

Philadelphia University
Faculty of Engineering
Department of Civil Engineering
First Semester, 2013/2014

ENVIRONMENTAL ENGINEERING 343

Lecture 10:
Air pollution

AIR POLLUTION

○ Atmosphere:

- Contains all the air in earth's system
- It is a mixture of gases that forms a layer of about 250 miles thick around the earth.

Composition:

- Clean Dry Air –
 - 78% nitrogen
 - 21% oxygen,
 - $\text{CO}_2 < 0.0387\%$ (387ppm)
 - Argon 0.93%
 - Neon, He, CH_4 , Hydrogen $< 20\text{ppm}$
- Water vapor up to 4%
- Ozone (O_3)
- Aerosols; tiny solids and liquid particles (Solid particles; e.g., sea salt, fine soils, smoke, pollen, microorganisms and dust from volcanic eruption)

AIR POLLUTION

Definition of Air pollution:

- The phenomena of presence of one or more contaminants in air in such amount and duration that may adversely affect human, animal or plants life, property or comfort
- **Air Pollutants** are airborne particles and gasses that occur in concentrations that endanger the health and well-being of organisms or disrupt the orderly functioning of the environment.



AIR POLLUTION

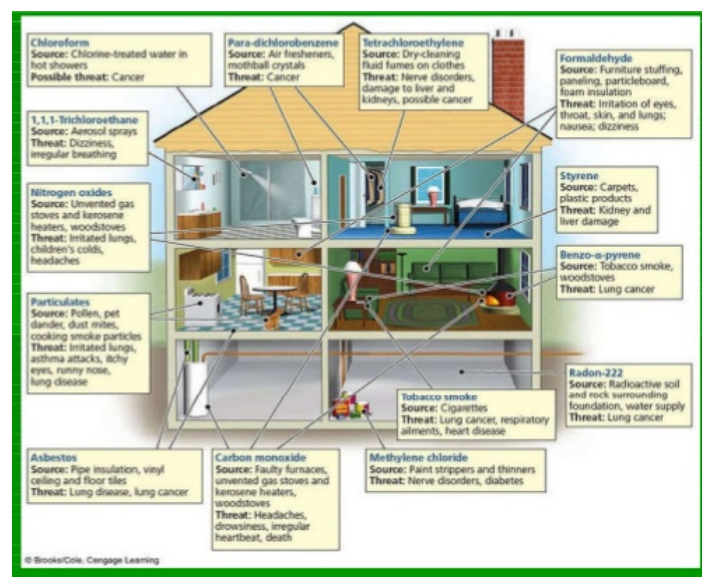
Source of Air pollution

- Natural Sources –Volcano, forest fire, dust storms, etc
- Anthropogenic Sources - created by human beings
 - Stationary sources
 - Point sources (Industrial processing, power plants, fuels combustion etc.)
 - Area sources (Residential heating coal gas oil, on site incineration, open burning etc.)
 - Mobile sources
 - Highway vehicles, railroad locomotives, channel vessels etc.



AIR POLLUTION

- Indoor Air pollution
 - Smoking
 - Stove
 - Insecticide
 - Cosmetics
 - Cleaning Materials
- Outdoor Air pollution
 - Atmospheric Air Pollution
 - Vehicles
 - Factories
 - Volcanic eruption etc



AIR POLLUTION

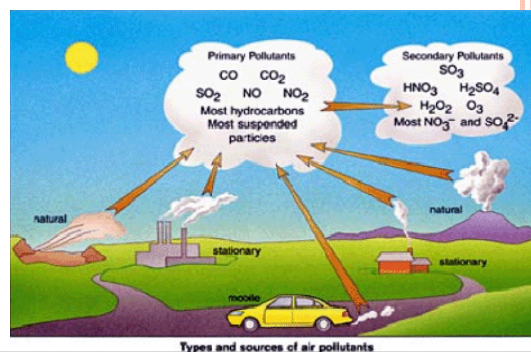
- Units of measurements:
 - Micrograms per cubic meter ($\mu\text{g}/\text{m}^3$)
 - Parts per millions (ppm) or part per billions (ppb)
 - $\text{ppm} = V_p/V_a$

