



What is Air Pollution?

- the presence of a substance in air that can be harmful to human health and/or damaging to organisms and the environment



- The substances released are called emissions and can consist of gases or tiny particles.

What is Air Pollution?

- Air pollution can occur indoors or outdoors and be from man-made processes or natural processes.

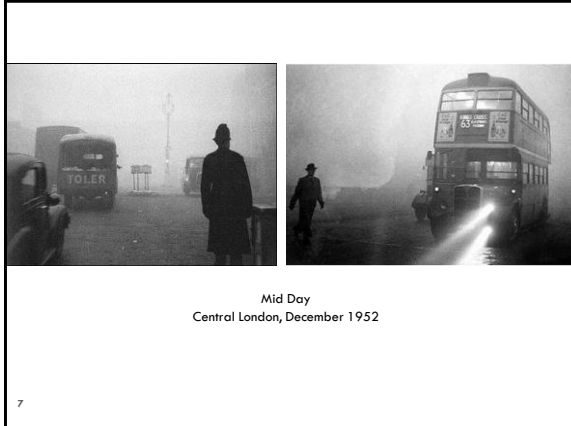


Why Should We Care?

The Great Smog of 1952

- In 1952, an unusually cold winter struck London, England.
- City dwellers were burning high amounts of sulfur-containing coal.
- In December, weather conditions were such that air pollutants became trapped over the city for days, creating a thick smog.

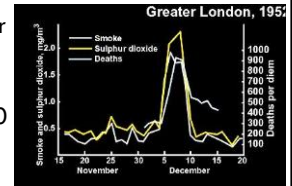




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The Great Smog

- Londoners breathed the heavily polluted air for days, causing many thousands to become sick.
- Especially dangerous for people with respiratory or heart problems, the smog caused over 4,000 deaths (some estimate up to 12,000).



Why Should We Care?

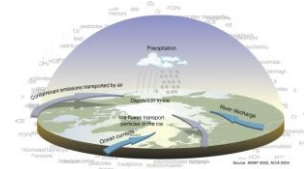
The World Health Organization estimates:

- A billion people live in places where the air is substandard.
- Air pollution kills 7 million people each year
 - (1 in 8 deaths are due to air pollution!)



Why Should We Care?

- ~ 90% of deaths occur in developing countries.
- But air pollution doesn't stay in one place – it can be transported 100s of km making it a global problem.



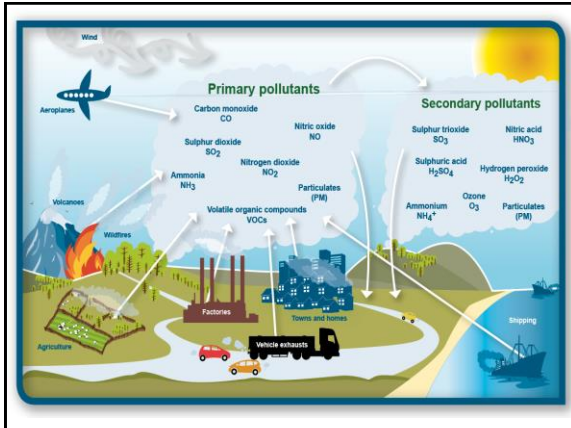
Causes of Outdoor Air Pollution

- Natural processes such as volcanic eruptions and forest fires.
- Human sources as the vehicles we drive, our industries, and how we produce electricity.



Primary vs Secondary Pollutants

- A primary pollutant is an air pollutant emitted directly from a source.
 - Carbon monoxide from vehicle exhaust
- A secondary pollutant forms when primary pollutants react in the atmosphere, either with water vapour or with sunlight.
 - Smog



