Welcome to Manure Du Jour – Season II

Serving Pennsylvania’s Best Practices for Animal Ag-, Air- and Water Quality Protection

Follow the Nutrients: Farm scale treatment (including digesters) and regional facilities

Bob Graves, Penn State Agricultural and Biological Engineering
Bill Shuffstall, Penn State Agricultural Economics & Rural Sociology

Moderator: Kristen Saacke Blunk
Penn State Agriculture & Environment Center
Manure Du Jour

Bob Graves

Penn State Agricultural & Biological Engineering
Follow the Nutrients: Farm scale treatment and regional facilities.

Robert E. Graves, Professor
Agricultural and Biological Engineering

reg2@psu.edu
www.biogas.psu.edu

Penn State is committed to affirmative action, equal opportunity, and the diversity of it’s work force

March 11, 2010   REG Agricultural and Biological Engineering   www.abe.psu.edu
Everything has to be someplace

**Manure Shell Game**

- manure
- air
- water
- soil
air

_____

water

_____

soil
Nutrient Flow on Livestock Farms

LAND

AIR

WATER

March 11, 2010   REG Agricultural and Biological Engineering   www.abe.psu.edu
Look at Manure

• Feces + Urine = Manure as voided by animal

• Feces + Urine + Bedding + Waste Feed + Wash water + ….. = Manure as handled
Dairy Manure as Voided
(90 Pounds) ASABE D384.2 MAR 2005

Moisture = 78#
Total Solids = 12#
Volatile Solids = 10.2#
Nitrogen (N) = 0.6 #
Phosphorus (P) = 0.1 #
Potassium (K) = 0.14 #
12 # Total Solids in 90# Dairy Manure

ASABE D384.2 MAR 2005

Volatile Solids = 10.2 #

Ash = 1.8 #
Nutrients in 12# of Manure Solids

ASABE D384.2 MAR 2005

Nitrogen = 0.6 #
Phosphorus = 0.1 #
Potassium = 0.14 #
Dairy Manure as Handled
(90 pounds of manure + 10 pounds extra water)

10 # extra water

78 # water in voided manure (87% moisture)

12 # Total Solids in Manure (12% dry matter)

100# Total
Manure Gases

- **Hydrogen Sulfide**—colorless, heavier than air, can cause death in seconds.
- **Carbon Dioxide**—colorless, odorless, heavier than air—asphyxiating.
- **Ammonia**—lighter than air, irritant—eyes, throat and lungs, low continuous exposure.
- **Methane**—flammable and odorless—lighter than air, accumulates under roofs, covers.
On-Farm Manure Systems

- Animal applied (pasture)
- Stackable, slurry or liquid
- Daily haul and spread
- Store – at barn or satellite
- Solids separation (physical treatment)
  - Settling; pan, tank or pond
  - Screen; sloping (gravity), rotating brush, extruder
  - Centrifugal
- Anaerobic Digestion (biological treatment)
  - Entire manure stream; liquid, slurry or stackable solid
  - Liquid stream after solid separation
- Composting
  - *Advanced Treatment* – *nutrient removal (biological and chemical treatment)*
Anaerobic digestion uses microbes in an oxygen-free tank to break down manure into Biogas and a nutrient-rich liquid.

How it works...

Air-tight digester vessel

First Phase:
- Liquefaction

Second Phase:
- Gasification

Complex Organic Material (Manure)

Simple Organics (Volatile Acids)

Acid-Forming Bacteria

Methane-Forming Bacteria

5 – 20 Days, Temperature dependent

Heat needs added to AD to maintain temperature range.
Nutrient Flow in Anaerobic Digester

Nutrients are not reduced through the anaerobic process.

Influent...
1. Organic N
2. Ammonium N
3. Phosphorus
4. Potassium

Anaerobic digesters do not significantly reduce manure nutrient content.

Digester
- Biogas:
  - Methane CH₄
  - Carbon Dioxide CO₂
  - Trace gases
- Slurry
- Settled Solids

Effluent...
1. Ammonium N
2. Organic N
3. Phosphorus
4. Potassium

Ammonium N increases as Organic N is transformed in the anaerobic process.

Solids accumulated in the bottom of the digester also contain some P & N.
Where the energy comes from...