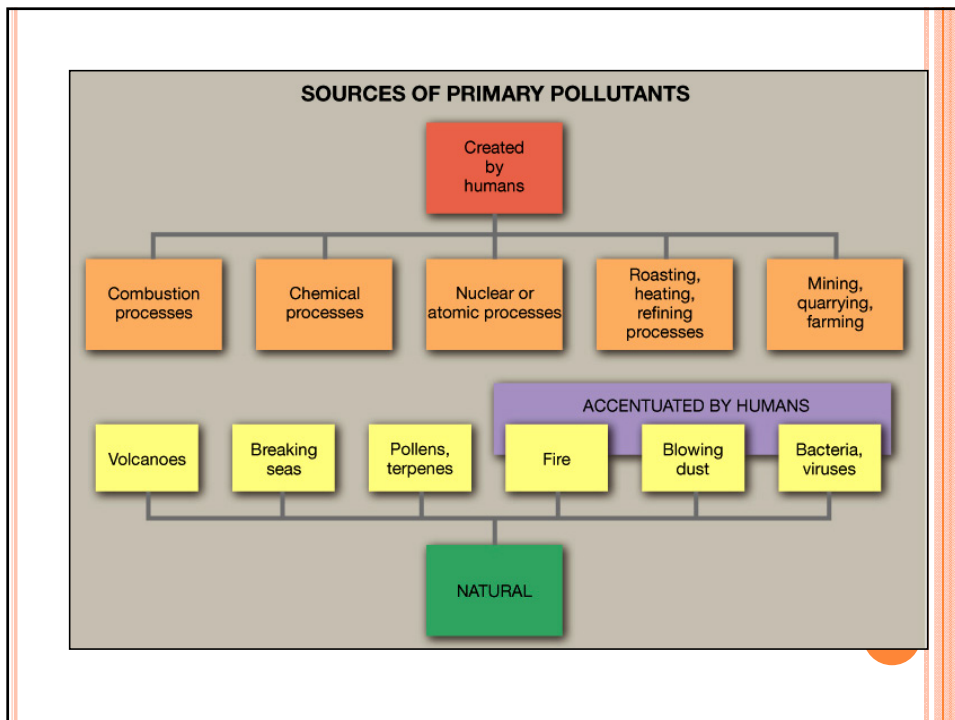
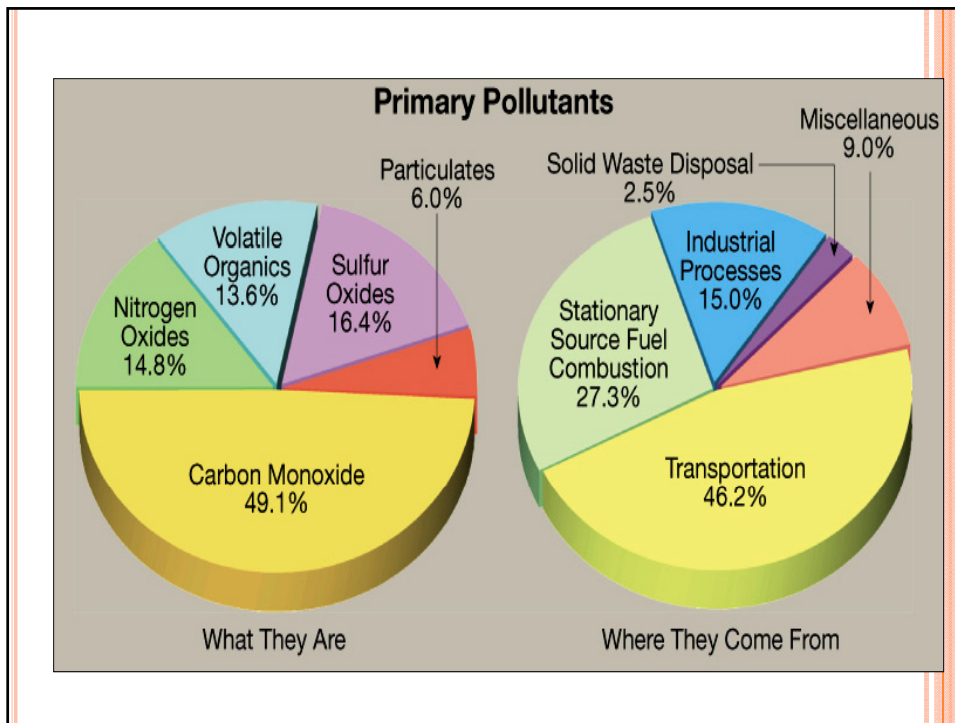
- Particulate matter, size are expressed in, micro; micrometer (μm)



AIR POLLUTANTS

- Air is never perfectly clean.
- Pollutants can be grouped into two categories:
 - (1) **Primary pollutants**, which are emitted directly from identifiable sources; materials released directly into the atmosphere in unmodified forms.
- The 5 major primary pollutants include:
 1. particulate matter (PM),
 2. sulfur dioxide,
 3. nitrogen oxides,
 4. volatile organic compounds (VOCs),
 5. carbon monoxide





AIR POLLUTANTS

- (2) **Secondary pollutants**, which are produced in the atmosphere when certain chemical reactions take place among primary pollutants.

