Air Control Technologies for Animal Production Systems

Larry D. Jacobson, Prof. & Ext Engineer
University of Minnesota

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

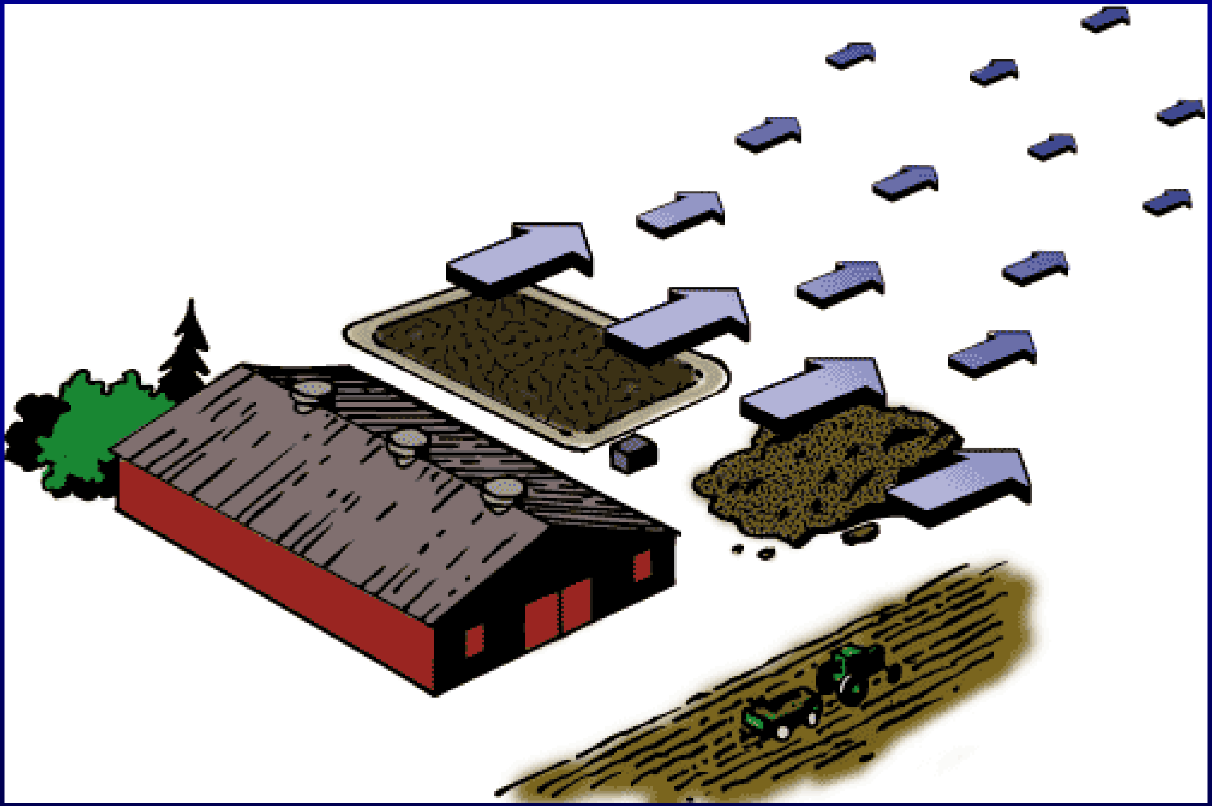
Diet Manipulation

“Good Housekeeping”

FO-07637 2001

Preparing an Odor Management Plan

David Schmidt, Extension Engineer
Larry Jacobson, Extension Engineer
Kevin Janni, Extension Engineer
Department of Biosystems and Agricultural Engineering



Department Bioproducts and Biosystems Engineering
University of Minnesota

Injection of Liquid Manure

Setback Distances

Department Bioproducts and Biosystems Engineering
University of Minnesota

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.