Carbon Monoxide, CO

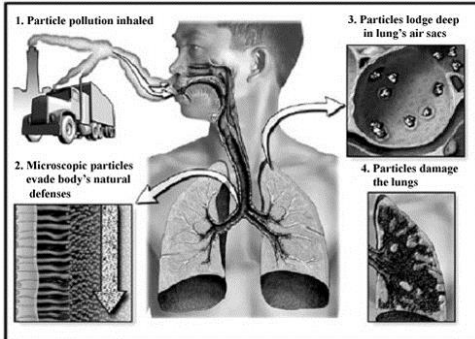
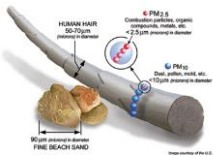
- Colourless, odourless gas formed when wood, gasoline or other fuels are burned
- Primary pollutant coming mostly from vehicle exhaust
- Very dangerous to human health because it reduces the amount of oxygen that blood can carry to cells

Particulate Matter

- Solid particles (ash, dust, soot, molds) or liquid droplets (chemical aerosols) suspended in air



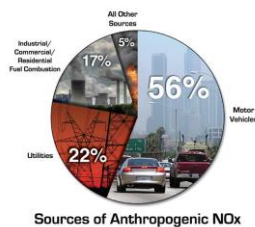
- Range in size from small to microscopic
 - > Particles up to 10 microns PM_{10}
 - > <2.5 microns in diameter are labeled $PM_{2.5}$



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Nitrogen Oxides, NO_x

- Reddish brown gas that readily reacts with other compounds
- Primary pollutant coming from vehicle exhaust, burning fossil fuels and even forest fires



Sources of Anthropogenic NO_x

Nitrogen Oxides

- Can also be a secondary pollutant when it reacts with sunlight to produce smog



Photochemical smog can cause serious haze in a city
(a) Smoggy condition (b) Clean condition

Smog

- Smoke + Fog = Smog
- Smog is the unhealthy mixture of air pollutants that may form over cities and nearby areas.
- Two types: Industrial and Photochemical

1. Industrial Smog

- Industrial smog is a whitish-grey haze produced when sulfur-rich coal is burned and the sulfur compounds combine with water droplets in air.
- Due to government regulations and advances in technology, this type of smog is less common in developed nations and more common in developing nations like China.

Industrial Smog

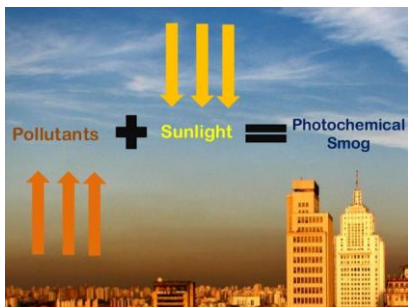


Shanghai People Square, China.

Photochemical Smog

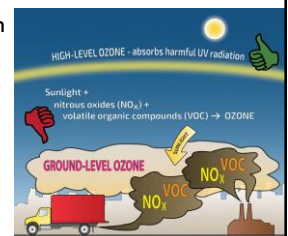
- Photochemical smog is brown-orange haze formed when sunlight acts on certain air pollutants, such as nitrogen oxides.
- Because the initial air pollutants come from vehicle emissions, photochemical smog is associated with large cities in developed nations.
 - Worse during summer months to increase in sunlight

Photochemical Smog



Photochemical Smog

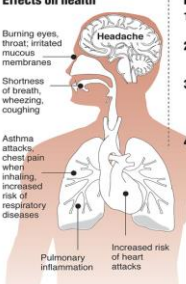
- A major pollutant in photochemical smog is ozone.
“good up high, bad nearby”
- “good” ozone occurs high in the atmosphere to absorb UV radiation
- “bad” ozone is ground level and can damage living tissue



Why smog is harmful

Ozone, the main ingredient in smog, is one of the most widespread air pollutants and among the most dangerous.