- Raw Dairy Manure: 100 lbs.
  - 87 lbs. Water
  - 13 lbs. Total Solids
- Potential for Producing Biogas: 2 lb. Ash
  - Volatile Solids (Available for Biogas Production)
- Efficiency of Most Digesters for Producing Biogas: 7 lbs. Not Converted to Biogas
  - Converted to Biogas
    - ≈ 70 ft³/Cow/Day
    - ≈ 11 ft³/Sow/Day
    - ≈ 25 ft³ Biogas/kWh
A Farm Biogas System

Collection Tank and Digester Loading Pump
Flexible Cover Digester
Liquid/Solids Separation – before or after digestion
CHP - Combined Heat and Power

Auxiliary Boiler
Biogas can be produced from a variety of organic material

- Stackable, porous solid
- High solids, “stew like” augerable material
- High solids pumpable material
- Slurry manure
- Liquid manure
- Liquids with dissolved and suspended solids
- High strength dissolved solids organic liquids
Epilogue

• Biogas can be produced from manure
• Manure is a consistent but lower yielding source of biogas
• Biogas is a dilute gaseous fuel- best used for stationary power
• Anaerobic Digester costs to consider
  – Design, materials, temperature, permits…
  – CHP Unit
  – Electric grid interconnection
  – Require extra management and knowledge: wastewater treatment plant operator, electric power supplier, organic materials broker…
• Feedstocks – manure, food processing wastes, crop biomass
References and other Resources

- PSU biogas website  www.biogas.psu.edu
- ABE Fact Sheets  www.abe.psu.edu
- U.S. Government AgSTAR  http://www.epa.gov/agstar
Time to take our biogas on the road and hand the program over to Bill Shuffstall.
Follow the Nutrients: Farm Scale and Regional Treatment Systems

Bill Shuffstall, Sr. Extension Educator
Ag Ec Rural Sociology
shuffy@psu.edu
Regional Nutrient Treatment System

• System Components – Follow the nutrients
• System stakeholders
• Relationships across the system
  – It is much more than applying technology
• Broad brush of issues impacting system sustainability
Follow the Nutrients
Regional Treatment System

FAR MS

Digester/Advanced Water Treatment Plant

N₂

Water

Solids

Think Again
Issues Needing Attention

• Farmers – Feedstock providers
• Transportation
• Public concerns
• Farm service organizations
• Local governments
• Processing facility
• Facility ownership structure
Happy Farmers

- Agreements with farmers
  - Manure value
  - Compensation
  - Revenue sharing
- Manure holding/loading facilities/pick-up schedule
- Long term Contracts ($)

- Nutrient management plans – (Follow the Nutrients)
- Changes in on-farm management practices
  - Cropping systems
  - Crop rotations
  - N, P, micro nutrients, organic matter
- Feeding
Transportation

• Transportation
  – Contracts
  – Additional Truck traffic on local roads
  – Logistics
  – Bio Security
Public

- Traffic
- Odor
- Plant safety
- Environmental organizations
- CAVE People
Farm service organizations

• Public
  – Conservation Districts
  – Cooperative Extension

• Private
  – Feed and fertilizer suppliers
  – Nutrient management consultants
  – Milk haulers
  – ???
Local Government

- Public safety services
- Planning/land use/zoning
- Road maintenance
- Monitoring?
- Citizen concerns
Processing Facility

- Siting
- Financial management
- Process management
- Financing
- Nutrient tracking

- Environmental compliance
- Sales of environmental attributes and other products
- Financial sustainability
Long Term Research and Outreach

• Impact on Watershed
• System analysis
  – Nutrient monitoring approach
  – Contracts and agreements
  – Farm size
• Community fit
• Stakeholder education
What Might Be in the Processing Plant

• Holding tanks (Nutrients, solids, water)
• Digester (Nutrients, solids, water)
• Generators
• Dryers (Nutrients, solids)
• Advanced water treatment system (N)
Treatment Plant

Mixing – Storage Tank

Digester
Treatment Plant

Mixing – Storage Tank

Electricity $

Generator

Bio Gas

Renewable Energy Credits $

Digester
Treatment Plant

Mixing – Storage Tank

Electricity $

Generator

Bio Gas

Renewable Energy Credits $

Heat

Solids (Dryer) N and P

-Bio Fuel

-Nutrient Credits $

Solids

Digester

Think Again
Regional Nutrient Treatment Systems

• One of several options with potential to help address Chesapeake Bay cleanup
• Complex
• Multiple stakeholder groups impacting sustainability
• New in US – what questions need answered
Question and Answers

• Questions received in writing will be directed to the speakers by the moderator.
• If your question is not answered during the time remaining, responses to the questions will be posted at www.aec.cas.psu.edu
• Recordings of this session can also be viewed at the URL listed above.
What’s ahead for season II?

• Next week:
  • Surplus Nutrients to Deficit Regions: Manure Application in PA’s Acid Mine Lands and Trading Scenarios
    • Rick Stehouwer, PSU Crop & Soil Sciences
    • Scott Van de Mark, PA Environmental Council
  – Full schedule for the Manure du jour program: http://aec.psu.edu
  • Nutrient Management Continuing Education Credits ARE AVAILABLE for Mar 18, Apr 15, Apr 22, Apr 29 programs.