Air Pollution

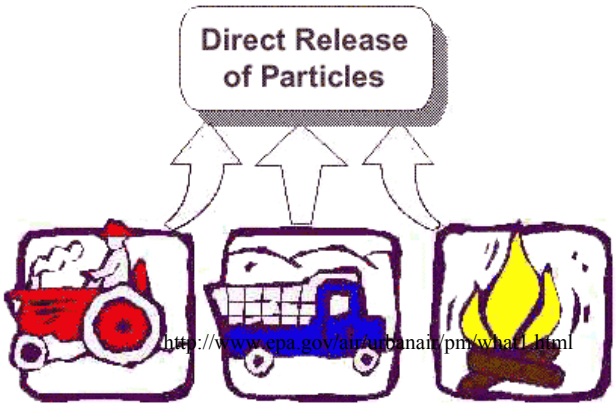
Seven Main Air Pollutants of Concern:

1. P_____
2. S_____ Oxides (SO_X)
3. O_____
4. N_____ Oxides (NO_X)
5. Carbon M_____ (CO and other hyrdrocarbons)
6. Volatile O_____ Compounds (VOCs)
7. L_____ (mercury, other inorganic metals, radon)

Particulates:

– released d_____ into the air
– largely a result of s_____ sources
– a nearly ubiquitous u_____ pollutant.

"Although particulate levels in North America and Western Europe rarely exceed 50 micrograms of particulate matter per cubic meter (μμg/m^3) of air, levels in many Central and Eastern European cities and in many developing nations are much higher, often exceeding 100 μg/m^3 (http://www.wri.org/wr-98-99/urbanair.htm)."



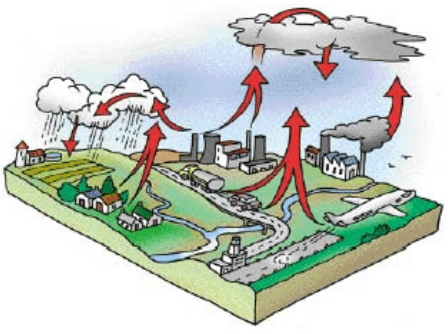
http://www.epa.gov/air/urbanair/pm/what1.html

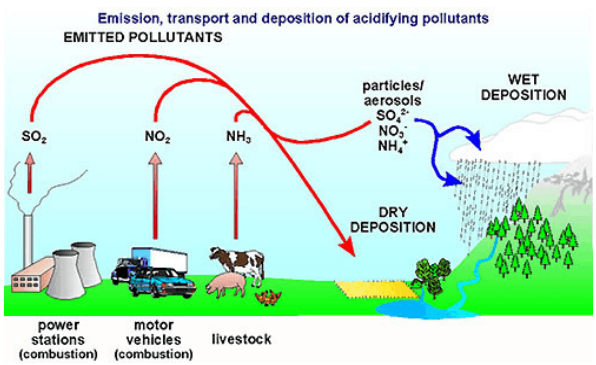
Size of Particulates:

– $PM_{2.5\text{-}100}$: 2.5 to 100 μ in diameter, usually comprise s_____ and d_____t from industrial processes, agriculture, c_____, and road traffic, p_____ and other natural sources.
– $PM_{2.5}$: particles less than 2.5 μ in diameter generally come from combustion of f_____ fuels.
  – vehicle exhaust s_____, which is often coated with various chemical contaminants
  – fine sulfate and nitrate a_____ that form when SO_2 and nitrogen oxides condense in the atmosphere.
  – largest source of fine particles is c_____-fired power plants, but auto and diesel e_____ are also prime contributors, especially along busy transportation corridors.

Health Effects:

– s_____ particulates most damaging ($PM_{2.5}$)
– $PM_{2.5}$ aggravate existing h_____ and lung diseases
– changes the body's defenses against i_____ materials, and damages l_____ tissue.
– e_____ children and those with chronic lung or heart disease are most sensitive
– lung impairment can persist for 2-3 weeks after e_____ to high levels of $PM_{2.5}$
– c_____ carried by particulates can also be toxic



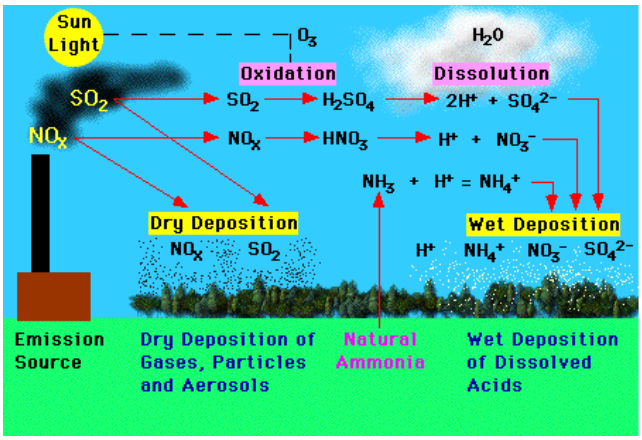


National Ambient Air Quality Standards (NAAQS)

