Urban Ambient Air Quality Trends

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N. O. Gerald, *Urban Ambient Air Quality Trends, in Air Quality Protection in the West* (Natural Res. Law Ctr., Univ. of Colo. Sch. of Law 1989).

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URBAN AMBIENT AIR QUALITY TRENDS

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AIR QUALITY PROTECTION IN THE WEST

Natural Resources Law Center
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School of Law
Boulder, Colorado

November 27-28, 1989
ABSTRACT

URBAN AMBIENT AIR QUALITY TRENDS

N. O. Gerald

Air quality problems, and perennially the urban problems, are not readily perceivable by the general public and are often relegated the positions of low priority. Such "invisible issues", however, are resurging as those which will drive the direction of our future urban and industrial development nationwide. A close look at the trends in the nation's air quality can lead us to a better appreciation of the scope of these problems and can help the Environmental Protection Agency and the State and Local air pollution control agencies more accurately define appropriate control strategies.

The Clean Air Act Amendments of 1977 established national requirements for ambient air quality monitoring and data reporting, subsequently resulting in the promulgation of comprehensive regulations for six criteria pollutants, i.e., particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. PM$_{10}$ replaced total suspended particulate as the measure of particulate matter impact in mid-1987. The 1979 monitoring regulations subsequently instituted a three-part network consisting of national trends monitoring stations, state and local monitoring systems, and special purpose monitors. These systems combined provide the nation with data sufficient to track progress in attaining and maintaining the National Ambient Air Quality Standards (NAAQS).

Although significant improvement has been demonstrated in past years, it is clear that without continued substantial commitment of resources and maintenance of existing strategy programs, that air quality can very quickly begin to deteriorate. Trends indicate, especially in urban areas, that high growth and increased emphasis on mobility continue to stretch the assimilative capacity of the atmosphere. With new understanding of the complexity of the urban air pollution problems comes the need for a sophisticated effort to implement effective means to reduce the pollutants and provide a measure of protection to the affected populace. Nationwide trends with a focus on western United States urban areas is discussed.

The future of air quality control programs must be assured by a commitment, not only from our industrial/commercial sector, but more importantly from the public, who in fact are the ultimate generators of our air quality problems.
URBAN AMBIENT AIR QUALITY TRENDS

N. O. Gerald

I. INTRODUCTION

A. Air Quality problems have often been termed invisible issues - They suffer from the "What you can't see, can't hurt you" Syndrome - Problems seem "Gone With the Wind"...such attitudes tend to add credence to the belief that a problem does not truly exist.

B. Ambient Air Quality Trends - Focus on the West and several western cites will be presented

C. Pointing the Finger, i.e., Who's at fault? What can be done and how can we participate?

II. MONITORING REQUIREMENTS

A. Clean Air Act Amendments of 1977 - Established monitoring requirements

1. Section 110 - Air monitoring and data reporting are imposed as a requirement of the State Implementation Plan for Air Quality (SIP) stipulations.

2. Section 319 - Establishes the bases for nationwide monitoring systems, including:
   a. Uniform monitoring criteria and methodology
   b. Nationwide scope
   c. Pollutant Standard Index (PSI)
   d. Reporting and recordkeeping requirements

3. Section 165 - Prevention of Significant Deterioration (PSD) monitoring requirements are outlined.

B. Criteria pollutant monitoring established pursuant to the Act

1. Total Suspended Particulate (TSP) - Very small particles of dirt, soot; and miscellaneous chemicals suspended in the atmosphere.

2. PM$_{10}$ - Respirable particulate matter with an aerodynamic diameter of less than or equal to 10 micrometers - Replaced former national TSP standard, July 1, 1987, except for current PSD requirements.
3. Sulfur Dioxide (SO₂) - Yellowish gas with distinctive odor, usually not detectable at normal atmospheric levels by most people. Primarily emitted from the burning of coal and oil.
4. Carbon Monoxide (CO) - Odorless, colorless gas formed by the incomplete combustion of fuels.
5. Ozone (O₃) - Colorless, highly reactive gas, a principal component of smog, which is formed by a complex photochemical reaction of nitrogen oxides and volatile organic compounds (VOC).
6. Nitrogen Dioxide (NO₂) - Brownish gas generally as a result of high temperature combustion processes such as automobiles and power plants.
7. Lead (Pb) - Generally fine particles of lead and lead compounds suspended in the atmosphere from nonferrous smelters, battery plants, and formerly automobiles.

