

NC STATE UNIVERSITY




## Livestock Barn Exhaust Air Treatment

Sanjay Shah  
21 April 2023  
LPELC Webinar Series

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### Outline

1. Background
2. EPA National Air Emissions Monitoring Study
3. Exhaust air treatment in the European Union
4. Current exhaust treatment options in the US

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### Background

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### Emission Impacts

- Poultry & swine farms important sources of ammonia (NH<sub>3</sub>) & other odorous gases
- NH<sub>3</sub> impacts: environmental quality, haze, & health (fine dust precursor)
- Odor combination of NH<sub>3</sub>, hydrogen sulfide (swine only) & other organic gases
- Dust emissions generally minor
- **Dust transports odorous gases & microbes**
- 1 in<sup>3</sup> of dust has more odorous gases than 1 in<sup>3</sup> of poultry house air
- **Reduce dust emissions to reduce odor**

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### Emission Impacts

- Several odor lawsuits & judgments in NC against Smithfield Foods (swine integrator)
- Anecdotal evidence of more poultry odor complaints than swine
- States and localities could regulate odor
- Risk of poultry odor lawsuits

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### Stages of Pollution Mitigation

1. Pre-excretion (modify diet), e.g., less crude protein to reduce ammonia excretion
2. Pre-release (reduce waste emissions), e.g., acidifier in litter to control ammonia
3. Pre-emission (treat house air), e.g., electrostatic precipitation to reduce dust levels
4. **Post-emission - exhaust air treatment**

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EPA - National Air Emissions Monitoring Study (NAEMS)

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EPA - NAEMS

- EPA has not used authority to regulate livestock farm emissions under Clean Air Act
- 2002: EPA advised to calculate confined livestock farm emissions
- 2005: Under Air Compliance Agreement, EPA used NAEMS to monitor emissions
- All draft emission models released for public comment
- Mid-2023: Undergoing stakeholder review
- Late-2023: All models finalized

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EPA –NAEMS

- EPA to develop web-based tool for producers to determine their annual & daily emissions using weather data (from ZIP code), # & size of animals
- **Unclear what EPA will do**
- See EPA-NAEMS detailed info at: (<https://www.epa.gov/afos-air/national-air-emissions-monitoring-study#naems-status>)

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## Exhaust Air Treatment in the European Union (EU)

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- ### EU Exhaust Air Treatment
- EU Common Ag. Policy (2023-27) incentivizes ag air quality
  - Regulations & incentives may vary with country
    - In Netherlands, producer must accept odor limit before starting production
  - Exhaust air treatment feasible because many barns have exhaust plenums

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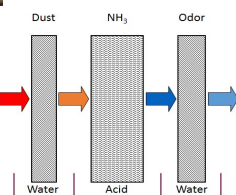
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### Scrubbers

- Dust, ammonia, & odor removed sequentially
- Removal higher than 75%
- One or two stage systems also used
- \$\$\$



Scrubber in livestock barn



Scrubber principle  
(Courtesy: N Ogink, NL)

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### Chimneys

- Chimneys used for dilution
- Reduce odor in vicinity
- \$2,500 for 7,500 cfm unit
- More feasible at lower ventilation rates
- Hurricanes, tornadoes?
- \$\$



Big Dutchman chimneys on organic chicken farm

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### Chimney-Scrubber Combo

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Courtesy: Big Dutchman

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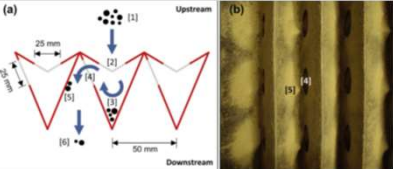
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### Dust Filter

- Dust filter upstream of fans removed up to 55% dust
- 0.12 in. pressure drop
- Clean every 4-8 weeks
- \$\$



Big Dutchman dust filter being cleaned



Dust filter (Stuffnix™) close-up  
(Courtesy: Winkel et al., 2015)

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## Current Exhaust Treatment Options in the US

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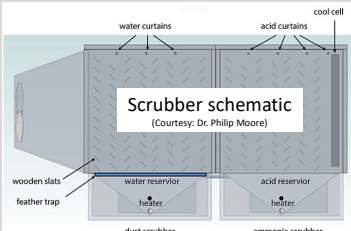
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### Ammonia Scrubber

- USDA-ARS design: Acid solution or water flowing down inclined slats trap ammonia or dust
- 36-in fan pressure drop of 0.12 in, 6000 cfm
- 75% ammonia removal @ 6000 cfm
- \$\$\$



USDA-ARS ammonia & dust scrubber (36-in fan)  
(Courtesy: Dr. Philip Moore)



Scrubber schematic  
(Courtesy: Dr. Philip Moore)