Criteria Pollutants	Standard Type	Avg. Time	Conc.	Health Risks and Concerns	Anthropogenic Sources	Natural Sources
Carbon monoxide	Primary	8 h 1 h	9 ppm 35 ppm	carboxy-hemoglobin (blood)	incomplete combustion from mobile and stationary sources	intermediate in breakdown of methane by hydroxyl radicals (OH·)
Hydrocarbons (measured as CH_4)	Primary	3 h	240 ppb	photochemical smog	incomplete combustion from mobile and stationary sources	see graph
Lead	Primary	24 h 3 month	18 ppb 6 ppb	CNS	leaded gasoline (obsolete?), smelters and refineries	volcanic activity and soils
Nitrogen dioxide	Primary	annual 1 h	53 ppb 250 ppb	health risks, visibility (NO_2 has a brown color)	high temperature combustion	bacterial processes in soil release nitrous oxide N_2O
Ozone	Primary	1 h 8 h	120 ppb 80 ppb	eye irritation, breathing difficulties	formed in nitrogen oxide photolytic cycle (NO_X + sunlight)	
Sulfur dioxide	Primary	annual 24 h	30 ppb 140 ppb	respiratory disease	sulfur in fuel	sulfur released in biological processes
Sulfur dioxide	Secondary	3 h	500 ppb	plant damage, material damage		
Total suspended particulates (TSP)	Primary	annual 24 h	75 µg/m^3 150 µg/m^3	visibility and respiratory effects	combustion of fossil fuels and industrial activity	soil, sea salt, sand, forest fires, volcanoes
Particulates (PM_{10})	Primary	annual 24 h	50 µg/m^3 365 µg/m^3	visibility and respiratory effects		
Particulates ($PM_{2.5}$)	Primary	24 h	65 µg/m^3	visibility and respiratory effects		

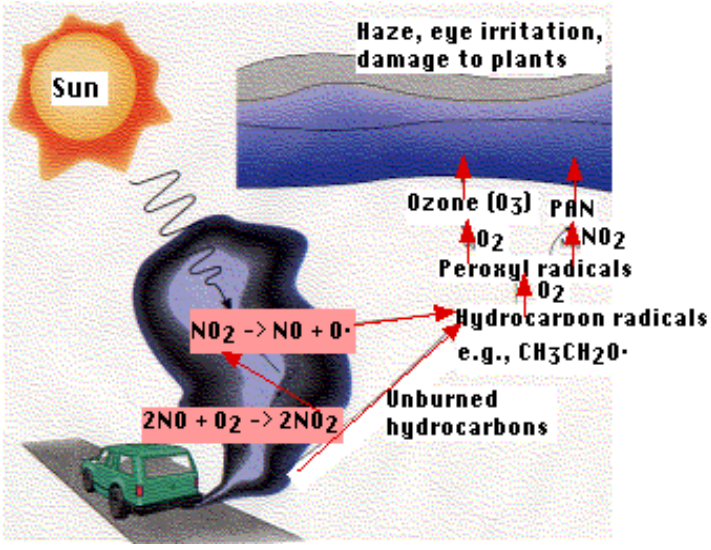
Sulfur Oxides (SO_X, mainly SO_2)

- emitted largely from burning c_____, high-sulfur o_____, and d_____ fuel.
- usually found in association with p_____
- SO2 is the p_____ for fine sulfate particles (separating the health effects of these two pollutants is difficult)
- SO_2 and particulates make up a major portion of the pollutant l_____ in many cities, acting both separately and in c_____ to damage health.
- concentrations are higher by a factor of _____ in a number of cities in Eastern Europe, Asia, and South America, where residential or industrial coal use is still prevalent and diesel traffic is heavy
- major component of a_____ r_____



Health Effects:

- SO_2 affects people q_____, usually within the first few minutes of e_____
- SO_2 exposure can lead to the kind of a_____ health effects typical of particulate pollution.
- Exposure is linked to an increase in h_____ and deaths from respiratory and cardiovascular causes, especially among a_____ and those with preexisting r_____ diseases
- severity of these effects increases with rising SO_2 levels, and e_____ enhances the severity by increasing the volume of SO_2 inhaled and allowing SO_2 to penetrate deeper into the respiratory t_____
- Asthmatics may experience w_____ and other symptoms at much lower SO_2 levels than those without asthma.
- When o_____ is also present, asthmatics become even more sensitive to SO_2 indicating the potential for s_____ effects among pollutants



