Welcome

A Lunchtime Webinar Series
Serving Pennsylvania’s Best Practices on Animal Ag, Water-, and Air Quality

TODAY’S FOCUS: Air Quality – Housing & Barnyards

- Eileen Wheeler, Professor of Agricultural and Biological Engineering
- Pat Topper, Senior Agricultural Research Technologist
- Robert Graves, Professor of Agricultural and Biological Engineering

Hosting Robb Meinen
Penn State Dairy and Animal Science
Manure Du Jour

April 2, 2009

Eileen Wheeler

PSU Department of Agricultural and Biological Engineering
Manure Du Jour  

Patrick Topper  
PSU Department of Agricultural and Biological Engineering  

April 2, 2009
MONITORING of EMISSIONS in PENNSYLVANIA AGRICULTURE

The Use of Flux Chambers for Emission Monitoring

Presented by: Patrick A. Topper
Agricultural Research Technologist
The Pennsylvania State University
As discussed earlier, measure concentration of emission leaving at the fan and measure the fan ventilation rate.
Monitoring of Emissions in Pennsylvania Agriculture

What if there are No fans?

Naturally ventilated freestall dairy barn
How do we measure emissions if the barn is naturally ventilated?

- Micrometeorological techniques
- Tracer gases including Sulphur hexafluoride ($SF_6$) and carbon dioxide ($CO_2$)
- Ultra-violet (UV) instruments based on differential optical absorption spectroscopy (UV-DOAS)
- Flux chambers

Ref. Biogenic Trace Gases: Measuring Emissions from soil and Water  P.A. Matson & R. C. Harris
Monitoring of Emissions in Pennsylvania Agriculture

– Micrometeorological techniques

– Tracer gases including Sulphurhexafluoride and carbon dioxide
Ultra-violet (UV) instruments based on differential optical absorption spectroscopy (UV-DOAS)

- Uses USDA BLS metrological system for air flow
- Cost = $50,000.00

Cerex Environmental Services, Inc.
www.cerexenv.com
Flux Chambers

Two basic types:

- Non-steady state: allows gas emissions to concentrate over time
- Steady state: needs constant supply of clean sweep air

Monitoring of Emissions in Pennsylvania Agriculture
What if the scenario requires comparison of emissions from different groups of animals in the same building, being fed different rations, either naturally ventilated or forced ventilated?

Which technique works for us?

Flux Chambers

At Penn State in Ag Eng., we have used both types depending on the research situation; dairy cows, heifers, and layers.
Monitoring of Emissions in Pennsylvania Agriculture

- In lab, steady-state flux chambers
- Data collection automated
  - MatLab™ control of switching and data recording
1 gallon glass jars (steady state flux chambers) with manure @ as produced urine : feces

At least one jar has water instead of manure. Provides background emission data.

Water bath controls temperature.
Multi-plexer: switches instrument samples sequentially among all sample jars
Uses filtered room air, flow meters, solenoids and computer program
Monitoring of Emissions in Pennsylvania Agriculture

**ODOR ASSESSMENT LAB MISSION**
To study air emissions for the development of improved agricultural management strategies.

**Current Project Objective:** To evaluate the impact of different manure amendments on odor from dairy manure.

**Method:** Odor panel sensory evaluation using Lab-based olfactometry and multi-chamber steady state gas emission Detection system with multi-gas field monitor.

**Sponsor:** USDA
Provide uniform conditions that affect gas emissions
- Temperature-controlled water bath
- Dust and ammonia filtered inlet air
- Calibrated sweep air flow meters
- Sweep air 0.5 air changes/minute

But this is not Barn measurements
We need to get into the field!
Monitoring of Emissions in Pennsylvania Agriculture

Portable, field use, Flux Chambers

Steady state flux chambers cover a portion of the manured floor surface, uses sweep air into and through the chamber, flux calculated by sweep air flowrate times change in gas concentration.
Non-Steady State Flux Chamber covers a portion of the floor surface, continuous concentrations recorded, sample analyzer returns air to chamber, flux calculated by change in concentration over time.
Monitoring of Emissions in Pennsylvania Agriculture

Flux chamber internals showing sweep air ring
Used our first generation flux chamber: 2005

Consisted of a stainless steel container (chili pot) modified inside with a sweep air ring. Used a multi-gas instrument for emission concentrations.
Innova model 1412

- Photoacoustic, measures up to 6 gases
- menu-driven software
- fast response time
- does not consume sample
- +/- 1% of calibration value
- annual calibration
- Cost = $42,000.00
Model 1412 Photoacoustic Field Gas Monitor interfaced with laptop. Internal sample pump flushes tubing and provides fresh sample to detection chamber.