State/Province	Setback Distance Range, ft or miles	Setback Distance Range, m or km	References
Illinois	0.25 to 1.0 miles	0.4 to 1.6 km	Illinois, 2000
Iowa	750 to 2500 ft	200 to 800 m	Kohl&Lorimor, 97
Kansas	0.25 to 3.0 miles	0.4 to 5 km	Heber, 1999
Missouri	1000 to 3000 ft	300 to 900 m	Missouri, 1996
Nebraska	1000 ft	300 m	Heber, 1999
North Carolina	500 to 2500 ft	150 to 800 m	North Carolina, 96
Oklahoma	0.25 to 3.0 miles	0.4 to 5 km	Oklahoma, 1998
South Dakota	0.25 to 1.5 miles	0.4 to 2.5 km	Heber, 1999

Minimum Distance Separation or MDS-II (Ontario)

- Distance = A*B*C*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.

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

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.

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

Department Bioproducts and Biosystems Engineering
University of Minnesota

MNSET

Minnesota Setback Estimation Tool

David Schmidt

Larry Jacobson

Department of Bioproducts and Biosystems Engineering

Background

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

Technical Overview

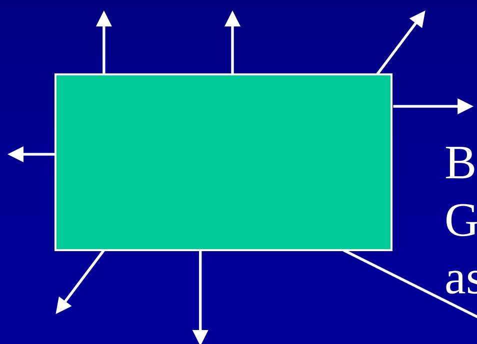
- Three siting parameters predicted
  - **Odor** (using OFFSET model)
  - **Hydrogen Sulfide** at property line to meet regulatory compliance
  - **Ammonia** – lbs emitted per day or per year from the site

Example: Swine Finishing Barn

Airflow from fans (cfm) multiplied by concentration gives **emissions** in mass per time (e.g. lbs/day or grams/sec)

