Welcome

A Lunchtime Webinar Series

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

TODAY’S FOCUS: Air Quality – Air Mitigation Strategies

• **Bob Mikesell**, Senior Instructor of Dairy & Animal Science
• **Ken Kephart**, Professor of Dairy & Animal Science
• **Paul Patterson**, Professor of Poultry Science

Hosting  Robb Meinen

Penn State Dairy and Animal Science
Bob Mikesell
PSU Department of Dairy & Animal Science
Pennsylvania Odor Siting Index

Dr. Robert Mikesell
Penn State Department of Dairy and Animal Science
History

• Extension Program initiated in 1999, funded by SCC
• Deliverables
  – Site map
  – Letter
    • Site description
    • Site advantages
    • Site disadvantages
    • Recommendations for improvement
• SCC asked for assistance in Odor Siting Index Development
Index Development Challenges

• Meeting Act 38 requirements
• Limited data availability
• Pennsylvania diversity
  – Landscape
    • Topography
    • Vegetation
  – Livestock
    • Species
    • Size
    • Management
Odor Siting Index

- Based on historical extension program
- Aligned with Act 38 requirements
- Points-based, scaled to P-index basis
- Objectives:
  - Predict potential for community odor impacts
  - Sort sites into groups
    - Low, medium, high impact potential
  - Require odor BMPs depending on group
Mapping

- Locate Proposed Facility
- Draw Property Lines
- Draw concentric circles at 600’ intervals to the evaluation distance (based on AEU’s)
- Mark receptors within the evaluation distance
- Determine if receptors are shielded by topography / vegetation
Three General Index Sections

• Odor Source Factors (+ Index points)
• Site Land Use Factors (- Index points)
• Surrounding Land Use Factors (+ Index points)

• Total of three sections = Final Index Score
• Lower index score = better location
Section 1: Odor Source Factors (+ Index Points)

• Number of Animal Equivalent Units (AEUs) Proposed
  – More AEUs = More odor generation
  – Number of AEUs determines evaluation distance

• Site Livestock History
  – Current animals = Current odors
Section 1: More Odor Source Factors (+ Index Points)

- **Species**
  - Some species more offensive

- **Manure Storage Type**
  - Liquid uncovered manure = Greater potential for odor generation
Section 2: Land Use Factors (- Index Points)

- Ag Security Area
- Zoning
- Farmland Preservation
Section 3: Surrounding Land Use Factors (+ Index Points)

• Other local livestock
  – Current livestock = current odors

• Distance to nearest property line
  – Encourage maximum separation distance
Section 3: More Surrounding Land Use Factors (+ Index Points)

• Number, distance, and direction of neighboring homes
  – Largest factor
  – If no receptors, no community odor impacts
  – Index point value adjusted for intervening topography / vegetation

• Number, distance, and direction of nearby public use facilities
  – Identifies groups of receptors
Number, Distance, and Direction of Neighboring Homes Details

- Prevailing winds
- Distance
Moving the Building Changes the Score

Index = 101

Index = 91
The Index does NOT include

- Application odors
- Visibility factors
- Social factors
Final Odor Score

• <50 – No BMPs Required
• 50-99.9 – Level 1 BMPs
  – Simple
  – Inexpensive
• >100 – Level 2 BMPs
  – Aimed at major odor source
  – Potentially more costly
Thanks – Back to Robb
Best Management Practices for Controlling Odor on Dairy and Swine Operations

Ken Kephart
Pennsylvania State University
BMP’s for Odor Control under PA’s new regulations

- **Level I BMP’s** - include most industry accepted practices.
  - Required when odor index $\geq 50$.
  - All Level I BMP’s appropriate for the species must be implemented.

- **Level II BMP’s** - Additional, specialized practices.
  - Required when odor index $\geq 100$.
  - Level II BMP’s selected by the plan writer and producer and will be specific to the operation.
Level I BMP’s for Swine

- Frequent or continuous manure removal; keep aisles and animals free of manure. Good ventilation is essential.
- High pressure wash between groups, annually for continuous flow
- Minimize feed waste
- Use drop tubes on feeders
- Phase feed
Level I BMP’s for Dairy
(and beef as applicable)

- Add sufficient bedding to prevent manure from sticking to cows.
- Provide at least 100 ft² floor space/cow when using conventional bedding.
- Flush or scrape frequently.
- Manage ventilation to keep cows and surfaces clean and dry.
Universal ventilation concepts

- Natural (wind, warm air rising through roof)
- Mechanical (fans) - more uniform ventilation rate, better control of bldg moisture and odor.
- An ideal ventilation system...
  - Responds to changes in ambient temperature immediately.
  - Provides optimal ventilation rate.
  - Has an effective inlet to distribute fresh air evenly.
- Signs of a poor ventilation system
  - Poor air quality, burning eyes, heavy chest.
  - Damp facility.
  - Filthy animals, coughing.
Level II BMP’s - subject to change

- Aeration of manure storage
- Air scrubbers
- Anaerobic digestion
- Biofiltration
- Composting manure
- Special feed formulation

- Covering manure storages
- Manure pit additives
- Oil sprinkling
- Wind barriers, shelter belts*
- Composted bed pack
The Level II references

- Remember that Level II’s are required when the odor site index > 100.
- Plan writers may use additional sources and information.