Primary pollutants interact with one another, sunlight, or natural gases to produce new, harmful compounds

- Atmospheric sulfuric acid is one example of a secondary pollutant.
- Air pollution in urban and industrial areas is often called **smog**.
 - **Photochemical smog**, a noxious mixture of gases and particles, is produced when strong sunlight triggers **photochemical reactions** in the atmosphere.
 - The major component of photochemical smog is **ozone**.
- Although considerable progress has been made in controlling air pollution, the quality of the air we breath remains a serious public health problem.

AIR POLLUTANTS - **PRIMARY POLLUTANTS**

1-Carbon Monoxide

- Produced by burning of organic material (coal, gas, wood, trash, etc.)
- Automobiles biggest source (80%)
- Cigarette smoke another major source
- Toxic because binds to hemoglobin, reduces oxygen in blood
- Not a persistent pollutant, combines with oxygen to form CO₂
- Most communities now meet EPA standards, but rush hour traffic can produce high CO levels

AIR POLLUTANTS - PRIMARY POLLUTANTS

2-Sulphur Dioxide

- Produced by burning sulfur containing fossil fuels (coal, oil)
- Coal-burning power plants major source
- Reacts in atmosphere to produce acids
- One of the major components of acid rain
- When inhaled, can be very corrosive to lung tissue
- London
 - 1306 banned burning of sea coal
 - 1952 “killer fog”: 4,000 people died in 4 weeks
- tied to sulfur compounds in smog


AIR POLLUTANTS - PRIMARY POLLUTANTS

3-Nitrogen Oxides (NO₂, NO & N₂O)

- Produced from burning of fossil fuels
- Contributes to acid rain, smog
- Automobile engine main source
- New engine technology has helped reduce, but many more cars


AIR POLLUTANTS - PRIMARY POLLUTANTS

4-Hydrocarbons

- Hydrocarbons - organic compounds with hydrogen and carbon
 - From incomplete burning or evaporated from fuel supplies
 - Major source is automobiles, but some from industry
 - Contribute to smog
 - Improvements in engine design have helped reduce
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AIR POLLUTANTS - PRIMARY POLLUTANTS

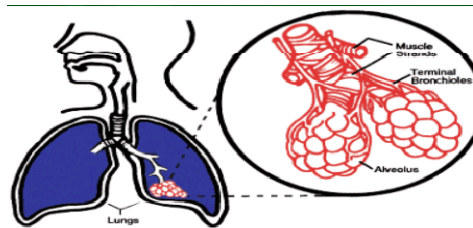
5- Particulates

- Particulates - small pieces of solid materials and liquid droplets (2.5 mm and 10 mm)
 - Examples: ash from fires, asbestos from brakes and insulation, dust
 - Easily noticed: e.g. smokestacks
 - Can accumulate in lungs and interfere with the ability of lungs to exchange gases.
Some particulates are known carcinogens
 - Those working in dusty conditions at highest risk (e.g., miners)
- 

AIR POLLUTION

○ Respirable Suspended Particulate Matter (RSPM) -

- PM1 having size $< 1\mu\text{m}$: effects in alveoli
- PM2.5 having size $< 2.5\mu\text{m}$: effects trachea
- PM10 having size $< 10\mu\text{m}$: effects in nasal part only



AIR POLLUTANTS-SECONDARY POLLUTANTS

- Smog is caused by the interaction of some hydrocarbons and oxidants under the influence of sunlight giving rise to dangerous peroxy acetyl nitrate (PAN)

○ **Photochemical smog**

Photochemical smog is a mixture of pollutants which includes particulates, nitrogen oxides, ozone, aldehydes, peroxyacetyl nitrates (PAN), unreacted hydrocarbons, etc. The smog often has a brown haze due to the presence of nitrogen dioxide. It causes painful eyes-eye irritation.

The EPA has set National Ambient Air Quality Standards (NAAQS) for these Six Criteria Pollutants.