C. Monitoring Network - (See Attached Table) - 1979 Monitoring Regulations (40CFR Part 58)

1. Components
   a. Quality Assurance procedures for monitor operation and data handling
   b. Methodology used in monitoring stations
   c. Siting parameters
   d. Equivalent method requirements
   e. Reporting

2. State and Local Air Monitoring Stations - SLAMS - Nationwide total of 3967 monitors (3010 exclusively SLAMS)
   a. Network size/distribution based on State/Local Needs
   b. Subject to EPA regional approval - Note ten EPA regions.
   c. Annual network review requirement
   d. Monitoring Objectives - SLAMS are sited to quantify:
      (1) Highest concentrations
      (2) Highest population exposure
      (3) Specific source impacts
      (4) Background concentrations

3. National Air Monitoring Stations - NAMS - 957 monitors nationwide
   a. Network size/distribution based on EPA/national needs
   b. Selected by EPA, approved by headquarters EPA
   c. Subset of SLAMS system.
   d. Monitoring objectives - NAMS sited to quantify:
      (1) Highest Concentrations
      (2) Highest Population Exposure
NOTE: Need to distinguish SLAMS from NAMS has blurred over time. Data is often utilized interchangeably.

4. Special Purpose Monitors - SPM's - 1028 monitors nationwide - utilized for monitoring:
   a. Short Term
   b. Special Problem Assessment

II. MONITORING SECTION - The missions of the Monitoring Section are:
   A. Direction/Oversight of the National Criteria Pollutant Ambient Air Monitoring Program
   B. Development of monitoring regulations/guidelines
   C. Management of the National Air Monitoring Stations (NAMS) Network
   D. Direction/oversight of ambient air toxics monitoring program
   E. Direction of Standing Air Monitoring Workgroup (SAMWG) - SAMWG is a group which consists of State, Local, and EPA representatives which develops recommendations concerning monitoring issues, problems, etc. in conjunction with STAPPA/ALAPCO

III. DATA ANALYSIS SECTION - A sister section to monitoring which has as its missions:
   A. Develop and apply statistical methodology for detecting air quality trends and interpreting air quality data
   B. Produce national air quality trends and reports
   C. Prepare design value/nonattainment lists
   D. Provide statistical support for EPA's Office of Air Quality Planning and Standards (OAQPS)
   E. Develop statistical bases for National Ambient Air Quality Standards (NAAQS)
   F. Utilize Geographic Information System (GIS) technologies
IV. CRITERIA EMISSION SECTION - The second section which coordinates with monitoring to:

A. Develop and publish emission factors - stationary point/area only (Mobile sources handled by the Office of Mobile Sources)

B. Prepare and issue emission inventory guidance for state/locals - especially for CO/Ozone & PM$_{10}$

C. Special projects to gather emission data bases

V. NATIONAL OVERVIEW OF AMBIENT AIR QUALITY TRENDS - EPA-450/4-89-001, "National Air Quality and Emissions Trends Report" - Interpreting data trends...

A. Particulate Matter

1. Total Suspended Particulate (TSP)
   a. Ambient trends follow emissions
      
      | Year | Geometric Mean | Emissions | Comment |
      |------|----------------|-----------|---------|
      | Decade | down 21 % | down 23 % | Change in Filters Used 79-81 |
      | Five | down <1 % | down 1 % | Increased Forest Fire Activity in 87 |
      | Recent | up 2 % | up 3 % |

b. Overall Flat Trend

c. Emissions do not include fugitive emissions such as unpaved roads or construction activity.

2. PM$_{10}$ - July 1, 1987
   a. Definition - Aerodynamic diameter < 10 micrometers
   b. Adverse Health Effects - Ability to penetrate thoracic or lower regions of the respiratory tract
   c. Lean Data Base - Insufficient for trends analysis
   d. Exceedances of NAAQS continue to be measured
   e. Estimated 22 million people live in areas where violations of the PM$_{10}$ standard are measured.

B. Sulfur Dioxide (SO$_2$)

1. Ambient trends track emissions overall
2. Trend continues to decline - Ambient $SO_2$ problems tend to be located near major emitters.

3. Vast majority of sites indicate compliance with NAAQS, but network is primarily population oriented.

4. No recent violations of annual standard, but 1.6 million people continue to live in areas violating the 24-hour standard.

