Air Control Technologies for Animal Production Systems

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Potential Air Control Technologies & Best Management Practices

• Best Management Practices (BMP’s)
  – Diet manipulation
  – Good housekeeping
  – Air management plan
  – Sufficient Setback Distance
  – Good Neighbor Policy

• Install Control Technologies
Diet Manipulation
“Good Housekeeping”
Preparing an Odor Management Plan

David Schmidt, Extension Engineer
Larry Jacobson, Extension Engineer
Kevin Janni, Extension Engineer
Department of Biosystems and Agricultural Engineering
Injection of Liquid Manure
Setback Distances
Methods to Determine Setback Distances

• Indirect methods
  – Zoning or land use guidelines
  – empirical formulas

• Direct methods
  – Dispersion Models
Selected Setback Distances from Some States

Table 4. Summary of setback distance ranges in miles for selected US states.

<table>
<thead>
<tr>
<th>State/Province</th>
<th>Setback Distance Range, ft or miles</th>
<th>Setback Distance Range, m or km</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>0.25 to 1.0 miles</td>
<td>0.4 to 1.6 km</td>
<td>Illinois, 2000</td>
</tr>
<tr>
<td>Iowa</td>
<td>750 to 2500 ft</td>
<td>200 to 800 m</td>
<td>Kohl&amp;Lorimor, 97</td>
</tr>
<tr>
<td>Kansas</td>
<td>0.25 to 3.0 miles</td>
<td>0.4 to 5 km</td>
<td>Heber, 1999</td>
</tr>
<tr>
<td>Missouri</td>
<td>1000 to 3000 ft</td>
<td>300 to 900 m</td>
<td>Missouri, 1996</td>
</tr>
<tr>
<td>Nebraska</td>
<td>1000 ft</td>
<td>300 m</td>
<td>Heber, 1999</td>
</tr>
<tr>
<td>North Carolina</td>
<td>500 to 2500 ft</td>
<td>150 to 800 m</td>
<td>North Carolina, 96</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>0.25 to 3.0 miles</td>
<td>0.4 to 5 km</td>
<td>Oklahoma, 1998</td>
</tr>
<tr>
<td>South Dakota</td>
<td>0.25 to 1.5 miles</td>
<td>0.4 to 2.5 km</td>
<td>Heber, 1999</td>
</tr>
</tbody>
</table>
Minimum Distance Separation or MDS-II (Ontario)

- **Distance** = \(A \times B \times C \times D\)
  - **Factor A** = type of animal (0.65 broiler chicken to 1.1 adult mink)
  - **Factor B** = \# of livestock units, LU (from 107 to 1455 for 5 to 10,000 LU)
  - **Factor C** = % > in animals (from 0.7 to 1.14 for 0 - 50% to 700% or new facility)
  - **Factor D** = type of manure system (0.7 for solid and 0.8 for liquid)
OFFSET
Odor From Feedlots Setback Estimation Tool

Larry Jacobson, David Schmidt, and Susan Wood

Introduction
When discussing odor problems related to animal agriculture, the following questions often arise:

• How far does odor travel?
• Are animal numbers or animal species accurate predictors of nuisance odors?
• How much odor control is needed to solve an odor problem from an existing facility?
• Can the odor impact from a new facility be predicted?

Answers to these questions are as varied as the people having the discussion. Until now, scientific methods to predict odor impacts did not exist. This publication discusses a new tool that has been developed at the University of Minnesota to answer some of these questions. The tool, “Odor From Feedlots Setback Estimation Tool” (OFFSET), is the result of four years of extensive data collection and field testing. It is a simple tool designed to help answer the most basic questions about odor impacts from livestock and poultry facilities.

OFFSET is designed to estimate average odor impacts from a variety of animal facilities and manure storages. These estimations are useful for rural land use planners, farmers, or citizens concerned about the odor impact of existing, expanding, or new animal production sites.