Instrument requires 100-240 VAC, 50-60 Hz, during field use, powered by deep cycle batteries and an inverter.
Second Generation: non-steady state, “Recirculation” Flux Chamber
Monitoring of Emissions in Pennsylvania Agriculture

Second Generation: modified by adding recirculation sweep airflow using air pumps
Third generation: redesigned into a uniform, horizontal, recirculating airflow, non-steady state, flux chamber

Used for emission monitoring:
- Manured soils
- Dairy manure storage
- Heifer emission trials
- Poultry layers (belts and deep pits) and broilers manure
Steady state, recirculating “static” vented flux chamber measuring emissions from a stacked manure testing site.
Monitoring of Emissions in Pennsylvania Agriculture

- Typical data from field measurements while using a non-steady state flux chamber

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<th>Nitrous Oxide [mg/m³]</th>
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Linear Gas Flux Equation

\[ f = \frac{V \left( C_t - C_o \right)}{At} \]

Hutchinson and Mosier (1981)

- \( f \) = flux (mg NH\(_3\) cm\(^2\) min\(^{-1}\))
- \( V \) = volume flux chamber (cm\(^3\))
- \( C_t \) = gas concentration final (mg/m\(^3\))
- \( C_o \) = gas concentration initial (mg/m\(^3\))
- \( A \) = floor area covered by flux chamber (cm\(^2\))
- \( t \) = time (minute)
Method: Initial Gas Flux Model

Non-linear relationship check

\[
\frac{C_1 - C_0}{C_2 - C_1} > 1
\]
Non-Linear Gas Flux Equation

\[ f = \frac{V \left( C_1 - C_0 \right)^2}{At \left( 2 C_1 - C_2 - C_0 \right)} \ln \left[ \frac{C_1 - C_0}{C_2 - C_1} \right] \]

Hutchinson and Mosier (1981)

\( f = \text{flux (mg NH}_3\text{ cm}^2\text{ min}^{-1}) \)
\( V = \text{volume flux chamber (cm}^3\text{)} \)
\( C_x = \text{gas concentration (mg/m}^3\text{)} \)
\( A = \text{floor area covered by flux chamber (cm}^2\text{)} \)
\( t = \text{time (minute)} \)
Hutchinson and Mosier (1981)

Monitoring of Emissions in Pennsylvania Agriculture
Validation of Ammonia Emissions from Dairy Cow Manure Estimated with a Non-Steady State, Recirculation, Flux Chamber with Whole Building Emissions

*Principal Investigators:* V. Blanes-Vidal, P. A. Topper, E.F. Wheeler

- constructed a special test room (2005) with a variable ventilation rate for validation of surface flux chambers.

- Room emission rate is compared with flux chamber flux rates.

- “Steady State” and “non-steady state” chambers tested, focus on non steady state!
Emissions Monitoring Equipment in Use

- Floor description
- Manure depth
- Urine, water, feces, silage presence
- General environment
- Weather, cow activity

Free stall dairy determining ammonia emissions rates from manured floor using 1st generation flux chamber. Two different diets for each group of 60 cows.
Heifer facility, measuring manure with 3rd generation flux chamber, determining ammonia emissions rates. Six different groups of heifers, 3 different diets.
Poultry layer facility, measuring manure with 4th generation flux chamber, determining ammonia and methane emissions rates. Three different diets, six different rows.
Flux Chamber Weaknesses

- Both types of flux chambers disturb the surface (temperature, wind, pressure effects) so errors in reported calculated emission rates can occur.
- Works well for gases generated only from the manure, but since carbon dioxide and methane are both produced directly from the animal, flux chambers underestimate those emissions.
- For non-steady state flux chambers, the gas detector cannot destroy the gas being measured.
Flux Chamber Strengths

- When using the non-steady state chambers, able to record many measurements in one facility (80 flux rate calculations per day)
- Portable, can bring chamber to the barn
- Rapid real time data
- Chambers are relatively low cost, but gas detection instruments can be expensive
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The Pennsylvania State University
Manure as a source?