C. Nitrogen Dioxide ($NO_2$)

1. Ambient Levels Are Flat Though Recent Emissions Up

<table>
<thead>
<tr>
<th>Year</th>
<th>Arithmetic Mean</th>
<th>Emissions</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decade</td>
<td>down 35%</td>
<td>down 17%</td>
<td></td>
</tr>
<tr>
<td>Five</td>
<td>down 10%</td>
<td>down 1%</td>
<td></td>
</tr>
<tr>
<td>Recent</td>
<td>down 3%</td>
<td>down 1%</td>
<td></td>
</tr>
</tbody>
</table>

2. Approximately 8.3 million people continue to live in areas violating the $NO_2$ NAAQS.

D. Carbon Monoxide (CO)

1. General agreement of estimated emissions to ambient trends - note monitors usually located in hot spots/suspected problem areas

<table>
<thead>
<tr>
<th>Year</th>
<th>2nd High</th>
<th>Emissions</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decade</td>
<td>down 32%</td>
<td>down 25%</td>
<td></td>
</tr>
<tr>
<td>Five</td>
<td>down 16%</td>
<td>down 14%</td>
<td></td>
</tr>
<tr>
<td>Recent</td>
<td>down 6%</td>
<td>up &lt;1%</td>
<td>$86-87$ Forest Fires</td>
</tr>
</tbody>
</table>

2. CO concentrations highly dependent upon vehicle ADT and travel patterns/roadway design - Total emissions may be on the rise.

3. Improvement despite 24% increase in VMT over decade - CO from motor vehicles down 38%...Controls more than offset growth.
4. Approximately 29.4 million people live in counties where violations of the CO NAAQS are measured.

E. Ozone ($O_3$)

1. Overall trend is mixed bag though seems to be up

<table>
<thead>
<tr>
<th>Year</th>
<th>Daily Mx</th>
<th>2nd High</th>
<th>VOC Emissions</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decade</td>
<td>down 9%</td>
<td>down 17%</td>
<td></td>
<td>Calibration</td>
</tr>
<tr>
<td>Five</td>
<td>down 8%</td>
<td>down 4%</td>
<td></td>
<td>Change in 79</td>
</tr>
<tr>
<td>Recent</td>
<td>up 5%</td>
<td>up 2%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Most Pervasive Urban Air Problem

   a. Complex Atmospheric Chemistry
   b. Near Impossible to Predict (or afford to)
   c. Control Strategy Unclear - NOx, CO, VOC, Biogenics??
   d. Meteorology Complicates - e.g. 1988

3. Without comprehensive study and strategy, concentrations/exceedances likely to rise

4. Approximately 100 million people now live in areas violating the ozone NAAQS.

F. Lead (Pb)

1. Success Story - Trends way down

<table>
<thead>
<tr>
<th>Year</th>
<th>Max Otr Avg.</th>
<th>Emissions</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decade</td>
<td>down 88%</td>
<td>down 94%</td>
<td>97% decrease in transportation emissions</td>
</tr>
<tr>
<td>Five</td>
<td>down 71%</td>
<td>down 83%</td>
<td>93% &quot;     &quot;</td>
</tr>
<tr>
<td>Recent</td>
<td>down 19%</td>
<td>down 6%</td>
<td>14% &quot;     &quot;</td>
</tr>
</tbody>
</table>

2. Urban impact from transportation down significantly - National problems likely only from point source impacts, though also down

3. Approximately 1.7 million people live in counties where exceedances of the lead NAAQS are measured.

VI. Western United States Cities
A. Denver, Colorado Metropolitan Area

1. Description: Denver County plus parts of Adams, Arapaho, Boulder, Douglas and Jefferson.

2. Altitude - Approximately one mile above sea level

3. Population - Approximately 1.9 million

4. Meteorology - Unique - Air masses from four different sources influence area
   a. Polar air - Canada and Northwest
   b. Moist air from Gulf of Mexico
   c. Warm dry air from Mexico and Southwest
   d. Pacific air modified by overland travel

5. Low relative humidity - Average precipitation only 14 inches per year.

6. Ozone - Triggered by sunlight.

7. Problems - CO and PM in winter
   a. Inversions
   b. CO Causes - Motor vehicles and residential woodburning
   c. "Brown Cloud" - small PM - < 2.5 microns or 1/10,000 inch
      (1) Refinery/Industrial Sources - 32 %
      (2) Motor vehicles - 27 %
      (3) Woodburning - 23 %
      (4) Electric power sources - 14 %
      (5) Space heating - 4 %