Department Bioproducts and Biosystems Engineering
University of Minnesota

Technical Parameters

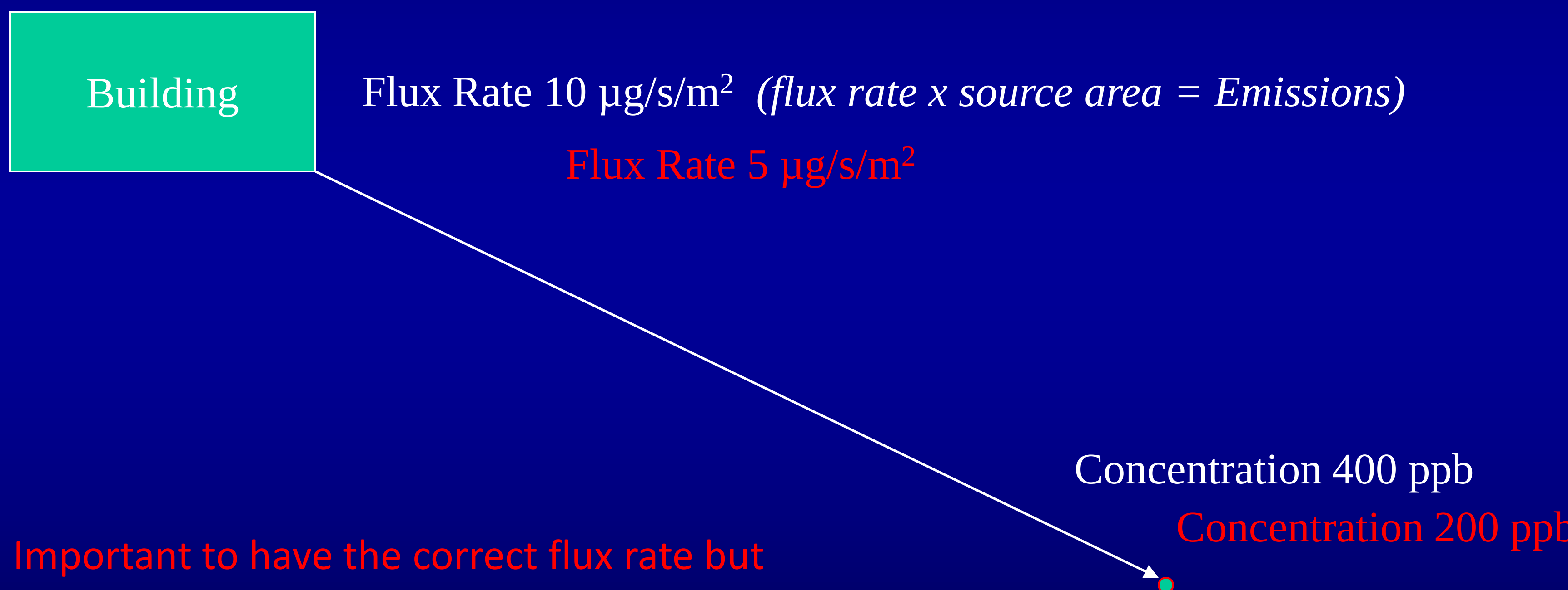


Building, lot or manure storage emits Gasses. The amount of gas release over time is known as Emissions.

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

