# CHAPTER 15: Air Pollution

## CASE STUDY

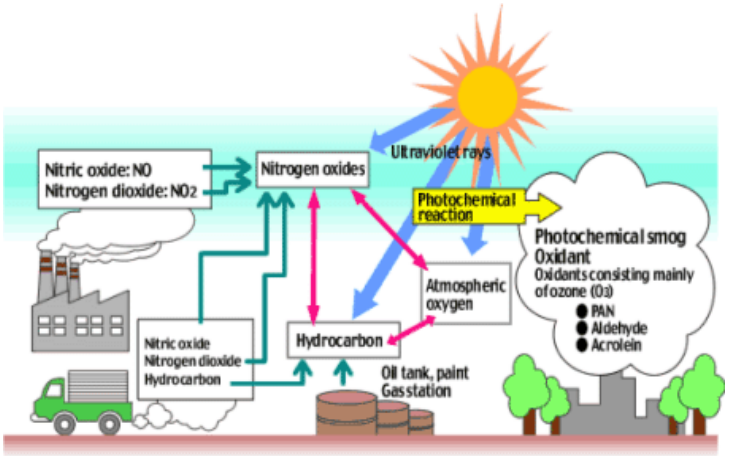
### "Cleaning Up in Chattanooga"

Chattanooga, Tennessee is located along the Tennessee River in a natural basin formed by the Appalachian Mountains. After the Civil War, Chattanooga's industrial was established and quickly boomed. Because it is surrounded by mountains, by 1957 Chattanooga had the 3rd worst particulate pollution in the country. It worsened over the years and eventually Chattanooga enacted it's own air pollution legislation, the Air Pollution Control Ordinance. Since then, recycling programs have taken place, transportation has improved, and the air pollution has receded.

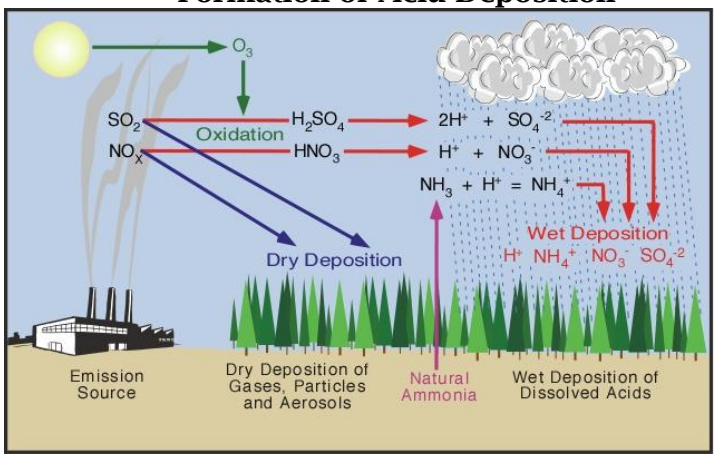
## KEY IDEAS

| MAJOR AIR POLLUTANTS (P.412) | | | |
|---|---|---|---|
| **POLLUTANT** | **SYMBOL** | **HUMAN-DERIVED SOURCES** | **EFFECTS/IMPACTS** |
| **Sulfur Dioxide** | $SO_2$ | Combustion of fuels that contain sulfur (coal, oil, gasoline) | Respiratory ailments. Sulfuric acid in atmosphere can harm aquatic life and vegetation. |
| **Nitrogen Oxides** | $NO_x$ | Combustion of fuel in the atmosphere (fossil fuels, wood) | Respiratory ailments, photochemical smog. |
| **Carbon Monoxide** | CO | Incomplete combustion (malfunctioning exhaust systems, cooking fires) | Restricts oxygen transport in the bloodstream. Headaches, death. |
| **Particulate Matter** | PM | Combustion of coal, oil, diesel, manure, wood. Agriculture, road construction, and activities that mobilize soil, soot, and dust. | Respiratory and cardiovascular disease and reduce lung function. Premature death. Contributes to haze and smog. |
| **Lead** | Pb | Gasoline, oil, coal, old paint | Impairs central nervous system. |
| **Ozone** | $O_3$ | Combination of sunlight, water, oxygen, VOCs, and NOx. | Reduces lung function. Adds a degrading agent to plant surfaces. Damages rubber and plastic. |
| **Volatile Organic Compound** | VOC | Evaporation of fuels, solvents, paints. | A precursor to ozone formation. |
| **Mercury** | Hg | Coal, oil, gold mining. | Impairs central nervous system. Bioaccumulates in the food chain. |
| **Carbon Dioxide** | $CO_2$ | Combustion of fossil fuels and clearing of land. | Affects climate and alters ecosystems by increasing greenhouse gas concentrations. |