8. Control Strategy
   a. Inspection/Maintenance for motor vehicles
   b. Oxygenated fuels program

9. Ambient Trends

B. Los Angeles - Riverside, California Metropolitan Area

1. Description - All or parts of Los Angeles, Orange, Riverside, and San Bernadino Counties

2. Population - Approximately 13.5 million

3. Meteorology - Complex
a. Wide variation in temperature, humidity, cloudiness, fog, rain, and sunshine over short distances
b. Wind Pattern - Land/Sea-breeze - out to sea at night, inland during the day.
c. Inversions - Especially May-October - Light winds/sunshine

4. Ozone - Mobile sources and various industrial sources
   a. Year-long season due to meteorology
   b. Highest values - spring to autumn

5. Carbon Monoxide - Mobile sources - 90 %

6. Ambient Trends

C. Phoenix, Arizona Metropolitan Area
   1. Description - Maricopa County - Southwest Arizona - One of the fastest growing areas of country
   2. Population - Up to nearly 2 million - more than doubled since 1970
   3. Economy - Commercial and service oriented
   4. Meteorology
      a. Surrounded by mountains - nocturnal inversions
      b. Worst in winter
   5. Carbon Monoxide - Levels high and parallel inversions
   6. Ozone - Strategy - Inspection/Maintenance for motor vehicles and Stage I fuel vapor control
   7. Ambient Trends

D. Portland-Vancouver, Oregon - Washington Metropolitan Area
   1. Description - Multnomah, parts of Clackamas, Washington and Yamhill Counties (OR) and Clark County, Washington.
   2. Population - 168,000
   3. Meteorology
      a. Shielded from maritime climate by hills/mountains
      b. Precipitation - 37 inches - 88 % in October - May
   4. Particulate Matter
a. Formerly high residential woodburning - Woodstove regulations promulgated in 1986
b. Open burning - Banned in most dense areas of Portland - 1984
c. Road paving program
d. Better winter sanding practices

a. Motor Vehicles - Inspection/Maintenance
b. Stationary source VOC reductions/bulk plant closings

6. Ambient Trends

VI. VISIBILITY MONITORING PROGRAM
A. Background
1. 1980 Regulations - Required states to conduct visibility monitoring in Class I Areas.
2. Environmental Defense Fund (EDF) suit and subsequent settlement agreement - Allows the IMPROVE (Interagency Monitoring of Protected Visual Environments) network to fulfill these monitoring requirements.

B. IMPROVE Network
1. Network Description - Twenty IMPROVE visibility monitoring sites were established in fourteen of the thirty-five states which have Class I Areas (Ref. Map)
2. IMPROVE monitoring areas:
   Alaska: Denali National Park
   Arizona: Chiricahua Wilderness
            Grand Canyon National Park
            Superstition Wilderness/Tonto National Monument
   California: San Gorgonio Wilderness
              Yosemite National Park
   Colorado: Mesa Verde National Park
            Rocky Mountain National Park
            Weminuche Wilderness
   Maine: Acadia National Park
   Montana: Glacier National Park
   Nevada: Jarbridge Wilderness
   North Carolina: Great Smoky Mountains National Park
   Oregon: Crater Lake National Park
Texas: Big Bend National Park  
Utah: Bryce Canyon National Park  
Virginia: Shenandoah National Park  
Washington: Mount Rainer National Park  
Wyoming: Bridger Wilderness

C. IMPROVE Monitoring System Components
   1. Photography
   2. PM Sampling
   3. Transmissometer

D. Existing Resources for IMPROVE:
   1. National Park Service - $1,000,000 per year
   2. Federal Land Managers - Local Servicing
   3. EPA - Section 105 Funds - $500,000 per year

E. Problem - What is the future of visibility monitoring?

F. Contingency Plan - In the event that visibility monitoring activities must be assumed by the states, EPA is:
   1. Developing reference methods for visibility monitoring
   2. Developing associated guidance
   3. Modifying the regulations

G. EPA Proposal
   2. Required Scene Measurement - camera method
   3. Optional Aerosol Measurement - For source or extinction apportionment

VII. AIR MONITORING FUTURE DIRECTION - New technologies - Long path/remote sensing techniques are expected to play a greater role.
VIII. CONCLUSION - WHAT'LL WE DO NOW? SYNDROME

A. Solutions to air quality problems require:
   1. Support for responsible regulatory programs - Local, State, & Federal
   2. Acceptance of responsibility for a share of the cost - Public and Industry
   3. Encouragement of conservation, reuse, recycle, etc., programs
   4. Most important...leave a legacy...educate our children

B. Pointing the Finger
   1. World according to POGO
   2. Summary and Questions
### TABLE 1. Summary of SLAMS, NAMS, and SPN by Region and Pollutant

