**Air Pollutants of Concern**

- **Ammonia (NH₃)**
  - Superfund and related federal legislation
  - Precursor to secondary fine particles
  - Health implications as co-pollutant with PM
- **Odor**
  - Not the same thing as NH₃, H₂S etc.
  - Regulated at municipal/county levels or by nuisance provisions
- **Particulate Matter (dust)**

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**TCEQ, Dairies and Air Quality**

30 TAC §321.43

- All AFOs must obtain air quality authorization in one of three ways:
  - **Permit by rule** under 30 TAC §106 (F)
  - **Individual permit** under 30 TAC §116
  - **Air standard permit** under 30 TAC §116.615 and 30 TAC §321.43

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**State Emission Limitations**

- AFOs must prevent *nuisance* conditions
- Must identify and abate any nuisance condition
- Buffer distance options:
  - ½ - mile buffer
  - ¾ - mile buffer
  - Odor control plan
  - Written consent from neighbors w/in minimum buffer distances

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**Odor Control Plan**

**Minimum Provisions**

- Manure collection and storage
- Land application procedures
- Dead animal handling
- Dust control
- Additional, site-specific provisions as required by TCEQ Executive Director
Airborne Nitrogen Emissions

Forms of Atmospheric Nitrogen

- $N_2$
- $NO_x$
- $NH_3$
- $N_2O$
- $NO$

Open-Lot Systems

- **Beef feedyards**
  - Animal spacing 75-250 ft/hd
  - Excreted N 90% of N consumed in feed (Bierman et al., 1996)

- **Open-lot dairies**
  - Animal spacing 200-400+ ft/hd
  - Excreted N 70% of N consumed in feed (Van Horn et al., 1996)

Fate of Excreted N in Open-Lot Systems

- Collected in solid manure
- Spread
- Stored (stockpiles, mounds, other)
- Composted and spread
- Remains on corral surface
  - Stable if it remains dry
  - Runs off into holding pond
- Volatilized as $NH_3(g)$ directly
  - Increases with wet/dry cycling

$NH_3$ – What’s the Big Deal?

- Superfund/EPCRA – Federal litigation on broad CAFO front
  - Multiple species
  - Multiple states
  - Do the math
- $NH_3 + (SO_4, NO_3, or Cl) \rightarrow PM$
- $NH_3 + PM \rightarrow$ synergistic effect on animal pulmonary health
  - No effect on human health?

Aggregate N Efficiency (%)
Almost, But Not Quite

- Oct. 25, 2005 – Senate conferees report agricultural appropriations bill with CERCLA/EPCRA exemption for animal feeding operations
- Exemption rider inserted by Larry Craig (R-ID) and Sam Brownback (R-KS)
- Oct. 27, 2005 – Final conference report does *NOT* contain Craig/Brownback rider

N Losses – Lagoons

- Significant nitrogen volatilization (40%-60% of excreted) is due to large surface area, long-term storage, and biological activity
- Manure may lose 15%-20% of its nitrogen before reaching the lagoon
- About 10% of the excreted nitrogen may accumulate in the sludge layer and is not available unless agitated
- The nitrogen available in a lagoon system may be only 10%-30% of the nitrogen excreted

NH₃ Loss: Open Lots vs. Ponds

- Open lots
  - Large area source, 2-9 acres per 1,000 head capacity
  - Variable emissions driven by wet/dry cycles, short-term temperature fluctuations
- Lagoons and holding ponds
  - Smaller area source, 1-10 acres total
  - Seasonal temperature fluctuations
  - Continuous releases; f(temp, wind speed, RH)
Source-Resolved NH$_3$ Emissions

- **CAAQES Faculty Investigators**
  - Dr. Saqib Mukhtar, PI
  - Drs. R. Lacey, C. B. Parnell, Jr., B. Shaw
- **Location**
  - Hybrid free-stall/open-lot dairy
  - Capacity >1,000 hd
  - Central Texas

Why Source-Resolved?

- Substantial variation among dairy production systems, ancillary operations
  - Free-stall barns vs. open lots
  - Ration, breed, milk yield
  - Lagoons, holding ponds
  - Composting and manure-storage areas
  - Bedding materials
  - Climatic factors
  - Management factors
- Appropriate regulation of a given source requires emission estimates that reflect actual production system, not “typical” or “model” farm


Flux Chamber Sampling Approach

- Direct, real-time measurement of emission rate
- Requires multiple sampling points to characterize a spatially variable source
- Portable, flexible, automated, versatile
- Not perfect
  - Chambers well known to modify the microclimate
  - Emission flux strongly dependent on sweep-air Q

Why Source-Resolved?

“Use of process-based modeling will help provide scientifically sound estimates of air emissions from AFOs for use in regulatory and management programs.”
**Data Summary – Emission Rates (kg/day)**

<table>
<thead>
<tr>
<th>Location</th>
<th>Area (m²)</th>
<th>NH₃ Jan 03</th>
<th>NH₃ June 03</th>
<th>ILS June 03</th>
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<tr>
<td>Compost</td>
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<tr>
<td>Correct</td>
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</tr>
</tbody>
</table>

**Distilled Findings**

- Nearly all emission rates are seasonal (main effect: temperature)
- Drier summertime open-lot surface emits less NH₃ than damp wintertime surface?
- Measured emission rates are a reasonable fraction of total N intake