Air Quality 101: Open-Lot AFOs

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Outline

- Particulate Matter (PM)
  - Total Suspended Particulate (TSP)
  - Inhalable PM (PM$_{10}$)
  - Respirable PM (PM$_{2.5}$)
  - Coarse PM (PM$_{10-2.5}$)
- Visibility
- Ammonia (NH$_3$)
- Odors
**Particle Size Distributions**

Manufactured Dust, Bushland, TX

- **TSP**
- **PM$_{10-2.5}$**
- **PM$_{2.5}$**

**Cumulative % ≤PD**

<table>
<thead>
<tr>
<th>Sample #1</th>
<th>Sample #2</th>
<th>Sample #3</th>
<th>Median</th>
<th>Average (n=3)</th>
</tr>
</thead>
</table>

**Aerodynamic Diameter (µ)**

- 1
- 10
- 100
Open-Lot Emissions Mechanisms and Principles of Control
Dust Emissions Result from the Interaction of:

- Dry manure
- Poor compaction
- Hoof shear

Driver #1: Surface Manure Depth

- Thin & Well Compacted
Driver #2: Cattle Behavior

Dust Generating Behaviors
(agonistic behavior, bulling and locomotion)
Driver #3: Corral Surface Moisture
Raising moisture content of corral surface material by 10% requires 6-9 gal/hd per 1” depth

**Example.** Raise moisture from 10% to 35% in a 2” layer of loose manure = \(7.5 \times 2.5 \times 2 = 39\) gal/hd

*Equivalent 24-hr continuous pumping rate:*

26.0 gpm per 1,000 hd

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**Case Studies:**

Fall 2000 & 2005
Monthly Precipitation
Bushland, TX, 2000

Month of Year 2000

Monthly Precipitation (in)
Cumulative Rainfall By Month
Bushland, TX, 2000

Cumulative Rainfall (in)

Month of Year 2000

Actual
Average

Monthly Pan Evaporation
Bushland, TX, 2000

Pan Evaporation (in)

Actual
Average
WHAT WE’RE SEEING THIS YEAR IN THE PANHANDLE

- Last meaningful rainfall was around 9/1/05
- Some feedyards rolled the dice:
  - Winterized sprinkler systems in September in anticipation of the October freeze (SOP)
  - Built wintertime mounds using what they had available: *dry, uncompacted manure*
  - Banked on some timely rainfall to ensure compaction
  - *Didn’t get it*
  - *September diesel fuel ($$$) and labor costs ($$$) were wasted*
Dust Control Options:

- Manure Harvesting
- Increased Compaction
- Supplemental Moisture
- Altered Cattle Activity
Why Manure Harvesting Makes Water Go Further in Dust Control

Uncompacted manure

Water penetration
Supplemental water
**Take-Home Messages**

- Applying water to an open-lot surface, either passively or actively, is not a cure-all.
- Frequent manure harvesting (>1 per turn) will decrease water requirements and increase water effectiveness.
- Use the off-season to get ready.
- Prioritize within the yard *and* the corral.

**Determination of Feedlot Surface Evaporation Using Weighing Lysimeters**
A Few Truisms

- Manure harvesting and moisture control will have a synergistic effect
- Building mounds with dry manure doesn’t work; needs 25-30% moisture for compaction
- Manure harvesting makes supplemental water go further (Auvermann, 2003; Maghirang et al., 2005)
**Integrated Corral Management (ICM)**

- Integrates environmental protection into the day-to-day operations of a cattle feedyard
- Puts practical information technologies into the hands of the employees best suited to collect economically and environmentally significant data at the corral level
  - Global positioning systems (Bluetooth/GPS)
  - Radio-frequency identification (RFID)
  - Wireless broadband (Wi-Fi/802.11)
  - Digital photography
  - Personal digital assistant (PDA) hardware platform

**Practical Applications of ICM**

- Photograph corral-surface conditions of concern
- Real-time tracking of pen riders
- Rapid cattle ID
  - Removal of mortalities
  - Treatment of sick cattle
- Sprinkler system overrides (leaks, poor performance, special conditions)
- Pipeline to feedyard database
Visibility

View S to Crestone Peak (14,294’)
From Challenger Point (14,081’)
Distance: <0.5 mi
Sangre de Cristo Range, CO

SW Colorado Wildfires, June 2002
PM_{2.5} > 75\% of airborne PM
Rayleigh (Molecular) Scattering

\[ I_R(x) = \frac{kI_0}{x^2} e^{-\alpha_R x}; \lim_{x \to 0} \alpha_R = 0 \]

\[ I_T(x) = \frac{kI_0}{x^2} e^{-\alpha_T x}; \alpha_T = f(C_{PM}, C_{gas}, ...) \]

Molecular and Particle Extinction

Extinction Efficiencies for Ubiquitous Particle Types (Malm, 1999)

<table>
<thead>
<tr>
<th>Particle Type</th>
<th>Dry Extinction Efficiency (m²/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfates</td>
<td>3.0</td>
</tr>
<tr>
<td>Organics</td>
<td>3.0</td>
</tr>
<tr>
<td>Elemental Carbon</td>
<td>10.0</td>
</tr>
<tr>
<td>Nitrates</td>
<td>3.0</td>
</tr>
<tr>
<td>Soil Dust</td>
<td>1.25</td>
</tr>
<tr>
<td>Coarse Particles</td>
<td>0.6</td>
</tr>
<tr>
<td>Feedyard Dust</td>
<td>???</td>
</tr>
</tbody>
</table>
Downwind Extinction Coefficient, Feedyard C
April 23, 2004