Pollutant	Standard	Type
Carbon Monoxide (CO)		
8-hours average	9 ppm (10 mg/m ³)	Primary
1-hour average	35 ppm (40 mg/m ³)	Primary
Nitrogen dioxide (NO ₂)		
Annual average	53 ppb(100 µgm/m ³)	Primary & secondary
Ozone (O ₃)		
8-hour average	75 ppb(157 µgm/m ³)	Primary & secondary
1-hour average	120 ppb (10 µgm/m ³)	Primary & secondary
Particulate Matter ≤ 10 µm (PM ₁₀)		
Annual average	50 µgm/m ³	Primary & secondary
24-hour average	150 µgm/m ³	Primary & secondary
Particulate Matter ≤ 2.5 µm (PM _{2.5})		
Annual average	15 µgm/m ³	Primary & secondary
24-hour average	35 µgm/m ³	Primary & secondary
Sulfur dioxide (SO ₂)		
Annual average	30 ppb (80 µgm/m ³)	Primary
24-hour average	140 ppb(365 µgm/m ³)	Primary
3-hour average	500ppb(1.3 mg/m ³)	Secondary
Lead (Pb)		
3-month average	1.5µgm/m ³	Primary & secondary

HAVE REGULATIONS HELPED?

- In 1997, the emissions of the five major primary pollutants in the United States were about 31 percent lower than 1970.
- In 1990, Congress passed the **Clean Air Act Amendments**, which further tightened controls on air quality.
- Regulations and standards regarding the provisions of the Clean Air Act Amendments of 1990 are periodically established and revised.

Table 13-2 Air Quality and Emissions Trends, 1988–1997

Pollutant	Percent Decrease in Concentrations	Percent Decrease in Emissions
Carbon monoxide (CO)	38	25
Lead (Pb)	67	44
Nitrogen dioxide (NO ₂)	14	1
Ozone (O ₃)	16	*
Particulate matter (PM ₁₀)	26	12
Sulfur dioxide (SO ₂)	39	12

*Ozone is not emitted directly into the atmosphere but rather is a secondary pollutant.

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343

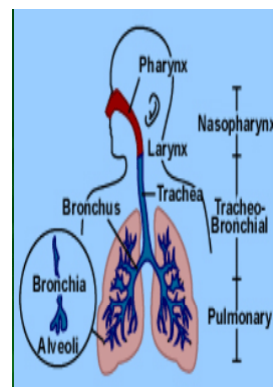
Lecture 12:
Air pollution 2

AIR POLLUTION EFFECTS : HUMAN HEALTH EFFECTS

- Exposure to air pollution is associated with numerous effects on human health, including pulmonary, cardiac, vascular, and neurological impairments.
- The health effects vary greatly from person to person. High-risk groups such as the elderly, infants, pregnant women, and sufferers from chronic heart and lung diseases are more susceptible to air pollution.
- Children are at greater risk because they are generally more active outdoors and their lungs are still developing.
- Exposure to air pollution can cause both acute (short-term) and chronic (long-term) health effects.
- Acute effects are usually immediate and often reversible when exposure to the pollutant ends. Some acute health effects include eye irritation, headaches, and nausea.
- Chronic effects are usually not immediate and tend not to be reversible when exposure to the pollutant ends. - Some chronic health effects include decreased lung capacity and lung cancer resulting from long-term exposure to toxic air pollutants.

EFFECTS ON HUMAN RESPIRATORY SYSTEM

- Both gaseous and particulate air pollutants can have negative effects on the lungs.
- Solid particles can settle on the walls of the trachea, bronchi, and bronchioles.
- Continuous breathing of polluted air can slow the normal cleansing action of the lungs and result in more particles reaching the lower portions of the lung.
- Damage to the lungs from air pollution can inhibit this process and contribute to the occurrence of respiratory diseases such as bronchitis, emphysema, and cancer.



Dangers of lead and arsenic poisoning

Arsenic poisoning

Nerve damage

Skin damage:

- Hyperkeratosis (scaling skin)
- Pigment changes

Increased cancer risk:

- Lung
- Bladder
- Kidney and liver cancers

Circulatory problems in skin


Lead poisoning

High levels of lead

- Mental retardation, coma, convulsions and death

Low levels of lead

- Reduced IQ and attention span, impaired growth, reading and learning disabilities, hearing loss and a range of other health and behavioral effects.




