The Regional Nature of PM$_{2.5}$ Episodes in Southwestern Pennsylvania

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PM$_{2.5}$ Regulatory Process

- 1997 National Ambient Air Quality Standards (NAAQS) for PM$_{2.5}$ based on “health effects”
  - Mean annual concentration $< 15$ µg/m$^3$
  - Maximum concentration $< 65$µg/ m$^3$
Why Is DOE Concerned About PM$_{2.5}$?

- **Goal 1 of Strategic Plan, DOE Office of Fossil Energy:**
  - “eliminate environmental issues as a barrier to fossil fuel production and use, while maintaining the availability and affordability of fossil fuels.”

- **Coal is vital source of electricity**
  - 56% in U.S; 42% worldwide
  - Reserves available for 200+ years
  - Low cost to consumers

- **Coal-based power systems contribute to PM**
  - Primary particles and precursors (SO$_2$, NO$_x$)
  - SIPs will likely restrict emissions from coal power plants
Eastern PM$_{2.5}$ Mass Apportionment

*Current Understanding?*

- Sulfate: 34%
- Nitrate: 1%
- Organic C: 21%
- Elemental C: 4%
- Unknown: 23%
- Ammonium: 13%
- Minerals: 4%

Source: EPA (1996)
Ambient Sampling and Analysis
Current Project Portfolio

Stuebenville Comprehensive Air Monitoring Project (SCAMP)

NETL-PGH In-house Monitoring Station

CMU/EPA “Supersite”

Upper Ohio River Valley Project (UORVP)

Great Smoky Mountains Project (GSMP)

Aerosol Research Inhalation Epidemiology Study (ARIES)

Southern Fine particulate monitoring Project (SRI)

Bravo Project

DOE-NETL Primary Funding

DOE-NETL Cost-sharing
Integration of NETL PM$_{2.5}$ Program Components

Component 1
Ambient sampling & analysis
SCAMP

Upper Ohio River Valley Project

Common Data Analysis Tool

Component 2
Regional emissions data

NETL in-house
CMU/EPA Supersite

Component 3
Regional source-based modeling and evaluation

CMU-Pittsburgh Air Quality Study

Link to human exposure studies
Link to instrumentation evaluations
Link to other ambient sampling programs
Link to other regional modeling studies
NETL’s Ambient Air Monitoring Facility
NETL's ambient air monitoring equipment

PM$_{2.5}$ Partisol®- Plus FRM Sequential Air Sampler (R&P),
ENVIROcheck Model 107M Environmental Particulate Monitoring System (Grimm),
PM$_{2.5}$ DustTrack Aerosol Monitor (TSI),
PM$_{2.5}$ TEOM® Ambient Particulate Monitor equipped with an AccuSampler (R&P),
PM$_{2.5}$ RAAS 2.5-400 Speciation Sampler (Andersen),
PAS 2000 Real-time PAH Monitor (EcoChem Analytics),
Seven Day Pollen and Mold Spore Trap (Burkard),
Continuous Gas Monitors -- SO$_2$, O$_3$, CO, NO$_X$, NO$_Y$, NH$_3$, H$_2$S (API),
PM$_{2.5}$ PC-BOSS Sampler (BYU),
High Volume Samplers (BYU and NETL),
PM$_{2.5}$ 5400 Ambient Carbon Particulate Monitor (R&P),
Highly Instrumented Meteorological Tower (Climatronics),
NETL's ambient air monitoring equipment
“NEW”

PM$_{2.5}$ 8400N Continuous Nitrate Analyzer (R&P),
PM$_{2.5}$ 8400S Continuous Sulfate Analyzer (R&P),
ELPI- Real-time Particle Size Distribution and Concentration Measurement System (Dekati),
Sir Galahad II Ambient Vapor Phase Mercury Analyser (PS Analytical) and,
PM$_{2.5}$ RTAA-1000 Seven Channel Aethalometer (Andersen).
BYU PC-BOSS

NETL PM2.5 and Electric Power Generation  PCR/ST-10/ 9-April- 2002, 10

Minor Flow
(2.5-<0.1 µm Particles Including Semi-Volatiles)

Discard
Major Flow
(Gases & <0.1 µm Particles)

Denuder Flow
~32 L/min

Side Flow
Filter Pack
20 L/min
(Gases & <2.5 µm Particles)

<0.1 µm Cut Fine Particle Concentrator

Inlet Flow
150 L/min

2.5 µm Inlet

~98 L/min
PM$_{2.5}$ Composition - Summer 2000

The diagram shows the total PM$_{2.5}$ mass concentration (µg/m$^3$) over the course of July and August. The x-axis represents the sample start date, with separate sections for July and August. The y-axis indicates the mass concentration of different components of PM$_{2.5}$, including Ammonium Sulfate, Nonvolatile Organic, Lost SVOC, Soot, Ammonium Nitrate, and Lost Nitrate. The chart visually represents the variation in these concentrations over the specified period.
Regional Power Plant SO$_2$ Emissions
TEOM Sampling Sites

- New Albany OH (NA)
- Athens OH (AT)
- Stuebenville OH (ST)
- Holbrook PA (HB)
- Hazelwood PA (HW,10)
- Kittanning PA (KI)
- Greensburg PA (GB,10)
- Liberty PA (LI)
- Flag Plaza in Pittsburgh PA (FP, 10)
- National Energy Technology Laboratory PA (NETL)
Regional Nature of High PM$_{2.5}$ at NETL

- PM$_{2.5}$ is generally less than 15 µg/m$^3$ at the NETL monitoring site
- Episodes of high PM$_{2.5}$ are generally short but can reach 50 µg/m$^3$
- During PM$_{2.5}$ episodes, high concentrations are seen at all sites, suggesting a regional source for the PM$_{2.5}$
- Concentrations of PM$_{2.5}$ during episodes and episode frequency are both higher during the summer than during the winter
Regional Episodes

PM$_{2.5}$, mg/m$^3$

Episode

October - December

January - March

April - May

June

SW$_1$, SW$_1$, SW$_1$, SW$_1$, SW$_1$, SW$_2$

W, SW$_1$, SW$_1$, SW$_1$, E

SW$_1$, E, SW$_2$, SW$_2$, W, SW$_1$

SW$_1$, SW$_2$, SW$_2$, SW$_2$, SW$_2$, SW$_2$, N
Regional Episodes - Continued

- **July**: PM2.5, µg/m³
- **August**: PM2.5, µg/m³
- **September**: PM2.5, µg/m³

Episode
Conclusions

• PM$_{2.5}$ concentration and composition has been measured for the last two years at NETL

• High PM$_{2.5}$ at NETL is associated with high regional PM$_{2.5}$ episodes of short duration

• Regional PM$_{2.5}$ concentrations are generally higher in the summer than in the winter

• During the winter, high regional PM$_{2.5}$ is dominated by organic material

• During the summer, high regional PM$_{2.5}$ is dominated by ammonium sulfate

• Episodes of high PM$_{2.5}$ are most often associated with transport from the southwest
Acknowledgments

• Dr. Elias J. George – Environmental Safety and Health Division, NETL

• The other PM$_{2.5}$ Sampling and Analysis team members

• Mr. Thomas J. Feeley – Product Manager: Environmental and Water Resources, NETL