

# Energy and Environment Engineering

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# Energy and Environmental Engineering CEME106

## ENVIRONMENT AND ECOSYSTEMS

Introduction: Concept of an ecosystem- structure and functions of ecosystem. Components of ecosystem - producers, consumers, decomposers, Food chains, food webs, ecological pyramids, Energy flow in ecosystem. Bio-geo- chemical cycles, Hydrologic cycle Components of Environment and their relationship, Impact of technology on environment, Environmental degradation. Environmental planning of urban network services such as water supply, sewerage, solid waste management.

## ENVIRONMENTAL POLLUTION

Water, air, soil, noise, thermal and radioactive, marine pollution: sources, effects and engineering control strategies. Drinking water quality and standards, Ambient air and noise quality standards

## GLOBAL ENVIRONMENTAL ISSUES AND ITS MANAGEMENT

Engineering aspects of climate change. Acid rain, depletion of ozone layer. Concept of carbon credit. Concepts of Environmental impact assessment and Environmental audit. Environmental life cycle assessment

# **Air Pollution**

# Introduction

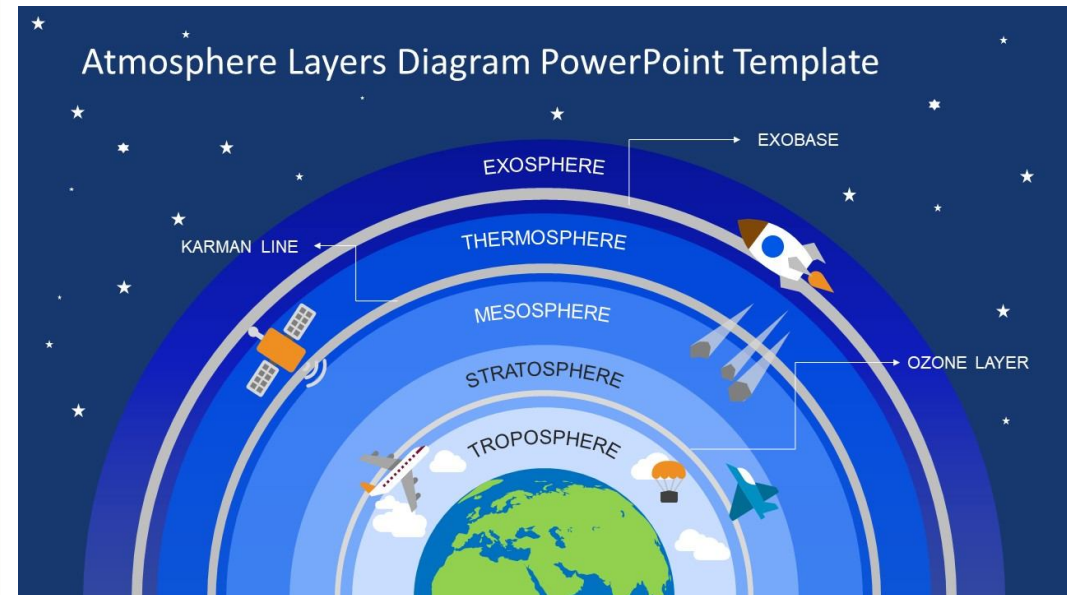
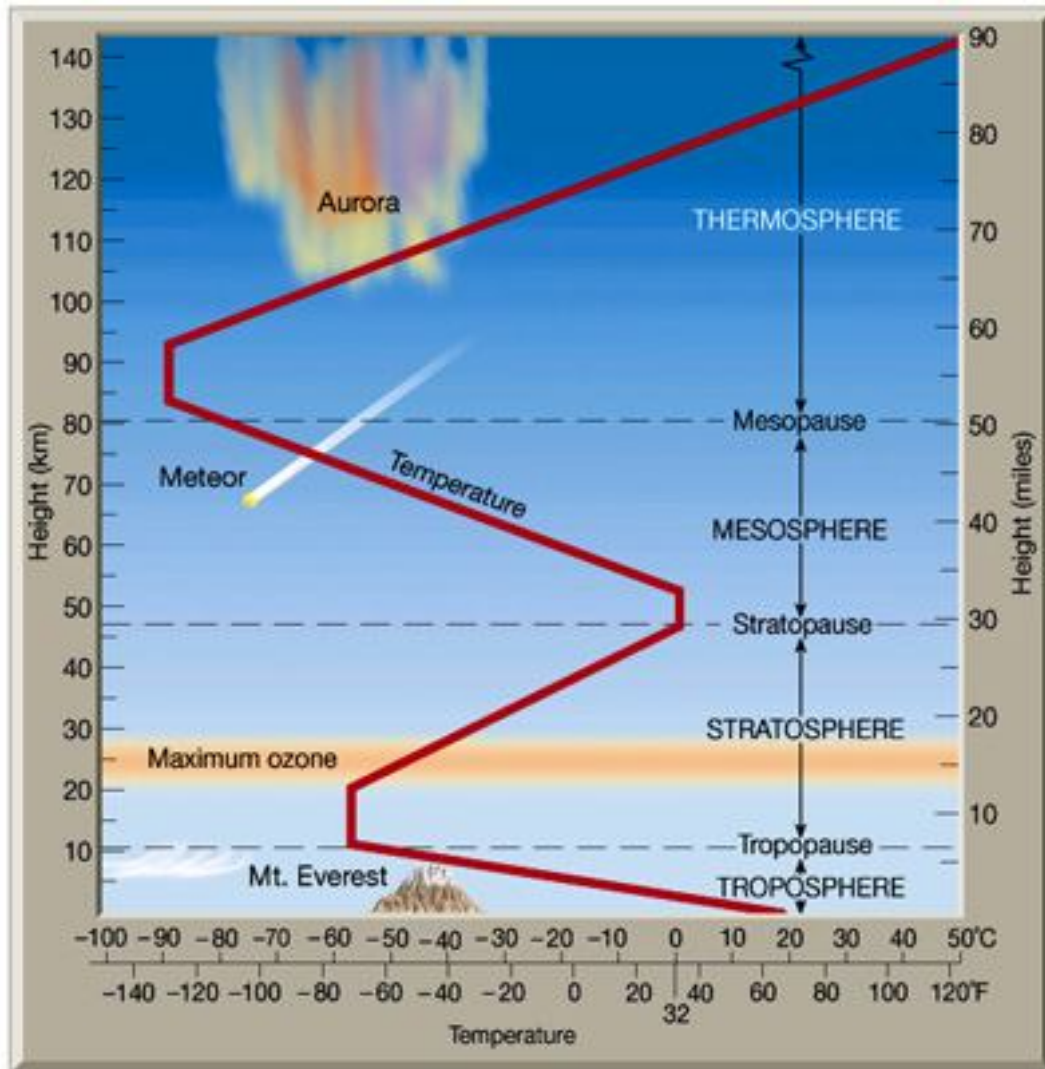
❖ Air is essential for life itself, without it we could survive only a few minutes.