Sources: Alliance to End Childhood Lead Poisoning and news wires The Denver Post


SOURCES, HEALTH AND WELFARE EFFECTS FOR CRITERIA

Pollutant	Description	Sources	Health Effects	Welfare Effects
Carbon Monoxide (CO)	Colorless, odorless gas	Motor vehicle exhaust, indoor sources include kerosene or wood burning stoves.	Headaches, reduced mental alertness, heart attack, cardiovascular diseases, impaired fetal development, death.	Contribute to the formation of smog.
Sulfur Dioxide (SO ₂)	Colorless gas that dissolves in water vapor to form acid, and interact with other gases and particles in the air.	Coal-fired power plants, petroleum refineries, manufacture of sulfuric acid and smelting of ores containing sulfur.	Eye irritation, wheezing, chest tightness, shortness of breath, lung damage.	Contribute to the formation of acid rain, visibility impairment, plant and water damage, aesthetic damage.
Nitrogen Dioxide (NO ₂)	Reddish brown, highly reactive gas.	Motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.	Susceptibility to respiratory infections, irritation of the lung and respiratory symptoms (e.g., cough, chest pain, difficulty breathing).	Contribute to the formation of smog, acid rain, water quality deterioration, global warming, and visibility impairment.
Ozone (O ₃)	Gaseous pollutant when it is formed in the troposphere.	Vehicle exhaust and certain other fumes. Formed from other air pollutants in the presence of sunlight.	Eye and throat irritation, coughing, respiratory tract problems, asthma, lung damage.	Plant and ecosystem damage.
Lead (Pb)	Metallic element	Metal refineries, lead smelters, battery manufacturers, iron and steel producers.	Anemia, high blood pressure, brain and kidney damage, neurological disorders, cancer, lowered IQ.	Affects animals and plants, affects aquatic ecosystems.
Particulate Matter (PM)	Very small particles of soot, dust, or other matter, including tiny droplets of liquids.	Diesel engines, power plants, industries, windblown dust, wood stoves.	Eye irritation, asthma, bronchitis, lung damage, cancer, heavy metal poisoning, cardiovascular effects.	Visibility impairment, atmospheric deposition, aesthetic damage.

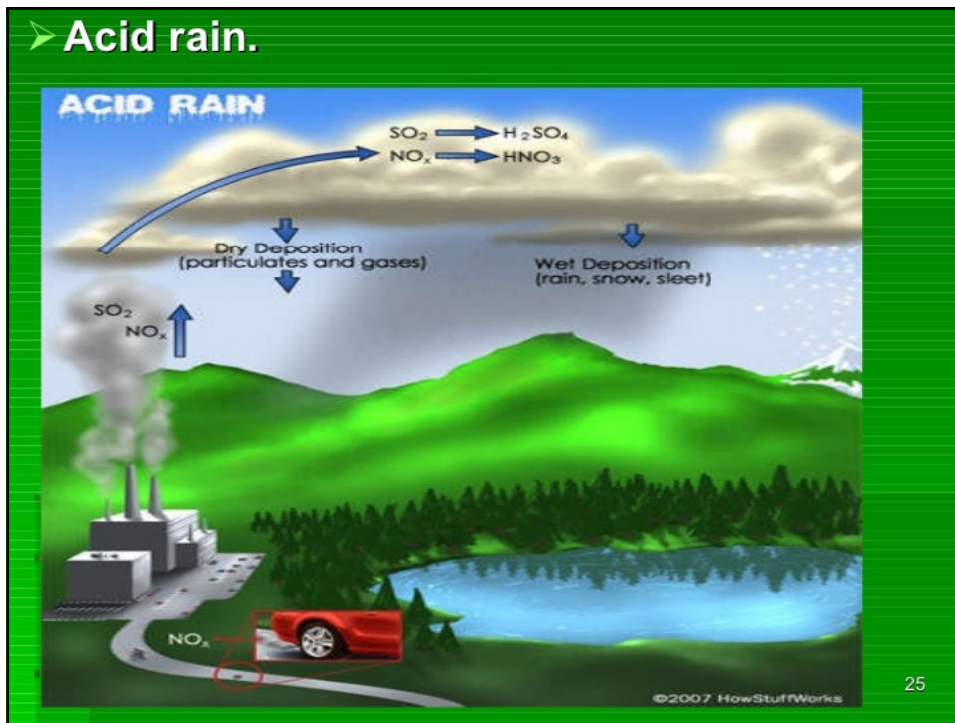
ACID PRECIPITATION

- In most areas within several hundred kilometers of large centers of human activity, the pH value is much lower than the usual value found in unpopulated areas.
 - This acidic rain or snow, formed when sulfur and nitrogen oxides produced as by-products of combustion and industrial activity are converted into acids during complex atmospheric reactions, is called **acid precipitation**.
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ACID PRECIPITATION (CONT.)

