Introduction to Air Pollution

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Outline

• Important Air Quality Regulations
  • Clean Air Act and Amendments
  • Others
• Methods for Quantifying Pollutants
• Air Pollution Control
• Field Trip to Bondville Atmospheric Environmental Research Station (BEARS)
• Summary
Air Pollutant Regulations

  - Provided funds to research air pollution monitoring and abatement techniques
  - Began to develop emission inventories for select pollutants
Air Pollutant Regulations

• **Clean Air Act (1970)** – Created federal regulations on emissions for select contaminants from stationary and mobile sources
  – National Ambient Air Quality Standards (NAAQS)
  – State Implementation Plans (SIP)
  – New Source Performance Standards (NSPS)
  – National Emission Standards for Hazardous Air Pollutants (NESHAPs)

• Contributed to the development of the US EPA

• Small amendments made in 1977
Air Pollutant Regulations

• **Clean Air Act Amendments (1977)** – Updates to the previous CAAA that address specific air quality issues
  – States must submit revised SIPs
  – Classification of areas with respect to NAAQS
  – Establish policies for non-attainment areas
  – New major facilities must apply specific standards
  – Good Engineering Practice for stack height
Air Pollutant Regulations

• **Clean Air Act Amendments (1990)** – Updates to the initial Clean Air Act that address specific problems and increased ability to control and detect pollutants
  – Control of Acid Rain
  – Control of Hazardous Air Pollutants
  – Control of Ozone Depleting Chemicals
  – New Requirements for Motor Vehicles
  – New Permitting Requirements for Sources
National Ambient Air Quality Standards

• Standards set for the six criteria air pollutants

• **Primary Standard** – Protection of health
• **Secondary Standard** – Protection of welfare
  
  – Pollutant Concentrations
  – Averaging Times – Average pollutant concentration during a given amount of time (to remove outliers)
# National Ambient Air Quality Standards

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Primary/Secondary</th>
<th>Averaging Time</th>
<th>Level</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide</td>
<td>primary</td>
<td>8-hour</td>
<td>9 ppm</td>
<td>Not to be exceeded more than once per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-hour</td>
<td>35 ppm</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>primary and secondary</td>
<td>Rolling 3 month average</td>
<td>0.15 µg/m³ (1)</td>
<td>Not to be exceeded</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>primary</td>
<td>1-hour</td>
<td>100 ppb</td>
<td>98th percentile, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>primary and secondary</td>
<td>Annual</td>
<td>53 ppb (2)</td>
<td>Annual Mean</td>
</tr>
<tr>
<td>Ozone</td>
<td>primary and secondary</td>
<td>8-hour</td>
<td>0.075 ppm (3)</td>
<td>Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM2.5</td>
<td>primary</td>
<td>Annual</td>
<td>12 µg/m³</td>
<td>annual mean, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>secondary</td>
<td>Annual</td>
<td>15 µg/m³</td>
<td>annual mean, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>primary and secondary</td>
<td>24-hour</td>
<td>35 µg/m³</td>
<td>98th percentile, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM10</td>
<td>primary and secondary</td>
<td>24-hour</td>
<td>150 µg/m³</td>
<td>Not to be exceeded more than once per year on average over 3 years</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>primary</td>
<td>1-hour</td>
<td>75 ppb (4)</td>
<td>99th percentile of 1-hour daily maximum concentrations, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>secondary</td>
<td>3-hour</td>
<td>0.5 ppm</td>
<td>Not to be exceeded more than once per year</td>
</tr>
</tbody>
</table>

Source: US EPA
Monitoring/Measuring Air Pollutants

• **What Effects an Air Pollutant’s Concentration?**
  – Location of Source Compared to Receptor (x, y, z)
  – Type of Source (stationary, mobile, area)
  – Source Strength
  – Atmospheric Conditions
    • Wind Speed/Direction
    • Precipitation
    • Atmospheric Stability
Gaussian Dispersion Model

Determining contaminant concentrations resulting from a stationary pollutant source...

\[
C_{(x,y,z)} = \frac{Q}{2\pi u_g \sigma_y \sigma_z} \left\{ \exp \left[ -\frac{1}{2} \left( \frac{y}{\sigma_y} \right)^2 - \frac{1}{2} \left( \frac{z - H}{\sigma_z} \right)^2 \right] + \exp \left[ -\frac{1}{2} \left( \frac{y}{\sigma_y} \right)^2 - \frac{1}{2} \left( \frac{z + H}{\sigma_z} \right)^2 \right] \right\}
\]

\[Q = \text{Source Strength (mass / time)}\]
\[u_g = \text{Wind Speed (length / time)}\]
\[\sigma_y \text{ and } \sigma_z = \text{Parameters Describing the Weather Conditions (length)}\]
\[(x, y, z) = \text{Position of Interest}\]
\[H = \text{Height of Pollutant Source (length)}\]
Atmospheric Conditions Impact Pollutant Dispersion
Radioactive Materials from Fukushima Detected at Sites in the USA

Weatherbee, et al., Environmental Science and Technology, 2012
Radiation Dispersion (and decay) from the Chernobyl Disaster

Bq/m$^3$ of $^{137}$Cs

Bq = Becquerel
(SI Unit for Radioactivity)

Quelo, et al., Atmospheric Environment, 2007
Sulfur Dioxide Emissions from Abbott Power Plant

- AERMOD model from EPA
Types of Air Pollutant Monitoring

Outdoor Ambient Monitoring is the systematic, long-term assessment of pollutant levels by measuring the quantity and types of pollutants in the outdoor air.

Emissions Measurement is the process of monitoring particulate and gaseous emissions from specific sources.
National Trends Network Measurement Sites


IL 11 = Bondville, IL – Tour of this site next week!
Ambient Atmospheric Sampling at Bondville Environmental Atmospheric Research Site
Ambient Atmospheric Sampling at Bondville Environmental Atmospheric Research Site

- Basic Air Quality
  - Sulfur dioxide, ozone, particulate matter, organics
- Precipitation Chemistry
  - Major ions, mercury, event based longer term sampling
- Long-Term Climate
  - National Weather Service site
- On-Site Meteorology
  - Wind velocity, air and soil temperatures, dew point temperature, pressure, radiation
- Atmospheric Visibility
- Solar Physics
- Continuous Particulate Monitoring using Chromatographic Methods
Sampling Platforms – Ships

NOAA Research Vessel: Ronald H. Brown

http://www.moc.noaa.gov/rb/
Sampling Platforms – Aircraft

NOAA DHC-6 Twin Otter Aircraft

Balloon

Satellites

http://www.ncdc.noaa.gov/weather-balloon-data

http://www.nosa.gov/vision/earth/lookingatearth/earthweek.html
Sampling Platforms – Personal Samplers

http://www.munroinstruments.co.uk/Environmental/contents/en-us/d27_Standard_Personal_Air_Samplers.html
Stack Sampling
Air Pollution Control

• Major Techniques
  
  – Adsorption – Adhesion of a contaminant to the surface of a solid
    • Volatile Organic Compounds
    • Mercury
  
  – Absorption – Concentration of a contaminant into the bulk of another solid or liquid
    • Sulfur Dioxide
    • Carbon Dioxide (?)
  
  – Filtration – Removing solids/liquids from a gas stream by imposing an impenetrable barrier
    • Particulate Matter
  
  – Catalytic Destruction – Conversion of a contaminant to an inert compound via catalytic processes
    • Nitrogen Oxides (Catalytic Reduction to \( N_2 \))
Next Week... (Thursday)

• Tour of Bondville Environmental and Atmospheric Research Site (BEARS)