Welcome

A Lunchtime Webinar Series

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

TODAY’S FOCUS: Air Quality – Land Application, Treatment and Storage

- **Curtis Dell**, USDA Agriculture Research Service
- **Patrick Topper**, PSU Ag & Biological Engineering
- **Bob Graves**, PSU Ag & Biological

*Hosting: Kristen Saacke Blunk, Director*  
Penn State Agriculture and Environment Center
Gaseous Emissions Following Land Application of Manures

Curtis Dell

USDA-ARS Pasture Systems and Watershed Management Research Unit
University Park, PA
Gases of Concern

Basically the same gases that have been discussed for animal production facilities and manure storage, but differences in their impact

- Ammonia (NH₃)
- Greenhouse gases
  - Nitrous Oxide (N₂O)
  - Methane (CH₄)
  - Carbon Dioxide (CO₂)
- Others such as NOx’s, sulfur compounds, and volatile organic compounds
Ammonia

- Large pathway for loss of crop-available N
  - $\text{NH}_4^+ \rightarrow \text{NH}_3$
  - Up to 50% loss of manure $\text{NH}_4^-$-N is typical

- Contributes to smog formation
  - Particulate matter (PM$_{2.5}$ regulations)

- Source of N deposition to waterways

- NH$_3$ volatilization
  - Increases as soil and air temperature increase
  - Increases as soil and manure pH increase
  - Greatly influenced by timing and method of soil incorporation
Ammonia volatilization and incorporation

Broadcasting without incorporation
- Greatest potential for NH$_3$ emissions

Tillage Incorporation
- Can greatly reduce NH$_3$ emissions
- Timing effects amount of N conserved
- Not compatible with many conservation practices
Ammonia volatilization and incorporation

Incorporation by aeration

➢ Less loss of residue cover
➢ Multiple configurations/approaches
➢ Mixed results for NH$_3$ emission
➢ Appears to be most effective with hog manure (low solids)
Ammonia volatilization and incorporation

Shallow disk injection

- Greatly reduces $\text{NH}_3$ emissions
- Very little residue disturbance

Other types of injectors

- Wide variety of designs
- $\text{NH}_3$ emission usually directly related to amount of manure left on soil surface
- Applicators that reduce $\text{NH}_3$ emissions generally reduce odor
Ammonia volatilization and incorporation

Dairy slurry application

- Broadcast
- Aeration with banding
- Shallow disk injection
- Tillage incorporation after 1 hr
<table>
<thead>
<tr>
<th>Method</th>
<th>Cropland</th>
<th>Pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chisel/knife injection</td>
<td>73% less\textsuperscript{12}</td>
<td>40% to ~100% less\textsuperscript{6,9,12}</td>
</tr>
<tr>
<td>Disk Injection</td>
<td>58 to ~100% less\textsuperscript{2}</td>
<td>20 to 75% less\textsuperscript{4,5,10}</td>
</tr>
<tr>
<td>Pressure Injection</td>
<td>57 to 64% less\textsuperscript{2}</td>
<td>62% less\textsuperscript{7}</td>
</tr>
<tr>
<td>Aerator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>banded over holes</td>
<td>No difference to 70% less\textsuperscript{2}</td>
<td>33% less\textsuperscript{1}</td>
</tr>
<tr>
<td>pre/post application</td>
<td>50-75% less\textsuperscript{8}</td>
<td>No difference\textsuperscript{3}</td>
</tr>
<tr>
<td>Tillage</td>
<td>50 to 92% less\textsuperscript{2,10,12}</td>
<td>------</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Bittman et al, 2005; \textsuperscript{2}Dell et al, submitted; \textsuperscript{3}Gordon et al, 2000; \textsuperscript{4}Hansen et al, 2003; \textsuperscript{5}Lambert and Bork, 2003; \textsuperscript{6}Misselbrook et al, 1996; \textsuperscript{7}Morken and Sakshaug, 1998; \textsuperscript{8}Myers et al, unpublished; \textsuperscript{9}Rodhe et al, 2006; \textsuperscript{10}Smith et al, 2000; \textsuperscript{11}Weslien et al, 1998; \textsuperscript{12}Wulf et al, 2002.
Agricultural Sources of Greenhouse Gas Emissions in 2005 (CO$_2$ + CH$_4$ + N$_2$O)

