Environmental Air Quality

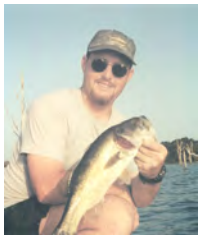
Monitoring Methods in Agricultural Settings

The Posse

Acknowledgments

Kevin Heflin, M. S.

- Water quality
- Manure combustion
- Carcass composting
- *Micropterus salmoides*



Gary Marek, (soon-to-be) M. S.

- Feedyard evaporation
- Instrumentation
- *Odocoileus virginianus*

Jack Bush, M. S.

- Feedyard dust control
- Ambient $PM_{2.5}$ monitoring
- *Ursus arctos horribilis*

Billy Chaffin, B. S.

- Mechanical engineering
- Biomass energy
- Mechanics of dust emissions
- Ongoing study of the aerodynamics of the common *Horseshoe*

	Nuisance-Neighbor	Nuisance-Community	Current Regs	Anticipated Regs
PM	☑	☑	☑	⊗
Odor	☑	☑	⊗	☑
NH_3	⊗	⊗	⊗	☑
H_2S	⊗	⊗	⊗	☑
VOCs	⊗	⊗	⊗	☑
GHGs	⊗	⊗	⊗	☑

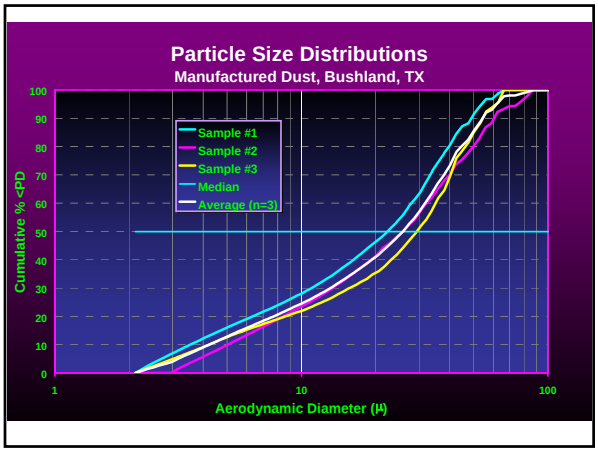
	First Impressions	Environmental Justice	Nutrient Efficiency
PM	☑	☑	☑
Odor	☑	☑	☑
NH_3	⊗	☑	☑
H_2S	⊗	☑	⊗
VOCs	⊗	☑	⊗
GHGs	⊗	⊗	☑

This PM factor is intended to include viable bioaerosols, endotoxin etc.

	Health-Human	Health-Occupational	Health-Animal	Visibility/ Liability
PM	☑	☑	☑	☑
Odor	☑	⊗	⊗	⊗
NH_3	☑	☑	☑	⊗
H_2S	☑	☑	☑	⊗
VOCs	☑	☑	⊗	⊗
GHGs	⊗	⊗	⊗	⊗

Regulatory Environment

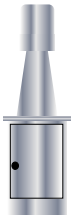
- Federal Clean Air Act
  - Title V (major source emissions fees)
  - National Ambient Air Quality Standards (NAAQS) for "criteria pollutants," including PM, CO, Pb, NO_x, SO_x, O_3
    - ☞"PM" includes 2 fractions: PM_{10} and $PM_{2.5}$
    - ☞Chronic and acute standards
- State-specific air-quality regulations
- Nuisance litigation & case law
- Local ordinances



PM_{10} and $PM_{2.5}$

- Refer to "aerodynamic equivalent diameter," not physical dimension
- PM_{10} – generally, "inhalable" PM
- $PM_{2.5}$ – "respirable" PM

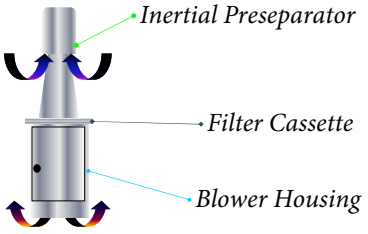
Anatomy of an FRM Sampler for PM_{10}



Principles of Operation

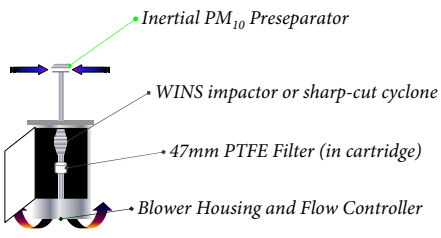
1. Move air at a specified rate
2. Remove the "boulders"
3. Capture what's left and weigh it
4. FRM standard: *performance*

