Clean air act and National Ambient Air Quality Standards (NAAQS)

Ozone: Sources/Environmental Effects

Particulates (PM): Sources/Environmental Effects
National Ambient Air Quality Standards (NAAQS)

The Clean Air Act requires EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. Established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards (OAQPS) has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants.
Clean Air Act (CAA) Goals

Protecting and promoting human health & public welfare by:

- Mitigating potentially harmful human and ecosystem exposure to six criteria pollutants: CO, NO₂, SO₂, O₃, PM(2.5, 10), and lead (Pb).
- Limiting the sources of and risks from exposure to HAPs (air toxics).
- Protecting and improving visibility impairment in wilderness areas and national parks.
- Reducing the emissions of species that cause acid rain, specifically SO₂ and NOx.
- Curbing the use of chemicals that have the potential to deplete the stratospheric O₃ layer.
The Air Pollutants of Concern in AQM

- Carbon monoxide (CO)
- Sulfur dioxide (SO$_2$)
- Nitrogen dioxide (NO$_2$)
- Particulate matter (PM)
- Ozone (O$_3$)
- Lead (Pb)
- Air toxics (solvents, fuels, metals, etc.)
- Haze (visibility)

“criteria” pollutants

EPA must describe the characteristics and potential health and welfare effects of these pollutants.
### NAAQS Effective January 2003

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Primary Standard (Health-Based)</th>
<th>Secondary Std (Welfare-Based)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td><strong>Type</strong>&lt;br&gt;Annual arithmetic mean&lt;br&gt;24-hr avg not to be exceeded more than 1/yr on avg over 3yr</td>
<td><strong>Type</strong>&lt;br&gt;Level&lt;br&gt;50 µg/m³&lt;br&gt;Same as primary</td>
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<tr>
<td>PM2.5</td>
<td><strong>Type</strong>&lt;br&gt;Spatial and annual arithmetic mean in area&lt;br&gt;98th percentile of 24-hr avg&lt;br&gt;3-yr avg of the annual fourth highest daily 8-hr average</td>
<td><strong>Type</strong>&lt;br&gt;Level&lt;br&gt;15 µg/m³&lt;br&gt;Same as primary</td>
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<tr>
<td>O3</td>
<td><strong>Type</strong>&lt;br&gt;Maximum daily 1-hr avg to be exceeded no more than 1/yr averaged over 3 consec years&lt;br&gt;3-yr avg of the annual fourth highest daily 8-hr average</td>
<td><strong>Type</strong>&lt;br&gt;Level&lt;br&gt;0.12 ppm&lt;br&gt;Same as primary</td>
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<tr>
<td>NO2</td>
<td><strong>Type</strong>&lt;br&gt;Annual arithmetic mean</td>
<td><strong>Type</strong>&lt;br&gt;Level&lt;br&gt;0.053 ppm&lt;br&gt;Same as primary</td>
</tr>
<tr>
<td>SO2</td>
<td><strong>Type</strong>&lt;br&gt;Annual arithmetic mean&lt;br&gt;24-hr average</td>
<td><strong>Type</strong>&lt;br&gt;Level&lt;br&gt;0.03 ppm&lt;br&gt;3-hr&lt;br&gt;0.50 ppm</td>
</tr>
<tr>
<td>CO</td>
<td><strong>Type</strong>&lt;br&gt;8-hr (not to be exceeded more than once per year)&lt;br&gt;1-hr (not to be exceeded more than once per year)</td>
<td><strong>Type</strong>&lt;br&gt;Level&lt;br&gt;9 ppm&lt;br&gt;No secondary&lt;br&gt;35 ppm&lt;br&gt;No secondary</td>
</tr>
<tr>
<td>Lead</td>
<td><strong>Type</strong>&lt;br&gt;Maximum quarterly average</td>
<td><strong>Type</strong>&lt;br&gt;Level&lt;br&gt;1.5 µg/m³&lt;br&gt;Same as primary</td>
</tr>
</tbody>
</table>

[http://www.epa.gov/air/criteria.html](http://www.epa.gov/air/criteria.html)
Four Topics of Concern for AQM

1. Elevated concentrations of ground-level ozone.

2. Elevated concentrations of fine particulate matter.

3. Emissions of air toxics and bio-accumulators (cause cancer, birth defects etc…).

4. Emissions of greenhouse gases and global climate change.
Ozone: $O_3$

Nonattainment and Maintenance Areas in the U.S.
8-hour Ozone Standard

0.075 ppm

293 Counties, 132 million people

http://www.epa.gov/air/oaqps/greenbk/o8index.html
Ozone is Regional: High in SE US

0.075 ppm 8h standard, 0.12 ppm 1 hr standard
Source of Trop. Ozone

\[ \mathrm{NO}_x \] 
oxides of nitrogen 
(NO + NO\(_2\))

\[ \text{hv} \] 
(sunlight)

\[ \text{O}_3 \]

VOCs
Volatile organic compounds
O₃ Adverse Health Effects (Acute)

Inhaled, even at very low levels can cause acute respiratory problems
1. Aggravate asthma.
2. Significant temporary decreases in lung capacity of 15 to over 20 percent in some healthy adults.
3. Inflammation of lung tissue.
4. Lead to hospital/emergency room visits (10 to 20 percent of all summertime respiratory-related hospital visits in the northeastern U.S. are associated with ozone pollution).
5. Impair body's immune system (more susceptible to respiratory illnesses, including bronchitis and pneumonia).
6. Children at most risk (active, higher volume breath/body mass)
O₃ and Human Health