- **Enteric fermentation** (CH$_4$) 22%
- **Managed livestock waste** (CH$_4$, N$_2$O) 10%
- **Grazed lands** (CH$_4$, N$_2$O) 18%
- **Rice** (CH$_4$, N$_2$O) 2%
- **Cropland soils** (N$_2$O) 35%
- **Energy use** (CO$_2$) 13%
- **12% from manure N**

USDA: U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005
Nitrous Oxide

- Usually relatively small portion of manure N
  - IPCC emission factor is 1.25% of applied N
- Main concern is its impact as a greenhouse gas
  - 300 times more effective than CO$_2$
- By-product of both nitrification and denitrification
- Denitrification expected to be largest source
  - Anaerobic process – controlled by soil aeration and water content
  - Can also occur in unsaturated soil when O$_2$-deleted zones develop within soil aggregates
Nitrous oxide emissions following manure (two rates) and mineral fertilizer application.
Nitrous oxide and application method

- Injection increases potential for N₂O emission
  - Concentrated bands of manure can promote microbial activity, which can decrease O₂ and create anaerobic zones
- Limited information
  - Three studies showed 15 to 300% more N₂O with chisel injections compared to surface broadcasting
  - 3 to 4 times greater N₂O with subsurface poultry litter application when measured following rainfall simulation
- Trade-off between reduced NH₃ and increased N₂O must be considered
Methane and Carbon Dioxide

- Land application not significant CH₄ source
  - CH₄ emissions dissipate quickly as manure dries
  - CH₄ consumption in soil offsets emissions from manure

- Land application not significant CO₂ source
  - Small in comparison to other CO₂ sources
  - Stable C compounds in manure contribute to soil C sequestration
For additional information, I can be contacted at:
Curtis.Dell@ars.usda.gov or 814-863-0984
Manure Du Jour  
April 16, 2009

Patrick Topper  
PSU Ag & Biological Engineering on storage and treatment
Manure Du Jour

Introduction to Farm Based Anaerobic Digestion as a Manure Treatment

Patrick A. Topper
Senior Research Technologist
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Intro to Farm Based Anaerobic Digestion as a Manure Treatment

Objectives:

- Define what anaerobic digestion is and what it isn’t
- Discuss biogas, which is a byproduct of anaerobic digestion (AD)
- Discuss AD systems in use on farms including odor and air quality issues
First, Let's define what anaerobic digestion is?

**Anaerobic Digestion** – the breakdown of animal manure (organic material) in the absence of oxygen, (methane producing bacteria are most active in two temperature ranges, 95 to 105 °F and 130 to 135 °F ref. www.biogas.psu.edu

Anaerobic Digestion (AD) occurs when organic material decomposes biologically in the absence of oxygen. (ID-406-W Purdue Extension fact sheet)

During the process of AD, biogas is produced when some of the organic solids are decomposed and are transformed into gases.
What’s Biogas?

It’s a gaseous biofuel made up of a mixture of methane (60% to 70%) and carbon dioxide (30% to 40%) – with trace amounts of hydrogen sulfide, ammonia and water vapor (contaminants).

What Biogas is NOT ...  
Biogas is NOT pure methane (natural gas).  
Biogas is NOT biodiesel.  
Biogas is NOT bioethanol.
Biogas is low in BTUs/gal. (80 BTU/gal. volume.) and it is energy intensive to clean and compress, so it is not feasible to use as a motor fuel. It needs to be used as a stationary fuel, such as in an electrical power-generating plant or a boiler.
Anaerobic digestion uses microbes in an oxygen-free tank to break down manure into Biogas and a nutrient-rich liquid.