Effects on health



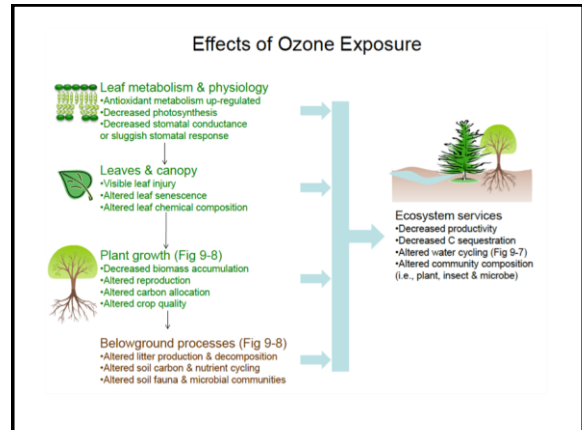
Burning eyes, throat, irritated mucous membranes
Headache
Shortness of breath, wheezing, coughing
Asthma attacks, chest pain when inhaling, increased risk of respiratory diseases
Pulmonary inflammation
Increased risk of heart attacks

How ozone forms

- 1 Oxygen in the atmosphere O_2
- 2 Nitric oxide, byproduct of combustion NO
- 3 Sunlight breaks up nitric oxide N and O
- 4 Ozone formed by three oxygen atoms O_3

U.S. ozone limits	
In parts per billion	
• 1997-2008	84
• 2008-present	75
• New EPA proposal	60-70

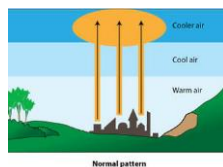
© 2010 MCT
Source: American Lung Association, State of the Air 2009, AP, Graphic: Staff



Smog and Temperature Inversions

Background:

- Air temperature usually decreases with distance above the ground.
- Since warm air rises, airborne pollutants are often carried up into the atmosphere where they disperse.

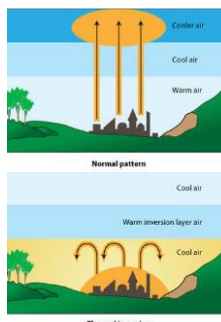


Normal pattern

Smog and Temperature Inversions

In a Temperature Inversion:

- The normal pattern switches and a layer of cool air is trapped beneath a layer of warm air.
- Since cool air is more dense, it cannot rise and thus air pollutants are trapped near Earth's surface.

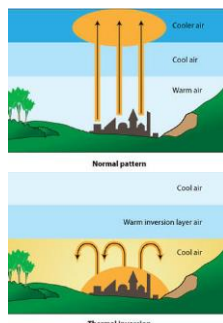


Normal pattern

Thermal inversion

Smog and Temperature Inversions

- Temperature inversions (also called thermal inversions) can thus worsen air pollution.
- It was a thermal inversion that led to the Great Smog of 1952.



Normal pattern

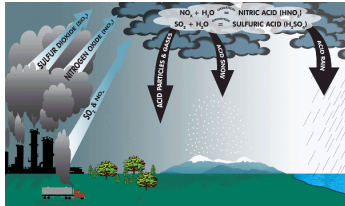
Thermal inversion

Sulfur Dioxide, SO_2

- Colorless gas with a strong "rotten eggs" odor
- Primary pollutant coming from coal-burning power plants
- Can be a secondary pollutant when it reacts with water vapor to produce sulfuric acid (acid deposition)

Acid Deposition

- Results when primary pollutants (SO_2 , NO_x) combine with water in the atmosphere to form sulphuric acid, nitrous acid, and nitric acid



Acid Deposition

- Wet deposition occurs when this acidic solution falls in various forms onto the landscape.
- In areas where the weather is dry, acid chemicals may attach to particles and fall to the ground through dry deposition.

Effects of Acid Deposition

- Acidic soils have their nutrients washed away, slowing the growth of plants.



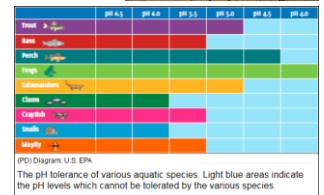
- Acid weakens plant tissues, resulting in defoliation and plant death.

Effects of Acid Deposition

- Certain aquatic plants and animals cannot survive in low pH



- Effects felt up the food chain
- Large loss of biodiversity



Effects of Acid Deposition



- Corrosive effects on buildings, statues and road structures.

Conclusions

- An air pollutant is any gas or particle in the atmosphere that can cause harm or damage to organisms and the environment.
- Primary pollutants are released directly into the air and include CO , PM , SO_2 , and NO_x .
- Secondary pollutants result from the interaction of primary pollutants and include smog and acid precipitation.