Anatomy of an FRM Sampler for PM_{10}

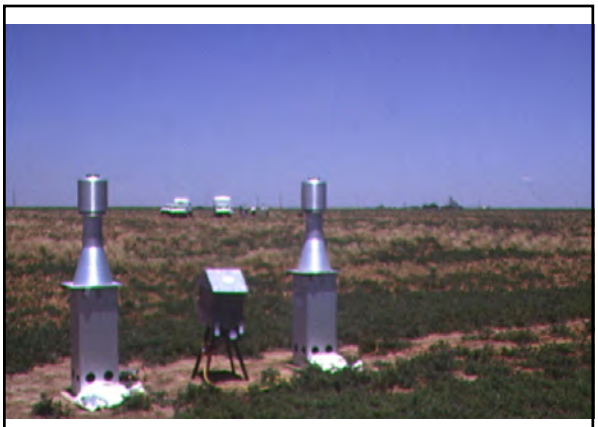


Microbalance Requirement: 0.1 mg accuracy

Anatomy of an FRM Sampler for $PM_{2.5}$



Microbalance Requirement: 0.1 µg accuracy



Federal $PM_{2.5}$ Air Monitoring

Amarillo, Texas

$PM_{2.5}$ FRM Air Sampler

- Rupprecht & Patashnick Partisol-Plus Model 2025 Sequential Air Sampler
- U.S. EPA Reference Method Designation RFPS-0498-118

A Closer Look

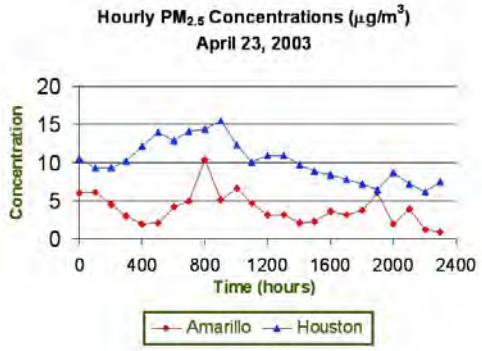
- A filter-based, gravimetric sampling method
- 24-hr samples every three days
- System is automated with some moderate maintenance and programming

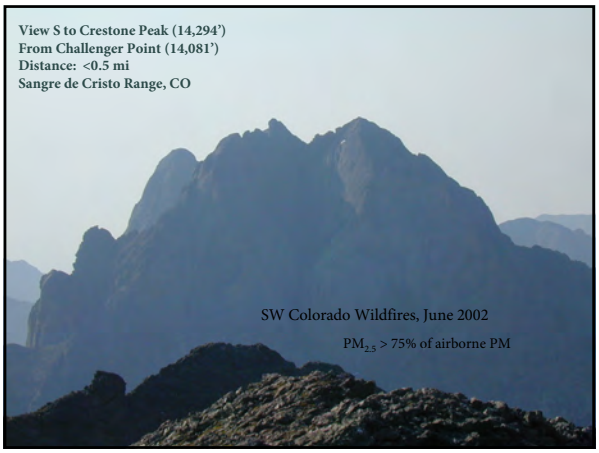
$PM_{2.5}$ Continuous Air Monitor

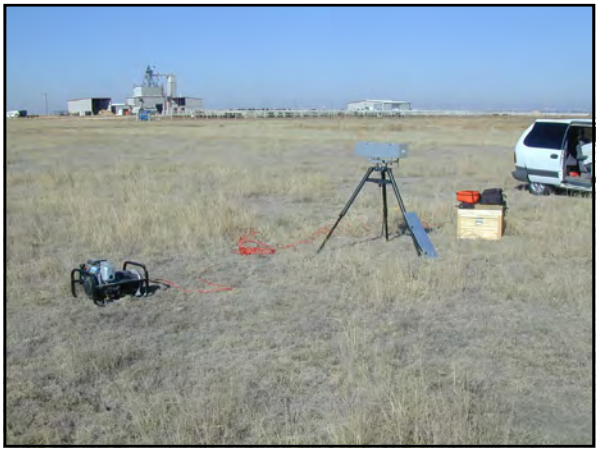
- TEOM Series 1400 Ambient Particulate Monitor
- Converts the change in oscillation frequency of a tapered element into a measure of increased PM mass on the end of the element