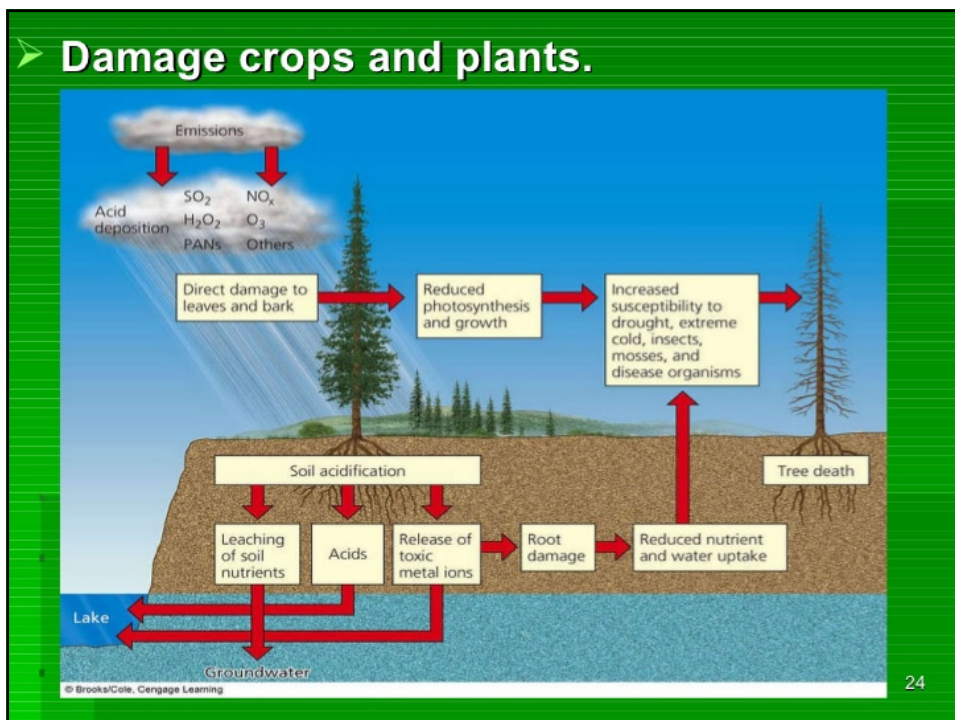
- The atmosphere is both the avenue by which offending compounds travel from sources to the sites where they are deposited and the medium in which the combustion products are transformed into acidic substances.
 - Beyond possible impacts on health, the damaging effects of acid precipitation on the environment include the lowering of pH in thousands of lakes in Scandinavia and eastern North America.
 - Besides producing water that is toxic to fish, acid precipitation has also detrimentally altered complex ecosystems by many interactions at many levels of organization.
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➤ Acid rain.



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➤ Damage crops and plants.

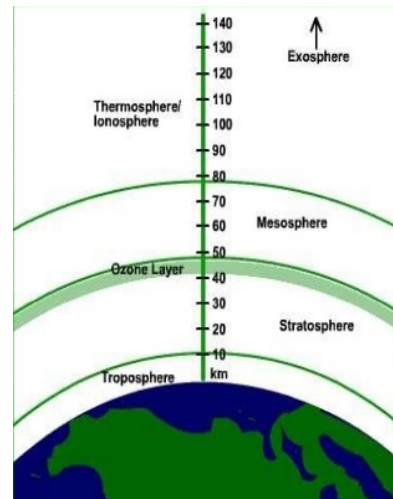


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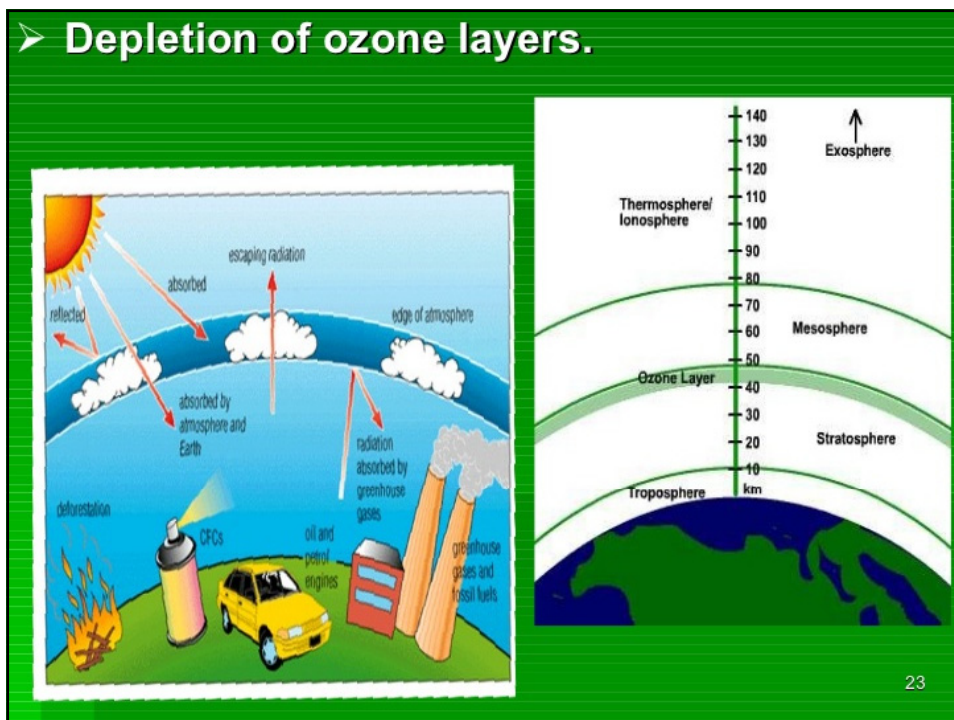
AIR POLLUTANTS-SECONDARY POLLUTANTS