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Penn State is committed to affirmative action, equal opportunity, and the diversity of its work force.
A look back to June 1996

Biological Manipulation of Manure:
Getting What You Want from Animal Manure

Jeannie A. Leggett, Extension Associate, Department of Agricultural and Biological Engineering
Les E. Lanyon, Associate Professor of Soil Fertility, Department of Agronomy
Robert E. Graves, Professor of Agricultural Engineering

www.abe.psu.edu – select Extension/Fact Sheets
A look back to June 1996

“Manure is a biologically active material, alive with bacteria and other microorganisms that depend on the energy contained in the manure. The use of manure energy by microorganisms—microbial activity—is a natural process of decomposition.”
Flow of non-fuel energy in animal production operations

Figure 1. The flow of non-fuel energy in animal production operations. Arrows denote a transfer of energy.
Look at the manure! (and its associated constituents)

“Manure is an energy-rich feedstuff that is filled with potentially active microorganisms. [or attracts them] These microorganisms will use the energy in manure, causing the manure to change. The challenge of biological manipulation is to manage the environment in which that change takes place in order to produce (or not produce) specific products.”
Today’s Webinar takes a closer look
What might mother nature and her workers being doing in manure?

heat and respiration

byproducts and stable humus
Manure is affected by:

- Animal (age, health…)
- Bedding (type, amount,….)
- Ration
- Storage (type, time)
- Temperature
- ??

- Housing
- Management
- Manure removal system
- Treatment system
- Climate
- Precipitation
- ??
3.77.1 liquid manure (thin slurry): Manure that by its nature, or after being diluted by water, can be pumped easily.

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. 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.

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. ASAE S292.5
Manure Gases – close in emission concern

• 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.
What microbial and physical activities might be occurring?
Drive in Settling Tank?

April 2, 2009  REG Agricultural and Biological Engineering – Penn State
Drive in Settling Tank?
Separated Solids?
Anaerobic Digester?
Composting?
YOUR COWS: a threat to the environment?

We studied the link between dairy farming practices and emissions.

by John Allen

print, but the trend is evident. The figures also show that the range in carbon footprints between the top 25 percent and bottom 25 percent of farms is more than 40 percent. The potential to make even more progress is clearly there!

What affects your carbon footprints?

Lower carbon footprints are closely correlated to high standards of husbandry which produce higher yields per cow and lower culling and replacement rates. This is because of the "fixed cost" of maintaining the rumen which generates the methane. A lower-yielding cow carries a higher maintenance cost per hundredweight of milk in terms of methane, whereas the higher-yielding cow spreads its methane maintenance cost over more pounds of milk. In addition, making efficient use of slurries and manures also lowers the carbon footprint, as well as reducing fertilizer costs and NOx emissions. Husbandry level and fertilizer use accounts for most of the differences we see on farms.

Findings in the pilot studies subsequently have moved onto the entire ASDA/Walmart dedicated supply group of 550 farmers. Participating farmers are sharing their ideas on best practices, are looking at practical ways to improve yields through better husbandry and lower costs, and are working to make better use of manures and slurries. We believe that there is the potential to reduce carbon emissions within the pool by 10 percent within three years. And, because reducing carbon
Your cows: a threat to the environment?

John Allen
Hoard’s Dairyman March 25, 2009

• “Carbon footprint – milk typically 45% CH$_4$, 30% direct CO$_2$, 25% NO$_2$”

• Lower carbon footprints come from better farming practices, and the more efficient, more profitable farms are likely to have a lower carbon footprint than less efficient ones,”
A look back to June 1996

“…Microbial activity can create a wide range of by-products. By storing, handling, or treating manure in various ways, farmers can control the byproducts produced by this activity.”
The End!

Questions?
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](http://www.aec.cas.psu.edu)
- Recordings of this session can also be viewed at the URL listed above.

Eileen Wheeler

Bob Graves

Pat Topper
Next Week on Manure Du Jour

April 9 Program: AIR QUALITY - Air Mitigation Technologies

Featuring

- **Paul Patterson**, PSU Poultry Science
- **Bob Mikesell**, PSU Dairy and Animal Science
- **Ken Kephart**, PSU Dairy and Animal Science

For more information  [www.aec.cas.psu.edu](http://www.aec.cas.psu.edu)