**Formation of Photochemical Smog**




**Formation of Acid Deposition**



| STRATOSPHERIC OZONE | | |
|---|---|---|
| **DEPLETION** | **HARMFUL EFFECTS** | **REDUCTION STRATEGIES** |
| • Primarily due to compounds containing halogens (chlorine, bromine, fluorine, iodine)<br>• **Chloroflourocarbons (CFCs)** are used as refrigerants and foam products<br>• Takes about 8 years for a CFC molecule to reach the stratosphere<br>• 1 CFC molecule can destroy 100,000 ozone molecule<br>• Ozone levels have decreased 60% over the Antarctic since 1970's<br>• Average loss of ozone of about 3% per year | • Increase in skin cancer<br>• Increase in cataracts of the eye<br>• Reduction in crop production<br>• Deleterious effects to animals<br>• Increased mutation rates, chromosomal damage, and immune systems<br>• Cooling of the stratosphere<br>• Climate Change | • Tariffs on products produced in countries that allow CFC use<br>• Use HCFCs instead of CFCs<br>• Use alternatives to **halon** fire extinguishers<br>• Use different coolant alternatives<br>• Use pump sprays instead of aerosols<br>• Tax credits for turning in old refrigerators and air conditioners |

**INDOOR AIR POLLUTION**

- Can be greater than outdoor pollution due to the confinement of space.
- **Sources** of contaminants include:
  - Formaldehyde – carpeting, plywood
  - VOCs – paint, solvents
  - Carbon monoxide – faulty gas appliances
  - Lead – old paint flaking and being inhaled
  - Asbestos – flaking asbestos used as insulation for heating ducts and ceiling and flooring tiles
  - Radon – release of radon gas from natural rock sources
- **Symptoms** include:

| | | |
|---|---|---|
| headaches | breathing difficulties | allergies |
| bronchitis | asthma | cancer |
| emphysema | nerve disorders | **sick building syndrome** |

- **Reduction** strategies:
  - Better cleaning products
  - Install air purification systems and ensure fresh air ventilation
  - Add plants that absorb toxins
  - Use natural pest control techniques
  - Maintain all filters and vents
  - Do not allow smoking in the home
  - Monitor humidity levels to reduce mold and mildew
  - Test for radon gas
  - Install a carbon monoxide monitor

**<u>CHAPTER CHECKPOINTS</u>**

**"Air pollutants are found throughout the entire global system."**

- ✓ Air pollutants are considered a global system because the atmosphere is one of the major repositories involved, which enveloped the entire globe.

- ✓ The **major air pollutants** include sulfur dioxide, nitrogen oxides, carbon oxides, particulate matter, and photochemical oxidants (tropospheric ozone), lead and other metals, and volatile organic compounds.
- ✓ **Primary pollutants** are polluting compounds that come directly out of the smokestack, exhaust pipe, or natural emission source (CO,CO2,SO2,NOx, VOCs).

  **Secondary pollutants** are primary pollutants that have undergone transformation in the presence of sunlight, water, oxygen, or other compounds (ozone).

  * Chart below*

**"Air pollution comes from both natural and human sources."**

- ✓ Major **natural sources** of air pollution include volcanoes, lightening, forest fires, and plants.
- ✓ Major **anthropogenic sources** of air pollution include on-road vehicles, power plants, industrial processes, and waste disposal.

**"Photochemical smog is still an environmental problem in the United States."**

- ✓ **Photochemical smog** is the result of the chemical reaction of sunlight with primary pollutants resulting in particulate matter and ground-level ozone.
- ✓ **Thermal inversion** traps air pollution during cold weather.