○ Ozone

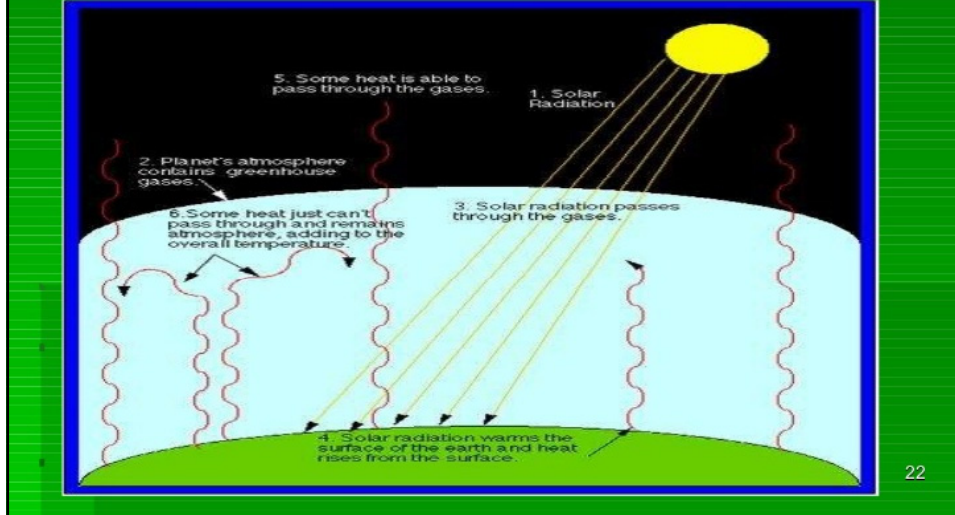
- Ozone (O_3) is a highly reactive gas composed of three oxygen atoms.
- It is both a natural and a man-made product that occurs in the Earth's upper atmosphere (the stratosphere) and lower atmosphere (the troposphere).



➤ Depletion of ozone layers.



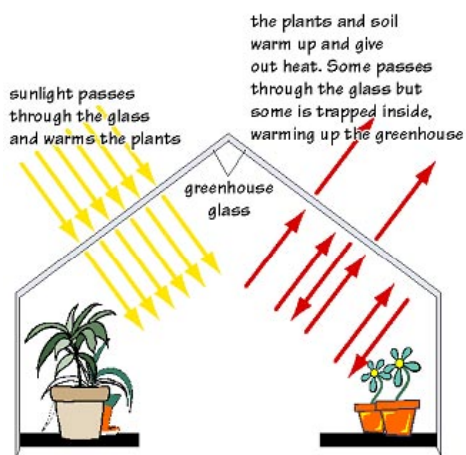
- Green house effect which increase average temperature.
- Global warming.



GLOBAL WARMING IS ALSO CALLED:

THE GREENHOUSE EFFECT!

So what is a greenhouse? How does it work? What has this got to do with global warming then??



So what is the Green house Effect?

Our earth is surrounded by a layer of gases called greenhouse gases which are naturally occurring (in other words they are meant to be there and would be there whether humans were on the planet or not!) Their job is to keep the planet at a nice warm temperature - in fact without them there would be no little life on our planet as the temperature would be 33 c colder and far too cold for plants and animals to survive. The main gases that make up this layer are carbon dioxide, methane, CFC and nitrous oxide. This layer of gas acts like the roof of a greenhouse and that is why it is called the greenhouse effect. They allow the sun's heat to pass through easily and warm the planet but they do not allow much to escape back into space thus keeping us all warm and able to survive.