The worksheet on the next page (Table 1) outlines a step-by-step process for determining the total odor emissions for a specific animal production site. This worksheet takes into account the strength of the odors and the frequency and duration of the odor events. OFFSET combines odor emission measurements with the average weather conditions to estimate the strength and frequency of odor events at various distances from a given farm.

Figure 1. Prediction of odor problems is important as rural and non-rural areas converge.
MNSET

Minnesota Setback Estimation Tool

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Background

- OFFSET – Odor From Feedlot Setback Estimation Tool – since 2001
- Requirement in EAW (Environmental Assessment Worksheet) for air dispersion modeling to assess hydrogen sulfide impacts.
  - Expensive ($1500-$2500)
  - Similar results with similar sites
Technical Overview

• Three siting parameters predicted
  – **Odor** (using OFFSET model)
  – **Hydrogen Sulfide** at property line to meet regulatory compliance
  – **Ammonia** – lbs emitted per day or per year from the site
Example: Swine Finishing Barn

Airflow from fans (cfm) multiplied by concentration gives emissions in mass per time (e.g. lbs/day or grams/sec)
Building, lot or manure storage emits Gasses. The amount of gas release over time is known as Emissions.

Downwind concentration at any point in time is a function of the emission rate and weather conditions.

Results in Downwind Concentration at some receptor (neighbor or property line)
Flux and dispersion

Building

Flux Rate 10 µg/s/m²  \( (\text{flux rate} \times \text{source area} = \text{Emissions}) \)

Flux Rate 5 µg/s/m²

Concentration 400 ppb

Concentration 200 ppb

Important to have the correct flux rate but currently this data is limited. Additionally, flux data is quite variable – hour by hour, site by site, season by season.
### Flux Examples

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Hydrogen Sulfide Flux rates found in Literature $\mu g/s/m^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hog finishing barn</td>
<td>6.03</td>
</tr>
<tr>
<td>Dairy barn</td>
<td>0.668</td>
</tr>
<tr>
<td>Beef Lot</td>
<td>1.72</td>
</tr>
<tr>
<td>Manure Storage</td>
<td>25.3</td>
</tr>
</tbody>
</table>
Development of MNSET

- Validate Existing Dispersion Model (AERMOD)
  - Field data from a swine farm in Iowa
- Use AERMOD to predict downwind concentrations from several case farms over 5 year period (hourly data)
- Consolidate case farm data into simple predictive tool
- Test predictive tool against existing feedlot evaluations.
Modeling with AERMOD

- EPA dispersion model approved for downwind predictions of H2S.
- Modeled 26 different case farms using 5 years worth of hourly meteorological data
- Used constant flux rate
Conclusion on Validation

• With same flux rates arrived at similar downwind concentrations
• Need to investigate appropriate flux rates

<table>
<thead>
<tr>
<th>Source Type</th>
<th>EAW Flux</th>
<th>MNSET Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>µg/s/m²</td>
<td>µg/s/m²</td>
</tr>
<tr>
<td>Hog finishing</td>
<td>3.35</td>
<td>6.03</td>
</tr>
<tr>
<td>Dairy Barn</td>
<td>0.45</td>
<td>0.668</td>
</tr>
</tbody>
</table>
Daily Loading (lbs/day)

- **Emergency Planning Community Right-to-Know Act is**
  - 100 lbs per day reporting requirement
  - MNSET can be used for this calculation

- **Future requirements for reporting of GHG**
  - Framework of MNSET will allow for this as GHG flux rates become known
Conclusions

• MNSET has been Shelved
• MNSET would work well for barns up to 500,000 square feet.
• MNSET provides ballpark estimates for sites up to 500,000 square feet (source dimensions)
• MNSET could be used to evaluate daily or annual emissions.
• Development of MNSET highlights the need to set standard flux rates for all modeling efforts
Good Neighbor Policy

- Avoid spreading on holidays and weekends
- Avoid high odor activities when wind are in the “wrong” directions
- Try to time high odor activities like spreading during the heating compared to the cooling parts of the day
Classifications of Air Emission Control Technologies

