

Air Pollution & the Urban Heat Island

Air Pollution

- As a by-product of some human and natural activities, undesirable gases, liquids & solids (called air pollutants) may be injected into the atmosphere.
- Emissions are classified into different sources:
- Point Sources: Emissions that come out of smoke stacks, usually large such as Power plants, iron and steel mills, auto manufacturers, etc
- Area sources: Emissions that come from diffuse area, such as storage tanks at petroleum refineries, gas stations, paint shops, solvent use, dry cleaners, residential combustion, forest fires, etc
- Mobile Sources: on and off road vehicles, railways, marine, airlines, etc
- Biogenic Sources: vegetation or other natural sources, such as forest fires (soot), sea salt, soil dust, volcanic ashes and gases (SO₂)
- Top sources of air pollution in the U.S.
 - Transportation
 - Fuel consumption in Stationary sources
 - Industrial processes
 - Solid waste disposal
 - All other stuff

Principal Air Pollutants

- **Carbon Dioxide** is an odorless, colorless gas that forms during the incomplete combination (combustion) of carbon based fuels. Roughly half of the CO_2 is produced by vehicles. Usually CO_2 is quickly removed by micro-organisms, such as in the soil. It can build up to dangerous levels in poorly ventilated structures, tunnels, etc. The main damage to humans is that CO_2 can combine with hemoglobin in the blood and prevent the blood from carrying oxygen to the brain.
- **Sulfur Oxides** consists mainly of sulfur dioxide SO_2 . SO_2 are produced when fossil fuels (coal, oil, natural gas) that contain sulfur are burned. Primary sources include power plants, furnaces, smelters, petroleum refineries & paper mills. Volcanic eruptions also inject SO_2 into the air. SO_2 may combine with H_2O in the air to produce sulfuric acid & contribute to acid rain. SO_2 tends to aggravate respiratory problems like asthma, bronchitis and emphysema.
- **Nitrogen Oxides** are gases that include Nitrogen and Oxygen. They form when nitrogen in the air combines with oxygen during combustion. The primary sources of NOX are vehicles, power plants, and waste disposal systems. The NOX may also combine with H_2O to produce nitric acid. In the presence of UV radiation, some of the oxygen atoms in the NOX may combine to produce ozone, which is another component of photo chemical smog that forms in places like LA. High concentrations of NOX also aggravate respiratory problems.
- **Volatile Organic Components** (VOC) are compounds that contain hydrogen & carbon. Many VOC's also are natural components of the atmosphere, such as methane. Other VOC's are produced during industrial processes & are injected into the atmosphere. The primary health concerns with some VOC's are that they may contribute to certain cancer developments.
- **Particulates** are solid particles & liquid droplets that are small enough to remain suspended in the air. They can be produced by combustion or by industrial processes. Particulates may aggravate respiratory problems or produce other harmful health effects, depending on their chemical composition. Particulates may eventually settle out of the air due to gravity (dry deposition) or they may be washed out of the air by precipitation. Particulates can have many different sizes from 0.01 to 10 micrometers in diameter. The smaller the particles, the deeper they will penetrate into the lungs and blood stream. It is the smallest particles which cause the worst health problems. The size of the particulates also determine how long they will stay in the atmosphere before settling.

- **Chlorofluorocarbons (CFCs)** which contribute to stratospheric ozone depletion
- **Ozone (O₃)** at the ground (as opposed to ozone in the stratosphere), which contributes to photochemical smog

Smog

- London Smog: In 1911 the London Fog, which was combined with Smoke was called SMOG. This very thick, polluted air was the result of soot and sulphate particles from the burning of large amounts of coal.
- The London smog was thought to be responsible for killing 700 people in 1873 and 1150 in 1911. The worst smog event recorded was in 1952 when 4000 people died when the smog stayed in the city for 5 days. People could not see where they were going.
- The Clean Air Act was passed in England in 1956
- Other European and American cities were also affected by air pollution in those days. Some cities in the 1940's were so polluted that headlights had to be turned on during the day!! .
- Los Angeles Smog (Photochemical Smog): This smog is different in nature from the London smog. It is currently found in most industrialized nations with large urban centers. This smog is formed of a mixture of NO_x and VOCs, which in the presence of sunlight and hot temperatures form ozone. Because this ozone, or smog, is formed by photochemical reactions in the atmosphere, it is called Photochemical Smog.
- Photochemical smog = yellowish-brown haze on hot summer days formed when NO_x and VOCs react in the presence of sunlight

Urban Heat Island

- When a city is built, changes are made to the natural environment that affect the temperature:

1. Building materials generally have higher heat capacities (the ability to store heat) than vegetation and soil. This means that buildings, streets and parking lots tend to retain heat longer and to stay warmer than surrounding rural areas, especially at night.

2. Building materials generally have a lower albedo than soil & vegetation. The result is that buildings, streets and parking lots absorb more solar radiation than soil & vegetation. The increased absorption of solar radiation makes the city warmer than surrounding rural areas.

3. Many of the activities that occur in the city generate heat as a waste by product. Vehicles, power plants, industry heat loss from buildings and heat exhaust to the atmosphere by AC are all sources of heat added to the air by human activity. The lower population density of rural areas & differences in human activity generate much less heat. The additional heat produced in the city tends to make it warmer than surrounding rural areas.

4. Storm drainage systems in the city are designed to remove rainfall rapidly from parking lots & streets. The result is that the surface of the city is usually much drier than the surface of the surrounding rural area. There is normally much less evaporation and transpiration from plants in the city. Since water absorbs energy during evaporation, the evaporation tends to cool the air. Less evaporation over cities means that they remain warmer than surrounding rural areas. The relative humidity is also lower over the city.

5. Buildings generally extend further into the atmosphere than most natural vegetation. The buildings in a city obstruct air flow and increase friction. The result is to slow the air & produce lower average wind speeds over the city.

Urban Heat Island

- One of the major effects of all of these changes is to produce warmer temperatures over a city. The warmest temperatures tend to occur near the center of the city & temps gradually become cooler as you move away from the center of the city.
- It can be as much as 8-12°F warmer at the center of a city than in the surrounding areas.
- This warmer center around the city is called the urban heat island. Measurements have shown that the biggest temp differences occur on the calm, clear nights in winter.