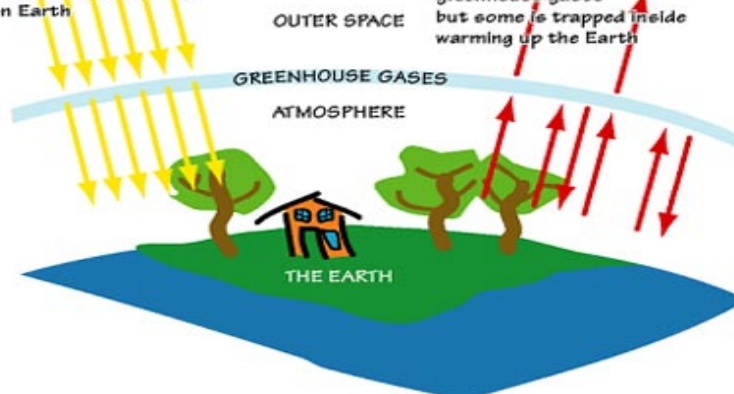


Think about the greenhouse as if it was the planet and this is....

GLOBAL WARMING

sunlight passes through the greenhouse gases and warms everything on Earth

the Earth warms up and gives out heat. Some passes through the greenhouse gases but some is trapped inside warming up the Earth



Human activity is adding more gases to the naturally occurring layer of greenhouse gases. This thickens it so it cannot let as much heat return to space and so the temperature of the earth gradually increases.....

GLOBAL WARMING!

What are greenhouse gases?

Name of gas	Contribution	Source(s)
Carbon dioxide (CO ₂)	50%	From burning coal and oil, and the removal of vegetation
Chlorofluorocarbons (CFCs)	20%	From air conditioners, refrigerators and aerosols
Methane (CH ₄)	16%	From rice growing, animal waste, swamps and landfills
Ozone (O ₃)	8%	From air pollution
Nitrous oxide (N ₂ O)	6%	From fertilizers and burning of coal and oil



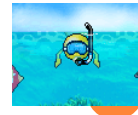
MANY OF THE WORLD'S ISLANDS ARE ALREADY DISAPPEARING BENEATH THE SEA.



The tiny island nation of the Maldives is in trouble. If global warming continues, say scientists, the country could sink beneath the ocean within 100 years. The average height of the islands above sea level is 1.5 metres and the rate of sea level rise is currently 59cm per century.



Global warming causes the polar ice sheets melt. It increases the sea-level. It will possibly rise 18 cm by 2030 and 58 cm by 2090. **Flooding** will probably occur in lowlands. Many cities along the coast may be under sea water.



EVIDENCE FOR GLOBAL WARMING

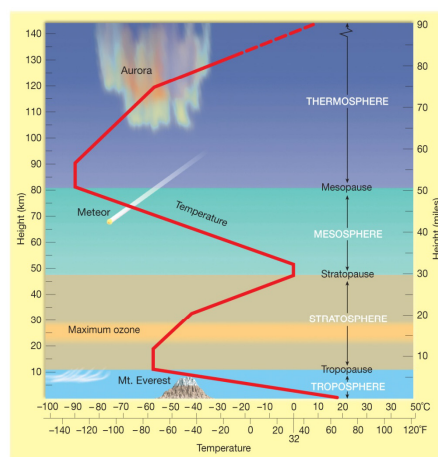
- **Since 1860**
 - **CO₂ concentration in atmosphere has increased by 24%**
 - **CH₄ concentration in atmosphere has doubled**
 - **Mean global temperature has increased by 2°F**
 - **10 hottest days on record have occurred since 1980**
- **Our Earth is warming.** Earth's average temperature has risen by 1.4°F over the past century, and is projected to rise another 2 to 11.5°F over the next hundred years. Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather.



ENVIRONMENTAL EFFECTS OF GLOBAL WARMING

- Average temperature will increase by 2 to 6°F in next century
- An increase in extreme weather events
 - Droughts, floods etc.
 - Concern for insurance industry
- Sea levels will increase .5 to 3 feet
 - Threaten coastal resources, wetlands, and islands
 - Saline water will pollute water supplies of coastal cities
- Increased range of diseases associated with tropical climates
 - Malaria, dengue fever, and yellow fever will occur at higher latitudes
- Heat stress and death of humans and animals
 - Particularly a concern in elderly
 - Increases air conditioning needs
- Rapidly reproducing species of weeds, rodents, insects, bacteria and viruses may occur at higher latitudes
- Crop may be susceptible to new insect and disease problems
- Reduced forest health and changes in tree species

THERMAL STRUCTURE OF THE ATMOSPHERE



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Figure 16.8