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

Flux and dispersion



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

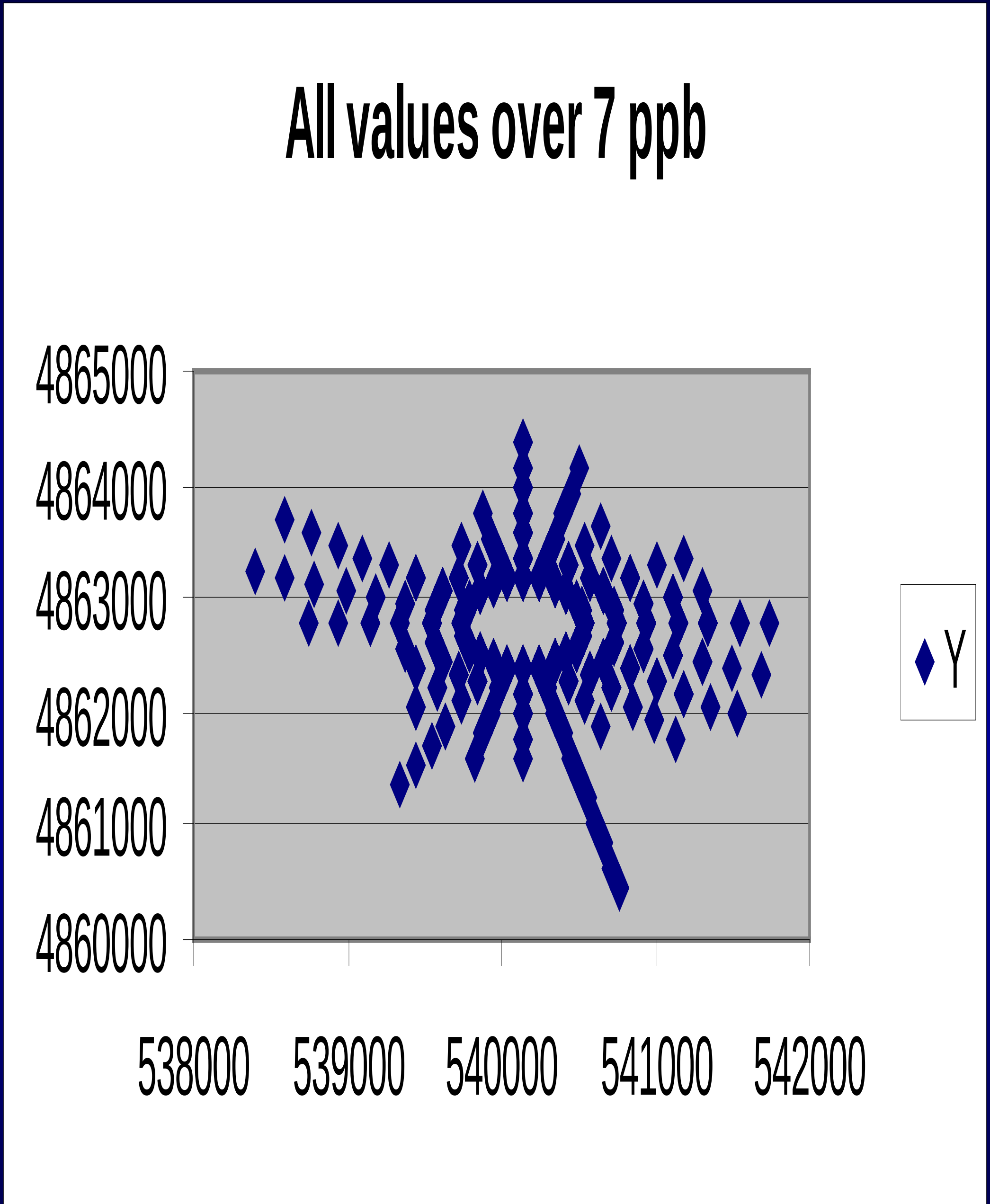
Source Type	Hydrogen Sulfide Flux rates found in Literature µg/s/m2
Hog finishing barn	6.03
Dairy barn	0.668
Beef Lot	1.72
Manure Storage	25.3