A Closer Look

- Inline filter method of sampling
- Fully automated with little maintenance
- Uploads hourly averages via the internet







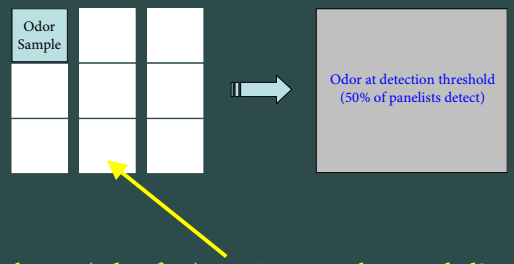
Nuisance Condition

Any condition that interferes with the reasonable use or enjoyment of property

The FIDO(H) Factors in Odor Assessment

Frequency
Intensity (DT)
Duration
Offensiveness
Hedonic tone (what does it smell *like*?)

Dilutions to Threshold



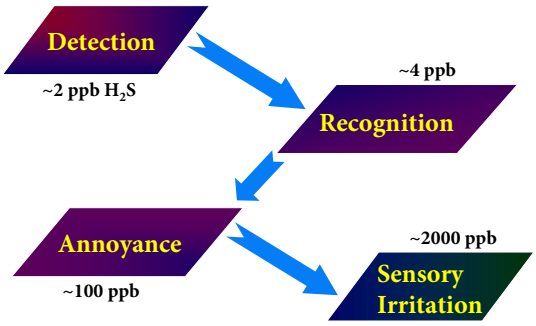
Dilution (odor-free) air: How much is needed?

Odorant Classifications

- S compounds ("rotten")
  - Mercaptans
  - H_2S
  - Organic sulfides
- N compounds ("fishy or pungent")
  - NH_3
  - Amines
  - Indole, skatole
- Phenolic compounds ("medicinal")
  - Phenol, cresol

Odorant Classifications

- Alcohols, aldehydes, ketones ("sweet")
  - Methanol
  - Acetaldehyde
  - Methyl ethyl ketone
- Organic acids ("sour")
  - Acetic acid
  - Butyric acid
  - Isovaleric acid



Introduction to Open-Path Transmissometry as a Surrogate Measure of Ambient PM at Cattle Feedyards

Difficulties Posed by Ambient PM_x Monitoring

1. Labor-intensive, esp. in research mode
2. Time resolution amplifies labor issue
3. Size-selective inlets not aerodynamically robust
4. PM_x not an intuitive concept to the masses
5. Not well suited to spatially chaotic plumes

What We Want

1. Reduce labor requirements;
2. Permit time-resolved measurements;
3. Avoid biases of inertial, size-selective inlets;
4. Deliver an intuitive and reliable surrogate for PM_x as a dust measure; and
5. Integrate measurement along a line transverse to plume drift

Where Doth Transmissometry Fit?

- Potentially:
  - ✓ Reduces labor requirements;
  - ✓ Permits time-resolved measurements;
  - ✓ Avoids biases of inertial, size-selective inlets *(sort of)*;
  - ? Delivers an intuitive and reliable surrogate for PM_x as a dust measure; and
  - ✓ Integrates measurement along a line transverse to plume drift

Caveat

Like substitutes for dynamic, forced-choice olfactometry, visibility data have little regulatory meaning *without being anchored to the accepted methods*:

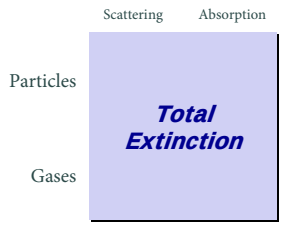
Odor: Human panelists

PM_x: Federal Reference Methods

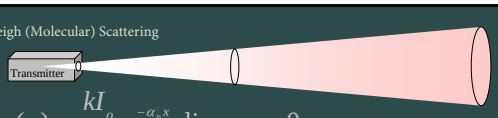
Principles of Visibility

- Image strength can be attenuated by reflection, refraction, absorption
- Contrast is modified by wavelength dependence of attenuating processes
- Instruments can differentiate among scattering processes, but…
- …our eyes and brains respond to the *integration* of those processes

Components of Total Atmospheric Extinction

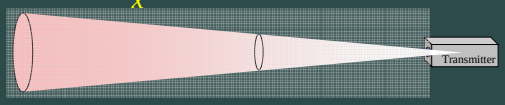


Rayleigh (Molecular) Scattering



$$I_R(x) = \frac{kI_o}{x^2} e^{-\alpha_R x}; \lim_{P \to 0} \alpha_R = 0$$

$$I_T(x) = \frac{kI_o}{x^2} e^{-\alpha_T x}; \alpha_T = f(C_{PM}, C_{gas} \ldots)$$



Molecular and Particle Scattering

Transmissometry Equation

$$f = \left\{ \frac{k_j}{r^2} \frac{I_{o,j}}{I_j(r)} \right\}^{1/r} = e^{-\alpha_j}$$

Koschmieder Equation

$$VR = \frac{3.912}{\alpha}$$

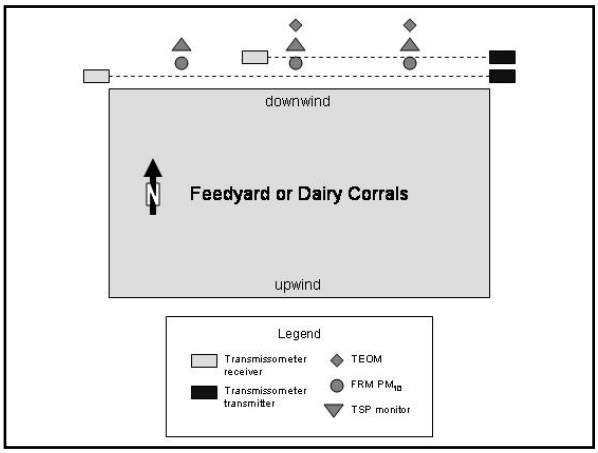
Extinction Efficiency of Air Pollutants

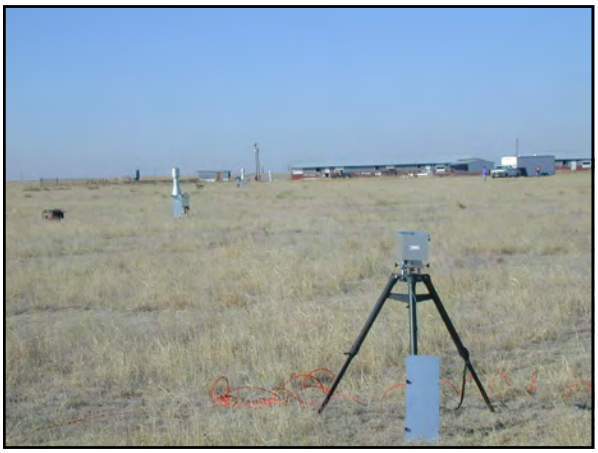
$$\beta_i = \frac{\partial \alpha_T}{\partial C_i}$$

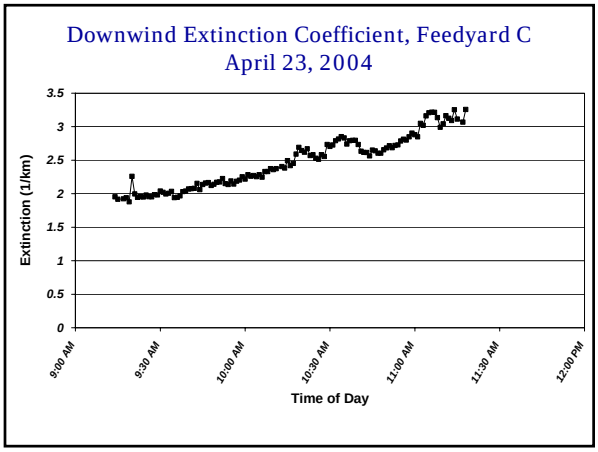
Units: $L^{-1} L^3 M^{-1} = L^2 M^{-1}$

Extinction efficiencies by particle type (Malm, 1999)