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### Electrostatic Precipitation

- High DC voltage charges dust in air
- Charged dust settles on grounded surface reducing dust, gas, & microbial levels
- Improve indoor air quality or reduce emissions
- Dust & odor emissions reduced by 50 & 30%
- Low power consumption
- \$-\$\$



Charging electrodes mounted on fans, dust accumulates on porous fence (Courtesy: EPI Air)

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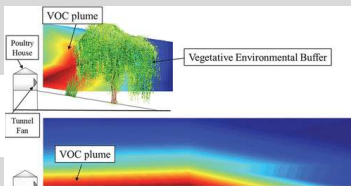
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### Vegetative Environmental Buffers (VEBs)

- Dust resistant shrubs & trees in front of fans
- VEBs trap dust, disperse pollutants, & screen emission sources

Modeled odorous gas plume interaction with VEB  
(Courtesy: Yao et al., 2018)

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### VEBs

- Reduce dust emissions by 50%, also odor
- Performance varies & depends on environmental conditions
- Minor impact on fan performance if designed well
- Requires establishment time & maintenance
- Federally approved for NRCS cost-share
- \$

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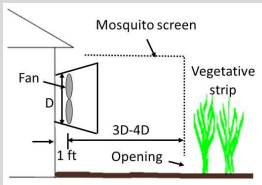
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### Windbreak Wall – Vegetative Filter Strip System

- Lumber frame & mosquito screen cover fans
- Dilution & trapping
- Bigger system for poultry than pigs due to more dust & down
- Low pressure (~0.05 in. WC)
- Federally approved for NRCS cost-share
- \$



System schematic

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### Windbreak Wall – Vegetative Filter Strip System

- Switchgrass requires annual planting but benefits not quantified
- Swine system cleans readily with rain but not poultry



Swine house system  
(~50,000 cfm), built Jul. 2016



Broiler house system (~100,000 cfm, pressure 0.045 in.), built Jun. 2021

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### Windbreak Wall Odor Measurement

- Compared odor in front of Test (wall-covered) & Control (uncovered) fans
- Measured odor as dilution to threshold (D/T) with Nasal Ranger 20 ft from fan
  - Example: D/T of 60 = 60 parts carbon filtered air to 1 part dirty
  - Panelist detects odor, report D/T
  - Else reduce D/T to 30 until odor detected
- Average of 4 panelists' scores reported
- Reduction (%) =  $\frac{Test \frac{D}{T} - Control \frac{D}{T}}{Control \frac{D}{T}} * 100$

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### Windbreak Wall Odor Results

<u>Swine house</u>	<u>Broiler house</u>
▪ 8 events	▪ 9 events
▪ Little to no Switchgrass	▪ No Switchgrass
▪ <b>Reduction ± SD = 58±21%</b>	▪ <b>Reduction±SD = 31±55%</b>
▪ Effective	▪ Less effective due to more dust on screen
	▪ Strong odor on windbreak wall when wind perpendicular to fan

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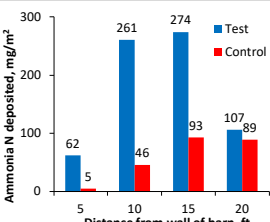
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### Broiler Farm Ammonia Trapping

- Petri dishes with acid placed 5, 10, 15, & 20 ft in front of system fan & control fan on ground for 1 hour
- 5, 10, & 15 ft inside system
- More ammonia trapped by system = less ammonia emitted
- Similar results on swine farm
- Ammonia in soil converted to nitrate but need longer term fix



Distance from wall of barn, ft	Test (mg/m²)	Control (mg/m²)
5	62	5
10	261	46
15	274	93
20	107	89

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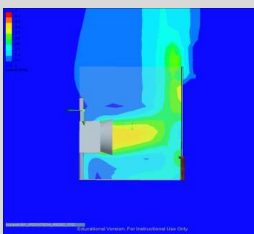
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### Broiler House Tarp Windbreak Wall

- Dilution & dust trapping
- Tarp 3 fan diameters from house
- 27 ft wide, 11.5 ft high
- Five 48-in fans (~100,000 cfm)
- Top 4 ft lowers under high winds
- **Stay tuned for results!**

Modeled velocity distribution

Tarp windbreak wall at broiler farm erected 19 April 2023

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### Closing Points

- Producers should plan for contingencies (regulation, litigation)
- Consider indoor air treatment first, then exhaust air treatment
- Some exhaust treatment systems compatible w/US barns & relatively affordable
- NRCS cost-share will help

Questions?  
 Sanjay Shah  
 BAE Dept., NC State University  
[sanjay\\_shah@ncsu.edu](mailto:sanjay_shah@ncsu.edu), 919-515-6753

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