**How it works...**

- **First Phase:**
  - Liquefaction

- **Second Phase:**
  - Gasification

- **Complex Organic Material (Manure)**
  - Citrus (Fruit)
  - Sugar (Sweetener)
  - Alcohol (Ethanol)

- **Simple Organics (Volatile Acids)**
  - Acid-Forming Bacteria
  - Methane-Forming Bacteria

- **Methane and Carbon Dioxide (Biogas)**

- **Low-Org Nutrient-Rich Liquid**

5 – 20 Days, Temperature dependent

Heat needs added to AD to maintain temperature range.
How Do Anaerobic Digesters (AD) Work?

Nutrients are not reduced through the anaerobic process.

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

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

Anaerobic digesters do not significantly reduce manure nutrient content.

Solids accumulated in the bottom of the digester also contain some P & N.

Ammonium N increases as Organic N is transformed in the anaerobic process.
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 ft³Biogas/kWh

Note: anaerobic digestion reduces manure volume by about 4%!
Benefits...

LOCAL:  - Reduced odor, fly eggs, weed seeds in digested manure
Revenues:
   On farm power production sales
   Tipping fees from other feed stocks (food wastes)

REGIONAL:  - Pathogen reduction of land applied nutrients
   - Rural electric grid voltage support

GLOBAL:  - Reduced methane emissions, a greenhouse gas
   - Reduced dependency on foreign fossil fuels

Notes and lessons learned:
- Anaerobic digestion “DOES NOT REDUCE NUTRIENTS IN MANURE”
- If considering to build an anaerobic digester, select an experienced “Farm Digester” consultant

Sources of additional information:
- www.biogas.psu.edu
- “AgSTAR”, www.epa.gov/agstar or phone 1-800-952-4782
- Publication A3756, Anaerobic Digester and Methane Production...
  Questions that need to be asked and answered before investing your money
Types of Anaerobic Digesters

Plug Flow dairy manure digester located in Central Pennsylvania
Types of Anaerobic Digesters

Modified Plugflow (slurry loop) dairy manure digester, located in Southwestern PA
Types of Anaerobic Digesters

Complete mix dairy manure digester located in South Central Pennsylvania
Types of Anaerobic Digesters

- Specialty digesters include:
  - Fixed film, fluidized bed, solids retention, temperature phased, community ....
Many, many citations for odor reduction of manure during AD

- University websites for Purdue, Penn State, Iowa, Cornell, PSU

Odor analysis and quantification is a growing science in the U.S. Manure odors are becoming a larger and larger part of the Air Quality concerns for animal agriculture.

When reviewing the literature, no real quantitative analysis was found, no in-depth studies, just the on-going theme that when the volatile fatty acids are decomposed in the AD, MANURE ODOR is REDUCED!
Introduction

Dairy farms are coming under increasing pressure to control the odors from their operations. Often nutrient management plans designed to protect water quality prescribe manure storage. Stored manure can produce objectionable odors, creating a conflict with neighbors. Anaerobic Digestion has the ability to significantly reduce the odors from the stored manure. This system will improve neighbor relations, reduce the impact on the environment, and will help provide for sustainable development of the dairy industry.

Conclusions

The anaerobic digester is a feasible system for dairy farms that will provide excellent odor control. The costs of this system is comparable or less than other manure handling systems. The management required is well within the abilities of most dairy farms.
Methane is 21 times more destructive as a greenhouse gas as compared to Carbon Dioxide.

Methane is produced, contained and destroyed within the anaerobic digester system.

Carbon credits can be generated by destroying the Methane.
...A (WEB-BASED) Biogas Outreach Education Tool

Check us out ONLINE!

Do I want to...
reduce manure odor coming from my farm?
generate electricity to power the farm?
sell excess electricity to the power grid?
determine the type of digester I need?