• Increase Dilution or Dispersion of Plume
• Reduce Emission of Gases (Capture and Treat)
• Reducing Generation of Odorous Gases
Shelterbelts for Air Emission Control

- Increase turbulence
- Encourage settling of dust from barns by reducing winds
- Dust and particulates may be caught by trees and shrubs
- Odorous chemicals may be absorbed onto shelterbelt foliage
Windbreak Walls

Tunnel ventilated barn

Dispersion effect

Dust deposition

Wind-break wall
Windbreak Walls

- Windbreak walls deflect exhaust air upward so it mixes with clean air so odors and gases become diluted. Windbreak wall is on the left building.
Chimney or stacks for fans
Reduce Emissions
(Capture and Treat)
**Biofilters**

Mechanically Ventilated Building

- Odorous Air
- Manure Pit
- Air Duct
- Air Plenum
- Treated Air Exhaust
- Biofilter Media
- Media Support

Department Bioproducts and Biosystems Engineering
University of Minnesota
Add Biofilters to Gestation and Farrowing Barns
Effectiveness

<table>
<thead>
<tr>
<th></th>
<th>% reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor threshold</td>
<td>80 - 95%</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>85 - 95%</td>
</tr>
<tr>
<td>Ammonia</td>
<td>50 - 60%</td>
</tr>
</tbody>
</table>

*Effectiveness improves with time and moisture control.*
Permeable Cover (straw)
Permeable Cover (geotextile fabric)
## Effectiveness

% Reductions

<table>
<thead>
<tr>
<th>Cover</th>
<th>Odor</th>
<th>H2S</th>
<th>NH3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural crust</td>
<td>60 - 85</td>
<td>N/A</td>
<td>75 - 90</td>
</tr>
<tr>
<td>Straw</td>
<td>60 - 90</td>
<td>80 - 95</td>
<td>40 - 95</td>
</tr>
<tr>
<td>Geotextile</td>
<td>10 - 60</td>
<td>10 - 70</td>
<td>10 - 25</td>
</tr>
<tr>
<td>Clay balls</td>
<td>60 - 90</td>
<td>80 - 90</td>
<td>N/A</td>
</tr>
</tbody>
</table>

N/A - Not available
Impermeable Cover

- Capture nearly all lagoon odors
- Reduce Gas Volatilization
- Should treat captured air emissions
Vegetable Oil Sprinkling

- Gases and odor attach to dust particles.
- Oil spray will reduce dust formation and emissions
Automated Oil Sprinkling

Oil injection pump, solenoid value, & timer

Distribute oil through “soaker” distribution system
Effectiveness

- Odor, NH3, & H2S reductions of 10-30%
- Good dust reduction – 50 to 70%
- Oil sprinkling may offer some odor reduction in a naturally ventilated curtain sided pig finishing barn.
Ozonation

- Ozone is generated outside the barn

• Human health hazard ??

• Limited positive research results

...and distributed with ventilation air
Chemical Addition
Alternative Housing Systems
## Results - NH$_3$ in Summer

<table>
<thead>
<tr>
<th>Barn</th>
<th>Conc. (sd) ppm</th>
<th>Emissions (sd) mg/s/pig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep-Bedded Hoop</td>
<td>5.9 (6.0)</td>
<td>0.43 (0.45)</td>
</tr>
<tr>
<td>Curtain-Sided Slatted</td>
<td>5.1 (2.9)</td>
<td>0.06 (0.06)</td>
</tr>
</tbody>
</table>
### Results - NH$_3$ in Winter

<table>
<thead>
<tr>
<th>Barn</th>
<th>Conc. (sd) ppm</th>
<th>Emissions (sd) mg/s/pig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep-Bedded Hoop</td>
<td>9.3 (5.0)</td>
<td>0.39 (0.2)</td>
</tr>
<tr>
<td>Curtain-Sided Slatted</td>
<td>8.5 (3.1)</td>
<td>0.02 (0.01)</td>
</tr>
</tbody>
</table>

Questions?

• www.bbe.umn.edu