*Here are a few take-home messages...*
Aeration - Important Points

- Complete mix aeration provides sufficient power to keep all solids in suspension. Very effective, very expensive.
- Facultative aeration will not keep all solids in suspension. At best, it keeps the surface aerated. This is probably the minimum for effective odor reduction.
- Passive aeration may provide limited odor reduction.
Air scrubbing technologies

Exhaust Air Stream

Dust Filter

Water Nozzles

Electrostatic precipitator

Clean Air Stream
Anaerobic Digestion

- Types
  - Complete mix (3-4% solids)
  - Plug Flow (11-15% solids)
- Converts volatile organic carbon compounds to CH₄ (odor control)
- Energy recovery
Biofiltration

- Effectively removes dust, NH$_3$ and odor
- Relatively expensive
  - Need high performance fans
  - Materials, labor are costly
- Requires frequent maintenance (rodents, weeds)
- Ventilation performance affected (increase backpressure)
- Allow for a roomy air plenum and sufficient retention time (3-5 sec minimum)
Composting Manure

- Reduces odor, moisture, pathogens and weed seeds.
- Requires special equipment and management.
- Add dry material so the final mix has these specs...
  - C:N 20-40 to 1
  - Moisture 40-65%
- Mix frequently to maintain high $O_2$. 
Feed Formulation

- Consider reducing dietary components that contribute to odors
  - Protein - replace with amino acids (lysine, methionine, threonine and maybe tryptophan).
  - Sulfur-containing minerals (e.g. ferrous oxide vs ferrous sulfate)
    - Fe, Zn, Cu, maybe manganese

- Consider adding a source of fiber for swine.
  - Soy hulls, oligosaccharides (reduces odor and NH$_3$ emissions).
Manure Covers

- Permeable
- Straw
- Geotextile
- Impermeable
- Floating HDPE
Manure Pit Additives - generally not too effective. Why not?

- Microbiology of odor generation poorly understood.
- Testing of additives has been based on trial and error.
- The manure pit environment does not enhance the growth of pit additive microbes.
- Probably best success when used with aeration.
**Pitfalls of manure pit additives**

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<td>1.</td>
<td>Ideal growth conditions for pit additive microbes rarely match what is in the pit (temperature and pH often too low).</td>
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<td>2.</td>
<td>After the microbes are added, they will probably not become the dominant strain found in the pit.</td>
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<td>3.</td>
<td>Massive inoculation is possible in laboratory setting, but not under field conditions.</td>
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<td>4.</td>
<td>The microbes may prefer to metabolize compounds that are not the most offensive.</td>
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<td>5.</td>
<td>Treatment bacterial usually prefer an aerobic environment, thus aeration is recommended.</td>
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A mixture of oil and water coats surfaces to reduce volatilization and airborne dust.

The material is usually proprietary; the same company typically provides the hardware.
Bed pack management

- Two types
  - Conventional bedding pack. Use bedding materials like straw and corn fodder (Level I).
  - Composted bed pack (Level II, seldom used in the U.S) - uses small-particle materials like sawdust
Additional management tips...

- For composted bedded pack
  - Sawdust is preferred because of the high C:N ratio and small particle size.
  - Must be stirred 2x/day to keep oxygen in the material.
  - If these techniques are followed, temperatures will reach 130°F, water evaporation is enhanced, weed seeds and microbes can be inactivated, odor can be controlled more effectively.
Summary

- All farms with an Odor Site Index $\geq 50$ required to implement Level I BMP’s.
- All farms with an Odor Site Index $\geq 100$ required to implement Level II BMP’s.
- Selection of Level II BMP’s is at the discretion of the plan writer and farmer, subject to approval by SCC.
- Remember that proper siting of facilities is still our most effective odor reduction strategy.
Manure Du Jour

Poultry Air Quality

Mitigation Technologies

Paul H. Patterson

Department of Poultry Science

Penn State University
Emission Sources

- Manure storage
- Housing
- Dead birds
Strategies Differ Depending on Ammonia, Dust or Odor

- Reduce Generation
- Reduce Emissions
- Enhance Dispersion
Enhance Dispersion

- Setback distances
- Uses site planning and weather dispersion
Enhance Dispersion

- Natural and artificial windbreaks

Natural windbreak

Windbreak wall

From Bud Malone
Windbreak Walls
Reduce Emissions
Dust Management

- Vacuuming
- Regular housecleaning
- Oil & oil-water emulsion spraying reduces:
  - Odor: average 50%
  - Dust: 23-79%
  - NH₃, H₂S: 20, 30%

Graph showing odor units for sample weeks 1 to 5.
Reduce Emissions
Washing Wall Filters

- Reduce emissions
- Reduces dust by 60% at low vent, and 20% at high (Bottcher et al., 1999)
- Similar reductions for ammonia: 50 & 33%
- Big Dutchman *MagixX* wet scrubber
Reduce Emissions
Housing Systems

- Takai et al. (1998) measured airborne dust in poultry/livestock buildings in England, Denmark, Germany & Holland (mg/h/500kg live wt)

- **Inhalable**
  - Cage: 398-872
  - Perch: 1771-4340

- **Respirable**
  - Cage: 24-161
  - Perch: 467-862

- Inhalable & respirable dust conc are higher in winter vs summer.