<table>
<thead>
<tr>
<th>Region</th>
<th>SLAMS*</th>
<th>NAMS</th>
<th>SPN</th>
<th>SLAMS*</th>
<th>NAMS</th>
<th>SPN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>** PM</td>
<td></td>
<td></td>
<td>** SO2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SLAMS</strong></td>
<td><strong>NAMS</strong></td>
<td><strong>SPN</strong></td>
<td><strong>SLAMS</strong></td>
<td><strong>NAMS</strong></td>
<td><strong>SPN</strong></td>
<td><strong>SLAMS</strong></td>
</tr>
<tr>
<td>Subtotal</td>
<td>1052 / 823</td>
<td>7</td>
<td>795 / 1005</td>
<td>319 / 368</td>
<td>306 / 312</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1534 / 1257</td>
<td>1</td>
<td>1322 / 1072</td>
<td>437 / 453</td>
<td>430 / 454</td>
<td>272 / 222</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th><strong>SO2</strong></th>
<th><strong>Subtotals</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>SLAMS</strong></td>
<td><strong>NAMS</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>SLAMS</strong></td>
<td><strong>NAMS</strong></td>
</tr>
<tr>
<td>I</td>
<td>11 / 11</td>
<td>8 / 5</td>
<td>13 / 9</td>
</tr>
<tr>
<td>II</td>
<td>17 / 17</td>
<td>11 / 11</td>
<td>7 / 7</td>
</tr>
<tr>
<td>III</td>
<td>20 / 20</td>
<td>10 / 10</td>
<td>5 / 5</td>
</tr>
<tr>
<td>VI</td>
<td>20 / 20</td>
<td>10 / 10</td>
<td>5 / 5</td>
</tr>
<tr>
<td>Subtotal</td>
<td>1322 / 1257</td>
<td>1</td>
<td>1322 / 1257</td>
</tr>
<tr>
<td>Total (SLAMS+NAMS+SPN)</td>
<td>473 / 408</td>
<td>1</td>
<td>473 / 408</td>
</tr>
</tbody>
</table>

---

a. Number of SLAMS monitors excluding NAMS.
b. Number of monitors operating in 1988/89).
c. Number of monitors operating/required.
SULFUR DIOXIDE
ANNUAL ARITHMETIC MEAN
National Ambient Air Quality Standards (NAAQS) in Effect in 1986

<table>
<thead>
<tr>
<th>POLLUTANT</th>
<th>PRIMARY (HEALTH RELATED)</th>
<th>SECONDARY (WELFARE RELATED)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVERAGING TIME</td>
<td>STANDARD LEVEL (^a) CONCENTRATION</td>
</tr>
<tr>
<td>TSP(^b)</td>
<td>Annual Geometric Mean</td>
<td>75 ug/m(^3)</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>260 ug/m(^3)</td>
</tr>
<tr>
<td>SO(_2)</td>
<td>Annual Arithmetic Mean</td>
<td>(0.03 ppm)</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>80 ug/m(^3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.14 ppm)</td>
</tr>
<tr>
<td></td>
<td>365 ug/m(^3)</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>8-hour</td>
<td>9 ppm (10 mg/m(^3))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(40 mg/m(^3))</td>
</tr>
<tr>
<td></td>
<td>1-hour</td>
<td>35 ppm (40 mg/m(^3))</td>
</tr>
<tr>
<td>NO(_2)</td>
<td>Annual Arithmetic Mean</td>
<td>0.053 ppm (100 ug/m(^3))</td>
</tr>
<tr>
<td>O(_3)</td>
<td>Maximum Daily 1-hour</td>
<td>0.12 ppm (^c) (235 ug/m(^3))</td>
</tr>
<tr>
<td>Pb</td>
<td>Maximum Quarterly Average</td>
<td>1.5 ug/m(^3)</td>
</tr>
</tbody>
</table>

\(^a\) Parenthetical value is an approximately equivalent concentration.

\(^b\) TSP was the indicator pollutant for the original particulate matter (PM) standards. New PM standards were promulgated in 1987, using PM\(_{10}\) (particles less than 10\(\mu\)m in diameter) as the indicator pollutant. The levels and averaging times for these new primary standards are 50 ug/m\(^3\) for the annual mean and 150 ug/m\(^3\) for the 24-hour average. Adjustments are made for incomplete data. The secondary standards are the same as the primary.

\(^c\) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than 1, as determined in accordance with Appendix H of the Ozone NAAQS.