Digester Types and Benefits
Case Studies and Resources
Where to Find Financing
Equipment Vendors
Safety Alerts and Tips

Department of Agricultural and Biological Engineering, The Pennsylvania State University
Deborah Topper, Agricultural/Research Technician, ABE
Patrick Topper, Senior Research Technologist, ABE
Robert Graves, Professor, ABE

Support and/or Funding:

[Logos of ABE, Department of Agricultural and Biological Engineering, College of Agricultural Sciences]
List of Resources:

- www.biogas.psu.edu
- AgSTAR  http://www.epa.gov/agstar
- ASAE D384.2 MAR2005 Manure Production and Characteristics, ASABE Standard
Manure Du Jour

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April 16, 2009
Looking at Manure in a Different Way

Who all is looking at manure and
What do they see?
3.77.1 liquid manure (thin slurry): Manure that by its nature or after being diluted by water, can be pumped easily. Normally fibrous material such as chopped straw or waste hay is not present.

ASAE S292.5
3.77.2 slurry manure: Manure in which the percent total solids approximates that of excreted manure for some species. The total solids content could vary by a few percent depending on whether water is added or a slight drying occurs. It can be handled with conventional, centrifugal manure pumps and equipment.

ASAE S292.5
3.77.3 semi-solid manure: Manure that has had some bedding added or has received sufficient air drying to raise the solids content such that it will stack but has a lower profile than solid manure, and seepage may collect around the outer edge. It may be pumped with positive displacement pumps or be handled with a front-end loader. ASAE S292.5
3.77.4 solid manure: Manure that has had sufficient bedding or soil added, or has received sufficient air drying to raise the solids content to where it will stack with little or no seepage. It is best handled with a front-end loader.  ASAE S292.5
Typical PA Species

- Swine
- Poultry – eggs and meat
- Dairy
- Horses
Swine

- Slotted floors – total, partial
- Under Slots – storage, scraper, pull plug, flush
Swine

Looking at Manure

April 16       R.E.G.
Poultry - Layer

- Floor birds – litter pack
- Cage Birds – high rise, under barn storage
- Cage Birds – manure belts/scrapers, out of barn storage
Poultry - Meat

- Litter pack
- Wire
Poultry - Meat
Dairy Tie Stall

- Gutter cleaner (solid/semi-solid, sand laden)
- Gravity gutter (slurry)
- Flush gutter (liquid)
Dairy Freestall

- Tractor scraper (semi-solid/slurry, sand laden)
- Alley scraper (semi-solid/slurry, sand laden)
- Flush (liquid, sand laden)
- Slotted floor (slurry/liquid)
Freestall Barns

Looking at Manure

April 16

R.E.G.
Bedded Pack — Beef, Dairy, Youngstock
Other Liquid Waste Streams

- outside lot runoff
- milking center waste water
- silage leachate
- building wash down water
- stock trailer and manure equipment wash down water
Outside Animal Areas
Milking Center Wastewater
Silage Leachate
Manure Storages
Manure Treatment

- Physical
- Biological
- Chemical
More to manure than meets the eye
What goes around, comes around!
So what does your eye see?
What do you see?

- What is the biggest air emission problem facing PA?
- Where do air emissions from PA farm animals fit in the greater scheme?
- How would you settle issues between competing/conflicting environmental quality interests or benefits?
- Do you see a future for a healthy vibrant and profitable livestock industry in PA?
Question and Answers

- Questions received in writing will be directed to the speakers by the host.
- Questions not answered during the time remaining, will be posted with answers at www.aec.cas.psu.edu
- Recordings of this session can also be viewed at the URL listed above.
Roundtable Discussion for Participants & Presenters

Friday, April 24 at Noon  Join us for a Roundtable Discussion on Manure Du Jour –

• Participants and program presenters about the research, practices, issues and opportunities identified.
• What are the next steps for Pennsylvania animal agriculture – and air and water quality protection?

For more information  www.aec.cas.psu.edu
Upcoming Webinars

**Friday, April 17, 2:30 PM**
What To Expect When You Are Inspected
[http://connect.extension.iastate.edu/lpelc](http://connect.extension.iastate.edu/lpelc)
Sponsor: National Livestock and Poultry Environmental Learning Center

**Monday, April 20, 2:00 PM**
American Recovery and Reinvestment Act & Green Project Reserve
[https://breeze.psu.edu/AgEnvPartnership](https://breeze.psu.edu/AgEnvPartnership)
Sponsor: PENNVEST and PA DEP, hosted by Penn State Agriculture & Environment Center