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


All values over 7 ppb
4865000
4864000
4863000
4862000
4861000
4860000
538000
539000
540000
541000
542000
Y

Conclusion on Validation

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

Source Type	EAW Flux µg/s/m2	MNSET Flux µg/s/m2
Hog finishing	3.35	6.03
Dairy Barn	0.45	0.668

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**

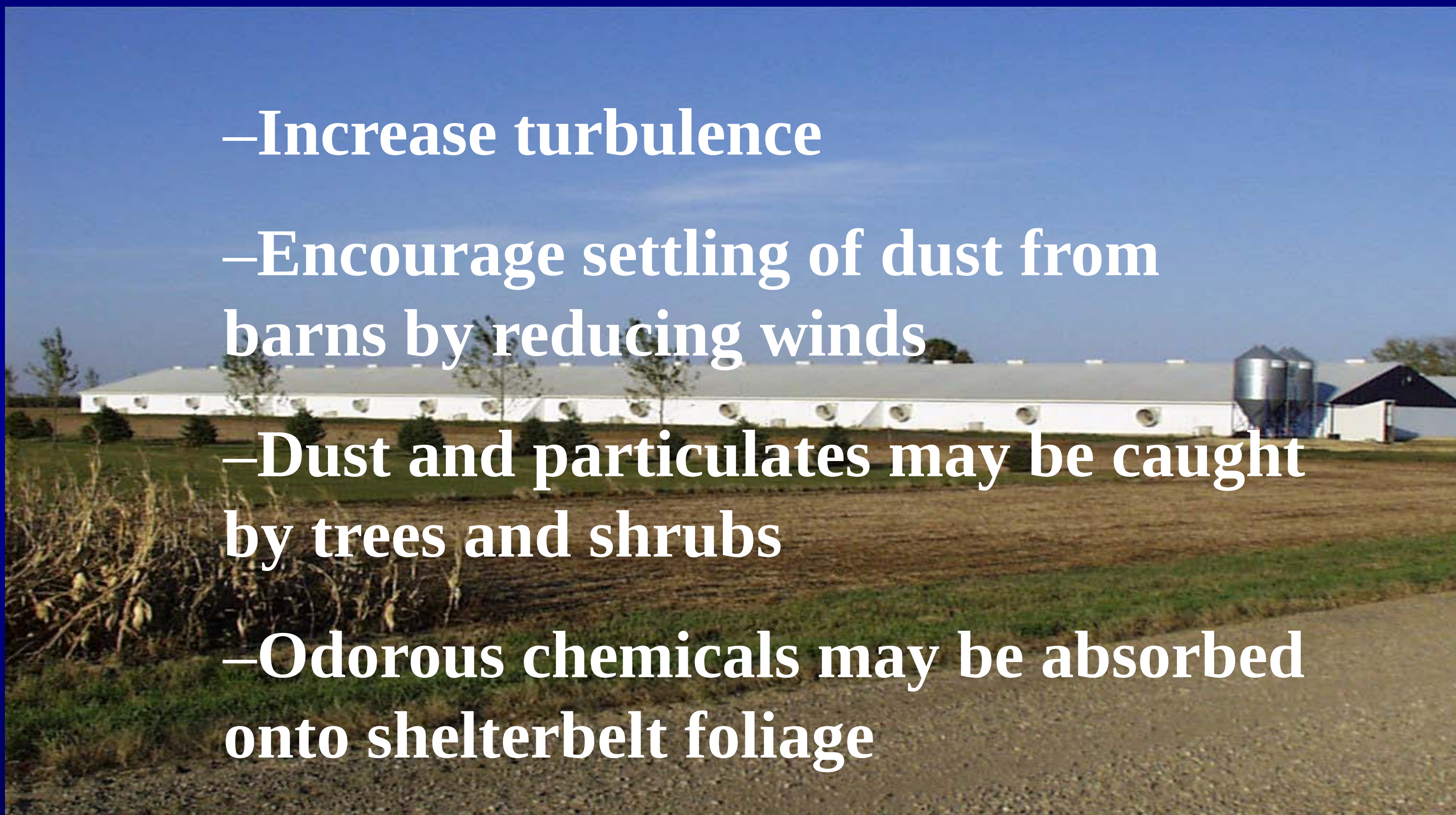
Good Neighbor Policy

- 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



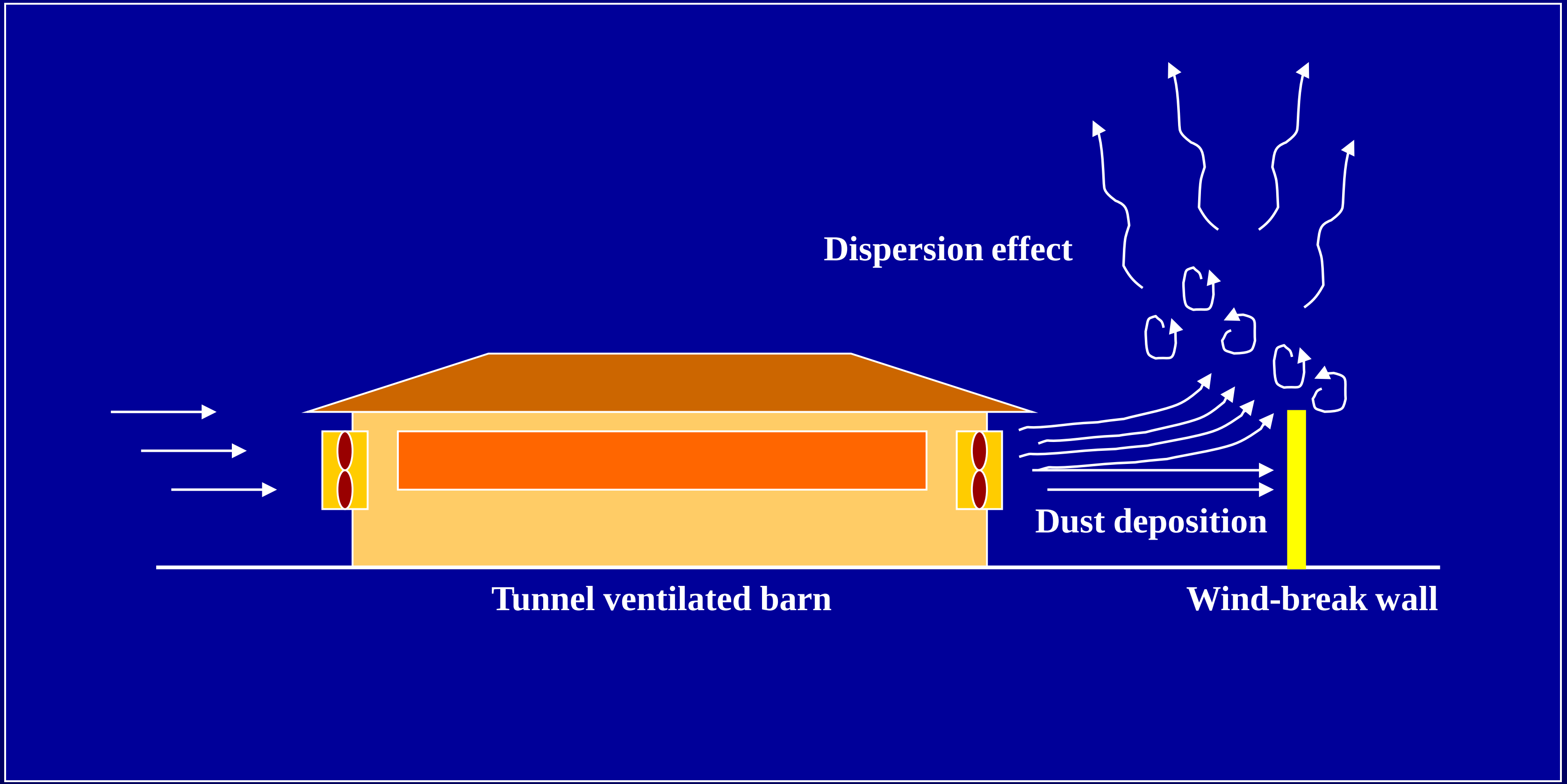
– Increase turbulence

– 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



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.