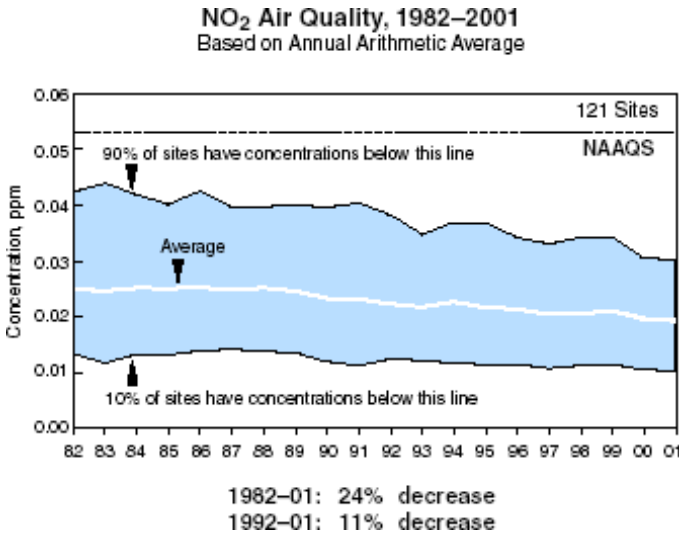
Ozone

- major component of p_____ smog
- formed when N_____ from fuel combustion react with V_____
- s_____ and heat stimulate ozone formation, peak levels occur in the s_____
- w_____ in cities in Europe, North America, and Japan as auto and industrial emissions have increased. Many cities in d_____ countries also suffer from high ozone levels
- powerful o_____, can react with nearly any biological tissue.

– concentrations of 0.012 ppm can irritate the respiratory tract and impair l_____ function, causing coughing, shortness of breath, and c_____ pain.
– Exercise increases these effects, and heavy e_____ can bring on symptoms even at low ozone levels (0.08 ppm).
– ozone exposure l_____ body's defenses, increasing susceptibility to respiratory infections
– hospital a_____ and emergency room visits for respiratory illnesses such as asthma, increase proportionally with ozone levels
– hospital admissions rise roughly 7 to 10 percent for a 0.05 ppm increase in ozone levels.
– in 13 cities where ozone levels e_____ U.S. air standards, the American Lung Association estimated that high ozone levels were responsible for ap proximately 10,000 to 15,000 extra hospital admissions and 30,000 to 50,000 additional emergency room v_____ in 1993-94

Nitrogen Oxides (NO_X, mainly NO_2)

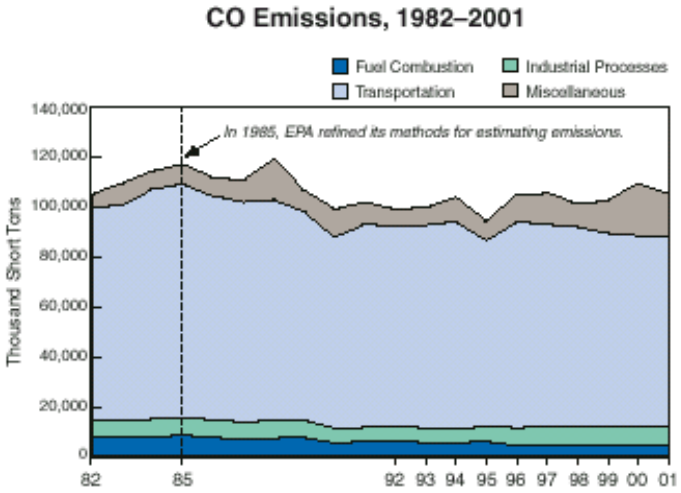
– principal p_____ component of photochemical smog
– component of a_____ rain (NO_X is oxidized to NO_3^- in the atmosphere, NO_3^- reacts with moisture to form nitric acid $H_2 NO_4$)
– formed i_____ due to high temperature of combustion of atmospheric nitrogen



1982–01: 24% decrease
1992–01: 11% decrease

Carbon Monoxide

– H_____ has an affinity for CO that is 200 to 250 times its affinity for oxygen - this reduces its affinity for oxygen, disrupts release of oxygen.
– Blood level of 0.4% is maintained by CO produced by b_____.
– Blood is cleared of 50% of CO in 3-4 hours after e_____.
– Global emissions of CO are 350 million tons per year, 20% from m_____ sources.
– CO concentration in c_____ smoke is ~400 ppm.
– 24% of emergency room patients complaining of f_____-like symptoms in one study showed carbon monoxide poisoning



1982–01: 0% change
1992–01: 6% increase

Volatile Organic Compounds (VOCs)

– contribute to o_____ generation
– many are subject to NESHAPS (benzene from gasoline vapors)
– significant i_____ emissions (e.g., perchloroethylene from d_____ cleaners)
– many are c_____ or suspected carcinogens