**Pollutant:** Any substance beyond the assimilating capacity of the system.

**“Air pollutant”** as any substance emitted into the air from an anthropogenic, biogenic, or geogenic source, that is present in higher concentrations than the natural atmosphere, and may cause a short-term or long-term adverse effect.



**Different types of Sphere**

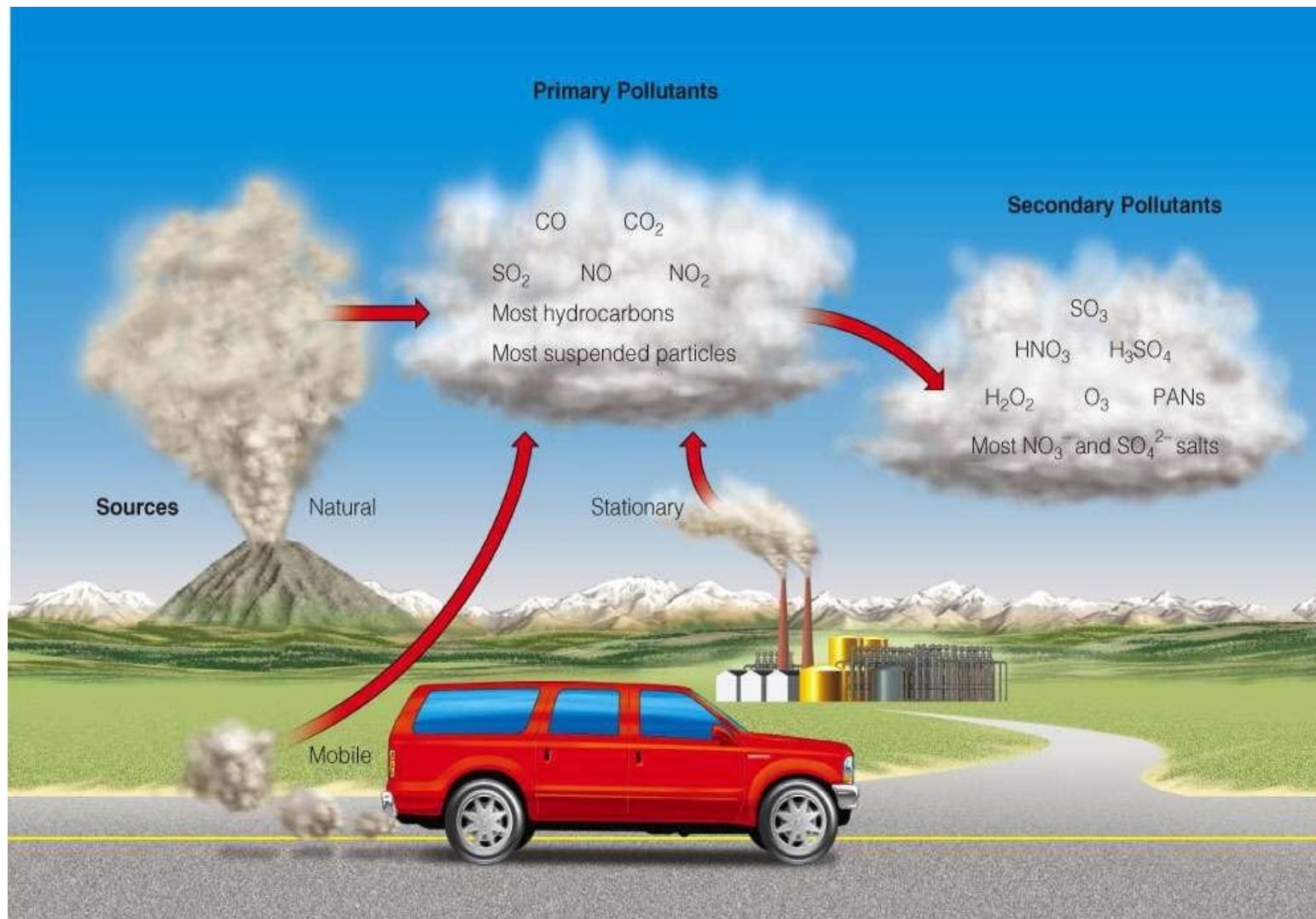


Sphere with temperature profile and height

# Components of our atmosphere

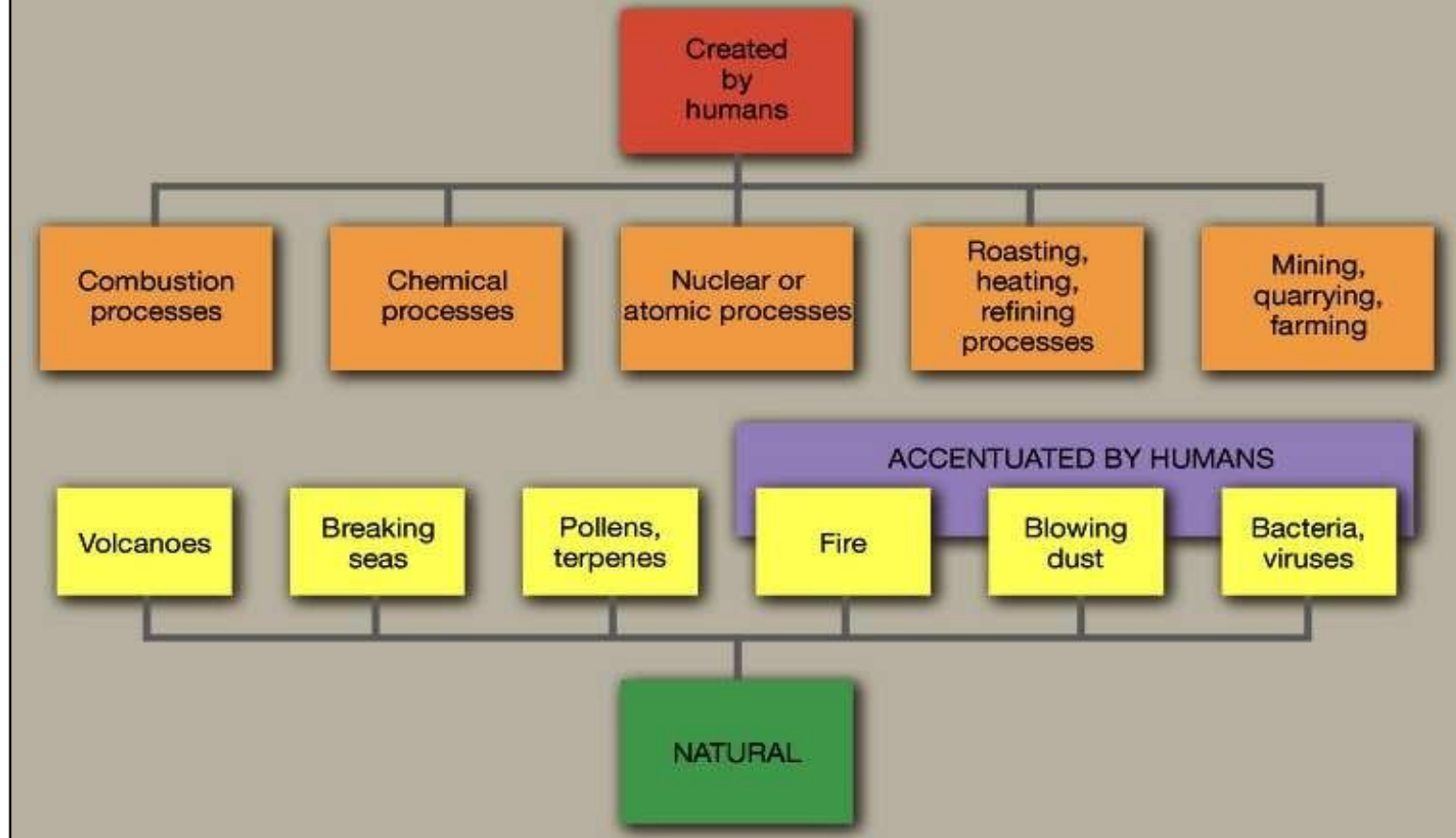
- Nitrogen - 78.1%
- Oxygen - 20.9%
- Carbon dioxide - 0.03%
- Everything else - 0.07%
  - ❖ Noble gases (krypton, xenon, argon, helium)
  - ❖ Methane
  - ❖ Sulfur dioxide

This is approximate concentration of gases in the atmosphere in natural environment





## SOURCES OF PRIMARY POLLUTANTS



# Air Pollution

**Air Pollution** can be defined as “ degradation of natural atmospheric composition by any means of anthropogenic, geogenic , or biogenic sources, which may cause a short-term or long-term adverse effect to both human beings and flora & fauna”.

- Air pollution consists of gases, liquids, or solids present in the atmosphere in high enough levels to harm humans, other organisms, or materials may be defined as any atmospheric condition in which certain substances are present in such concentrations that they can produce undesirable effects on man and his environment.
- Any visible or invisible particle or gas found in the air that is not part of the original, normal composition.
- Air pollutants may be either emitted into the atmosphere or formed within atmosphere itself
- Primary air pollutants: Sources such as factory chimney or exhaust pipe.
- Secondary air pollutants: Ex ozone.