Particle Type	*Dry Extinction Efficiency (m^2/g)*
Sulfates	3.0
Organics	3.0
Elemental Carbon	10.0
Nitrates	3.0
Soil Dust	1.25
Coarse Particles	0.6
Feedyard Dust	**???**



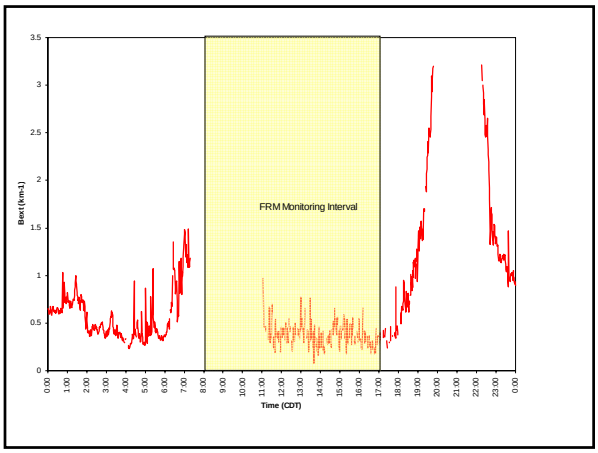


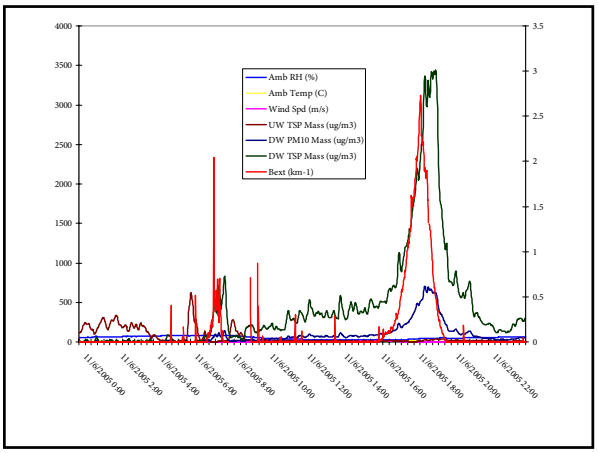


Elevations of transmitter and receiver must sum to 30' per km of path length

Depth of dust plume (50') limits us to about 3.0-3.6 km path length

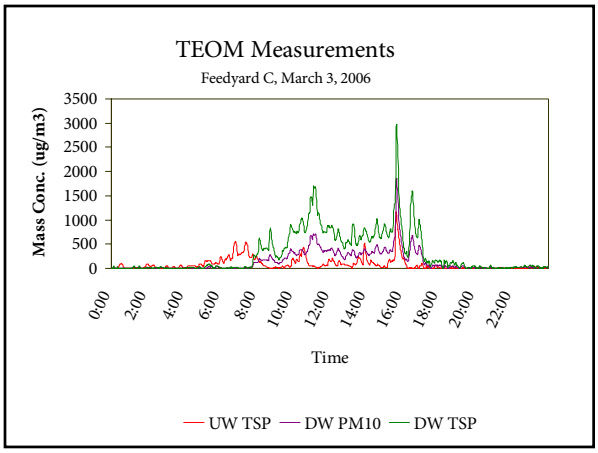
Physical dimensions of feedyards limit us to 1.5-2.0 km path length


FRM Monitoring Interval
Bext (km-1)
Time (CDT)


Amb RH (%)
Amb Temp (C)
Wind Spd (m/s)
UW TSP Mass (ug/m3)
DW PM10 Mass (ug/m3)
DW TSP Mass (ug/m3)
Bext (km-1)


3/3/2006 3:01pm


3/3/2006 6:01pm


TEOM Measurements
Feedyard C, March 3, 2006
Mass Conc. (ug/m3)
Time
UW TSP
DW PM10
DW TSP