- Dust in broiler houses was greater than perch or cage houses.

- Inhalable & respirable dust conc greater: Poultry > Pig > Cattle buildings
Reduce Emissions
Housing Systems

- Wathes et al. (1997)
- Endotoxin levels in inspirable fractions
Ammonia Strategies
Housing Systems

- **Groot Koerkamp (1994)**
  - Aviary: 200g NH$_3$/hen/yr
  - Highrise: 50g NH$_3$/hen/yr
  - Belted: 10g if 60% DM in 50hr

- **Ammonia 100 lbs/day**
  - Hens in manure-belted house
    (Liang et al., 2003)
    $3.46 \times 10^{-4} \text{ lbs NH}_3 / \text{bd/d} = 289,172 \text{ hens}$
  - Hens in high-rise house
    (Patterson et al. 1996) $33,000 \text{ hens}
Ammonia & Odor Strategies
Minimize Moisture Contamination

- Fecal moisture (diet)
- Drinker management
- Exogenous water:
  - Ground
  - Surface
  - Rain
Ammonia & Odor Strategies

- Implement rapid drying tech
Dust Management

- Reduce emissions:
  - Electrostatic space charging (swine and poultry)
    - Reduced dust levels (Mitchell et al., 2000; Mitchell et al., 2002)
    - Reduced Se transmission to chicks (Gast et al., 1999)
    - Reduced airborne Se in caged layers (Holt et al., 1999)

- Baumgartner Environics, Ag Solutions
  - www.beiagsolutions.com
  - Bio-Curtain® with (EPI) Electrostatic Particulate Ionization

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Bio-Curtain® with (EPI)
Ammonia & Odor Strategies

Composting

- NH$_3$ emissions during composting can be significant increasing environ load & reducing fertilizer value
- Compost manure or litter to stable end point
Kithome et al. (1999) studied composting amendments for layer manure

- Control lost 47-60% of total manure-N
- 28% Z1 - 16%, 38% Z1 - 44%
  “Coir” mesocarp from coconut- 48%
  20% CaCl₂ - 90%
- Adsorption vs microbial inhibition
Ammonia Strategies
Litter/Manure Amendments

- Utilize manure/litter amendments for N and NH₃ control
- PLT
- Al+Clear
- Gypsum
Reduce Emissions
Vegetative Shelter Belts

- Visual screen for neighbors
- Farm beautification
- Energy conservation
- Snow load
- Flies
- Emissions: NH$_3$, dust, odors, pathogens

From Bud Malone
Plants deposited N in leaves
- Poplar: 4.04 to 10.20%
- Locust: 5.32 to 8.99%
- Grass: 2.86 to 6.36%

Ambient NH₃
↓
Uptake by Water Film of Mesophyl Cell (Stomata)

NH₃ ↔ NH₄⁺ → NH₃

GLUTAMINE

ADP, H₂O, Pᵢ

GLUTAMATE

ATP

NH₄⁺ ↔ NH₃

gln synthetase (GS)

2-oxoglutarate
glu synthase (GOGAT)

2e⁻, 2H⁺ ↔ NAD(P)H, Fd^red

glutamate: amino acids proteins metabolism

(Krupa, 2003)
PSU Pot in Pot

Foliar-PM$_{2.5}$

Foliar-PM$_{10}$
Impact of Trees on Poultry Odor

Poultry Housing Shelterbelt Odor Emissions

Field Olfactometer C/T (LogBETm)

- Bars represent one standard error.
- Without Trees
- With Trees

Observation Location:
1. West
2. Middle
3. East
4. Background
Research Efforts: Odor and Virus Transmission

Kreider Farms
Mt Pleasant

Vegetation buffer:
1. streamco willow, 2. arborvitae
3. hybrid poplar, elm, maple, alder, oak
*Miscanthus floridus*, (Giant silver grass)
Summary

- NH₃, dust, odor are challenges, require site specific strategies for housing, manure storage and dead birds.
- Reducing overall generation of emissions is most effective first step, then reduce emissions.
- For odor, first reduce generation then enhance dispersion.
- Employ more than one strategy “no silver bullet”.
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.
Last Manure Du Jour
Served next week

April 16 Program: AIR QUALITY – Manure Storage, Treatment, and Land Application

Featuring
• Curtis Dell, USDA Agriculture Research Service
• Bob Graves, PSU Agricultural & Biological Engineering
• Pat Topper, PSU Agricultural & Biological Engineering

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