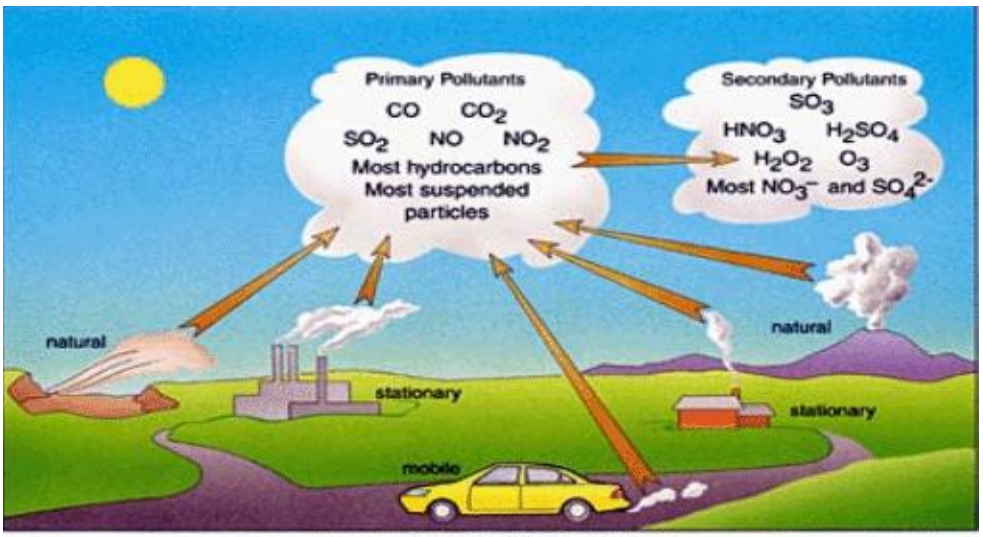
**"Acid deposition is much less of a problem than it used to be."**

- ✓ **Acid deposition** is rain or any other form of precipitation that has a pH less than 7.
- ✓ Caused by human emissions of primary pollutants containing sulfur compounds that react in the air.
- ✓ To reduce acid deposition, emissions produced from vehicles and power plants must be reduced.

**"Pollution control includes prevention, technology, and innovation."**

- ✓ **Pollution control** hints:
  - **Sulfur dioxide** – remove it from coal
  - **Nitrogen oxide** – require catalytic converters in automobiles
  - **Particulate matter** – gravitational settling, baghouse filter, electrostatic precipitator, the scrubber
  - **Smog** – reducing emissions of VOCs in urban areas
- ✓ **Sulfur allowances** are awarded annually to existing sulfur emitters proportional to the amounts of sulfur they were emitting before 1990. At the end of that given year, the emitter must possess a number of allowances at least equal to its annual sulfur emissions or suffer financial penalties.

**Primary and Secondary Pollutants**




Types and sources of air pollutants

**MATH FORMULAS**

**Calculating Annual Sulfur Reduction**

Calculate the total percentage reduction and the annual percentage reduction of SO2

emissions.

**Given:** 23.5 million metric tons – 10.3 million metric tons = 13.2 million metric tons total reduction

**Calculation:**

$$\frac{13.2 \text{ million metric tons}}{23.5 \text{ million metric tons}} \times 100 = \textbf{56\% total reduction}$$

2008 – 1982 = 26 years $\frac{56\%}{26 \text{ years}}$ = **2.2% reduction per year**

## THINGS WE NEED TO WORK ON

1. Reduce use of anthropogenic sources of air pollution.
2. Use cleaner, "greener" cleaning supplies.
3. Enforcing legislation involving the safeguarding of the ozone.
4. Innovate alternative sources for energy emissions.
5. Reduce pollutant emissions formed by industry and urbanization.

## LEGISLATION

**Air pollution Control Act of 1955:**

The nation's first piece of federal legislation regarding air pollution. Identified air pollution as a national problem and announced that research and additional steps to improve the situation were needed. Made the nation more aware of the environmental hazard of air pollution

**Clean Air Act:**

**1963** – Dealt with reducing air pollution by setting emission standards for stationary sources such as power plants and steel mills.

*__Amendments were passed in 1965-1969__ that set standards for auto emissions, expanded local air pollution control programs, established air quality control regions, and authorized research on low emission fuels and automobiles

**1970** – Established new primary and secondary standards for ambient air quality, set new limits on emissions from stationary and mobile sources to be enforced by state and federal governments, and increased funds for air pollution research.

**1990** – Addressed five main areas: air-quality standards, motor vehicle emissions and alternative fuels, toxic air pollutants, acid rain, and stratospheric ozone depletion.

**Kyoto Protocol 1997:**

An agreement among developed nations requiring greenhouse gas reductions. United States has not ratified the protocol.