract
- Upgrade
- Transport fuel
- Chemicals
- Electricity
- Heat
- Boiler
Pyrolysis Char of Broiler Litter
## Nutrient Composition Broiler Char

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<tr>
<th>Element/Compound</th>
<th>Wt%</th>
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<tr>
<td>Total N</td>
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<tr>
<td>P₂O₅</td>
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<tr>
<td>K₂O</td>
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<td>Ca</td>
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<td>B</td>
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<td>Cu</td>
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<tr>
<td>Fe</td>
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<tr>
<td>Mn</td>
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<table>
<thead>
<tr>
<th>Element</th>
<th>Value</th>
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<td>Na, (wt%)</td>
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<tr>
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<td>DL</td>
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<td>Se, mg/kg</td>
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<td>Mo, mg/kg</td>
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<tr>
<td>Co, mg/kg</td>
<td>5.0</td>
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Char is a slow release fert.

**PO4**

- % loss to soln vs. time
- Graph showing data points for RFM, RF1, RF2, RAT, F1, F2, and AT over time periods of 1 hour, 4 days, 7 days, 14 days, 1 month, and 2 months.

**TKN**

- % loss to soln vs. time
- Similar graph for TKN showing data points for RFM, RF1, RF2, RAT, F1, F2, and AT over the same time periods.
The pilot pyrolysis demonstration unit is located on the property of Mr. Oren Heatwole. The unit is transportable from farm to farm, but most of the initial research is done on-site. Poultry litter from a neighboring farm is used as the feedstock for the pilot project.
Transportable Pyrolysis Reactor

- Design capacity: 5 tons litter per day
- Bio-oil produced per day: 1.75 tons
- Bio-char produced per day: 1.4 tons
Recommendations

- State funding needed to
  - Conduct more research on conversion of manure to energy and other by-products
  - Develop pre-commercial pilot scale units to demonstrate and enhance the adaptation of these technologies
  - Research to characterize and quantify the nutrient content of byproduct feeds such as distiller’s grain
- Permitting issues with regard to pilot scale units for research and demonstration
- Include technologies: pyrolysis and precision feeding, as BMPs on state cost-share program
Poultry Powered!!!