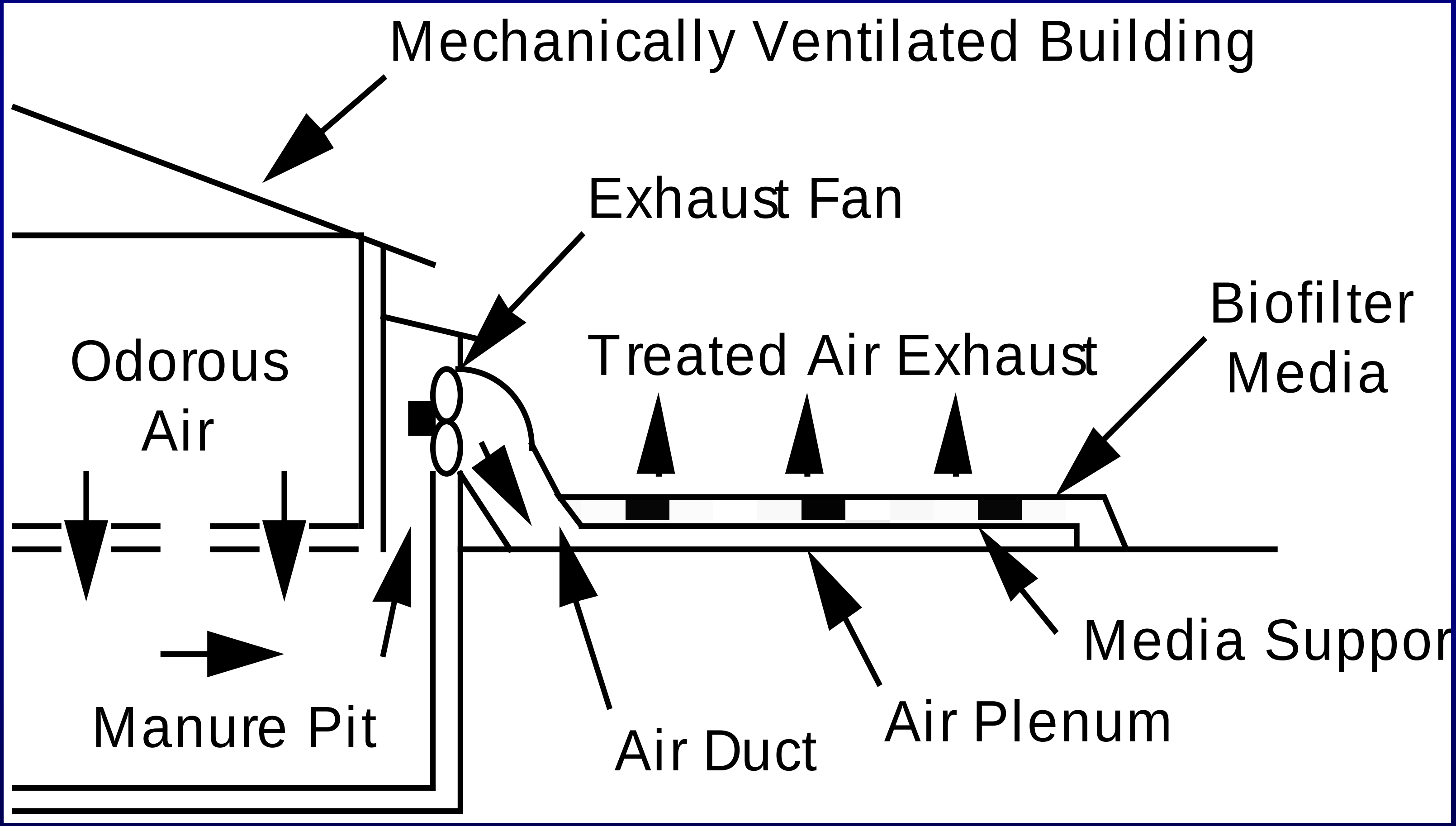
Chimney or stacks for fans

Department Bioproducts and Biosystems Engineering
University of Minnesota

Reduce Emissions
(Capture and Treat)

Department Bioproducts and Biosystems Engineering
University of Minnesota

Biofilters



Mechanically Ventilated Building
Exhaust Fan
Biofilter
Media
Odorous
Air
Treated Air Exhaust
Media Suppor
Manure Pit
Air Duct
Air Plenum

Department

Add Biofilters to Gestation and Farrowing Barns

Effectiveness

	% reduction
Odor threshold	80 - 95%
Hydrogen sulfide	85 - 95%
Ammonia	50 - 60%

Effectiveness improves with time and moisture control.

Permeable Cover (straw)

Permeable Cover (geotextile fabric)

Department Bioproducts and Biosystems Engineering
University of Minnesota

Effectiveness

% Reductions

Cover	*Odor*	*H2S*	*NH3*
Natural crust	60 - 85	N/A	75 - 90
Straw	60 - 90	80 - 95	40 - 95
Geotextile	10 - 60	10 - 70	10 - 25
Clay balls	60 - 90	80 - 90	N/A

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, NH_3, & H_2S 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

Department Bioproducts and Biosystems Engineering
University of Minnesota

Chemical Addition

Alternative Housing Systems

Results - NH_3 in Summer

Barn	Conc. (sd) ppm	Emissions (sd) mg/s/pig
Deep-Bedded Hoop	**5.9 (6.0)**	**0.43 (0.45)**
Curtain-Sided Slatted	**5.1 (2.9)**	**0.06 (0.06)**

Results - NH_3 in Winter

Barn	Conc. (sd) ppm	Emissions (sd) mg/s/pig
Deep-Bedded Hoop	9.3 (5.0)	0.39 (0.2)
Curtain-Sided Slatted	8.5 (3.1)	0.02 (0.01)

Questions?

- **www.bbe.umn.edu**

Department Bioproducts and Biosystems Engineering
University of Minnesota