Experimental study involving human subjects

healthy lung airway

airway inflamed from exposure to ozone

O₃ and Human Health

Asthma at epidemic proportions (esp. children)

Ozone can aggravate asthma causing:
1. More asthma attacks.
2. Increased use of medication.
3. More medical treatment (visits to hospitals & emergency clinics).

http://www.epa.gov/air/oaqps/greenbk/o3co.html#Ozone8
O₃ and Human Health (Chronic Exposure)

New Study in New England Journal of Medicine (March 2009)

- Exposure to high O₃ over life time has cumulative effect.
- Followed 450,000 people over 20 years, 118,000 died.
  - 30% more likely to die from lung related disease if live in smoggy city.
- Study accounts for (44) other factors
  - smoking, alcohol consumption, occupation, neighborhood factors …
O₃ and Ecological Health

1. Interferes with ability of plants to produce and store food.

2. Compromises growth, reproduction, overall plant health.

3. Weakens sensitive vegetation, plants more susceptible to disease, pests, and environmental stresses.

4. Shown to reduce agricultural yields for many economically important crops (e.g., soybeans, kidney beans, wheat, cotton). Effects of ground-level ozone on long-lived species such as trees are believed to add up over many years affecting whole forests or ecosystems.
Aerosols Also Have Many Effects

- Adverse Health
- Acid Deposition
- Haze, visibility reduction
- Aerosols and Climate
PM Air Quality: Regional Context

Visibility Corrected Fine Mass

Source: IMPROVE/NECESAUM/Visibility Data

Fine Mass Monitoring Stations
Visibility Monitoring Stations

ug/m3
15
13
11
9
7
5
3
Exceedances of the PM2.5 NAAQS,

Monitors at which the 1999 annual average PM$_{2.5}$ concentration exceeds (yellow and red) the 15 $\mu$g/m$^3$ annual average PM$_{2.5}$ NAAQS.
PM-2.5 ANNUAL STANDARD
(15 UG/M3)

Counties Exceeding the PM2.5 NAAQS Violations Based on 2000 - 2002 Data


Annual Average PM$_{2.5}$ in Urban Areas, 2002

Annual Average PM$_{2.5}$ in Rural Areas, 2002

Source: IMPROVE Network, 2002
Sources of PM

$\text{h} \nu$ (sunlight)

$\text{NO}_x$

PM

$\text{SO}_2$
Sulfur dioxide

VOCs,
OC & EC
Emissions and PM in the Southeast

- SO$_2$, NOx,
- NOx, AVOCs
- POA, EC
- BVOCs, $H_2O_v$
- BVOCs
- POA, EC, other

Coal Power Plants
Mobile Sources
Forests (Biogenic)
Biomass Burning

JJA-DJF

Goldstein et al, PNAS, 2009
Sources of PM2.5: Atlanta, August 1999

Aerosol Chemistry

- Minerals/Metals: 3
- Elemental Carbon: 10%
- Primary Organics: 20
- Secondary Organics: 20
- Sulfate: 34
- Nitrate: 12
- Ammonium: 1

Questions mark:

??
Health Studies: SOPHIA: Atlanta Epi Study

Participation Status of Atlanta Hospitals, 1993-2004

Paige Tolbert, Emory School of Public Health
Health Studies: Results for All CVD Visits Thru 2000

Diagram showing risk ratios for various pollutants such as PM$_{10}$, O$_3$, NO$_2$, CO, SO$_2$, PM$_{2.5}$, PM$_{2.5}$ metals, PM$_{2.5}$ sulfates, PM$_{2.5}$ acidity, PM$_{2.5}$ OC, PM$_{2.5}$ EC, and OHC, with risk ratios ranging from 0.94 to 1.06.
Health Effects: Example Studies

Dublin, Ireland: death rates and soot (black smoke)

1990 law prohibiting sale of coal

Cardiovascular deaths per 1000 people per year

Clancy et al, 2002
Health Studies Harvard 6 Cities Studies

Normalized Deaths/Year

Normalized to cleanest city, Portage, WI

Dockery et al., NEJM 329 1753, 1993
Health Effects of Transient Events

Acute vs Chronic

Rapid changes in PM due to:
1. Activity; e.g., driving, work related…
2. Plumes

Increased Particulate Air Pollution and the Triggering of Myocardial Infarction

Annette Peters, PhD; Douglas W. Dockery, ScD;
James E. Muller, MD; Murray A. Mittleman, MD, DrPH

Conclusions—The present study suggests that elevated concentrations of fine particles in the air may transiently elevate the risk of MIs within a few hours and 1 day after exposure. Further studies in other locations are needed to clarify the importance of this potentially preventable trigger of MI. (Circulation. 2001;103:2810-2815.)
Health Effects:
Pope et al, NEJM, March 2009

• Every 10 μg/m$^3$ decrease in PM2.5 on average gain 7 months of life.
• Average drop in pollution across 51 metropolitan areas between 1980 and 2000 added ~ 5 more months to people's lives.
• Cities with greatest AQ improvements, greatest increase in life expectancy (e.g., Pitts, 10 mnth increase in life expectancy).
• EPA: PM2.5 decreased an average of 11% between 2000 and 2007.