# Sources of Air Pollution

## Natural:

- Volcanic eruption ( ash and Dust)
- Forest burning ( Ash and Smoke)
- Dust

## Anthropogenic / Manmade:

- Industrial sources
- Vehicular sources
- Domestic sources
- Area/volume sources



Three-dimensional source of pollutant emissions- Ex Dust emission

Regular ( Point sources -Stack, Tail Pipe)

Fugitive ( non point sources-

Paved/unpaved roads,

Building construction,

Loading/unloading- oil container, solvents, cement bags,

Agriculture activities- spraying of pesticides

Refuse burning- MSW, Leaf burning

Smoking

Material handling / storage - coal

## Sources of Pollution:

### Category-I

1. Natural
2. Manmade

### Category-II

1. Point
2. Non Point
3. Area/ Volume

### Category-III

1. Indoor
2. Outdoor

# Type of Pollutant

**Primary pollutants:** Directly emitted in the atmosphere

- Particulate Matter (PM-10,2.5,1.0)
- Carbon oxides
- Nitrogen oxides
- Sulfur oxides
- Lead, and
- Volatile organic compounds

**Secondary pollutants:** Form from chemical reactions that occur when pollution is exposed to sunlight or reaction of primary pollutant.

- Sulfuric Acid
- Photochemical smog
- Ozone

# Major Air Pollutants

## Carbon monoxide

- It is colorless , odorless gas , a product of incomplete combustion of carbon containing materials, such as in automobiles, industrial process, heating facilities and incinerators

### Effect of CO pollution on the health:

- It causes harmful effect by reducing oxygen delivery to body organ , in extremely high level it can cause death.
- CO's affinity for hemoglobin is 240–270 times greater than oxygen and hemoglobin has higher affinity for CO , so it competes with O<sub>2</sub> to bind (irreversibly) with hemoglobin.
- By this exposure to it reduce the oxygen -carrying capacity of the blood to the heart, brain and other organs .
- Deprives body of O<sub>2</sub> causing headaches, fatigue, etc

## Sulphur dioxide

- It is one of the several forms in which sulphur exists in air like  $\text{H}_2\text{S}$ ,  $\text{H}_2\text{SO}_4$  and sulphate salts.
- Sulphur dioxide results from the combustion of sulphur containing fossil fuel, and when coal and fuel oil are burned.
- Domestic fires can also produce emissions containing sulphur dioxide.
- Acid aerosol - sulphuric acid ( $\text{H}_2\text{SO}_4$ ) is a strong acid that is formed from the reaction of sulphur trioxide gas with water.

## Nitrogen Dioxide

- Nitric oxide ( $\text{NO}$ ) is produced by combustion.
- Nitrogen dioxide ( $\text{NO}_2$ ), which has greater health effects, is a secondary pollutant created by the oxidation of  $\text{NO}$  under conditions of sunlight, or may be formed directly by higher temperature
- Combustion in power plants or indoors from gas stoves.
- Reddish, brown gas present in car exhaust and power plants.

## **Particulate matter :**

- Represents a complex mixture of organic and inorganic substances.
- The monitored size of particles 10µm, 2.5 µm, 1.0 µm in aerodynamic diameter, and fine particles smaller
- The smaller particles contain the secondarily formed aerosols ,combustion particles and recompensed organic and metal vapours.
- The large particles usually contain earth's crustal material and fugitive dust from roads and industries.
- Particulate matter of respirable size may be emitted from a number of sources, some of them natural (e.g. dust storms)and many others that are more widespread and more important (e.g., power plants and industrial processes, domestic coal burning, industrial incinerators).

## **Ground level ozone**

- This is formed when pollutants such as nitrogen oxides and volatile organic compounds (VOCs) react in sunlight .
- High levels can cause breathing problems, reduce lung function and trigger asthma symptoms.
- Ground level ozone can also seriously damage crops and vegetation.
- Ozone is a powerful greenhouse gas and contributes to global warming both directly and by reducing carbon uptake by vegetation.

## **Volatile organic compounds**

- VOCs are divided into the separate categories of methane ( $\text{CH}_4$ ) and non-methane (NMVOCs)
- Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming
- NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukaemia through prolonged exposure.

## **Polynuclear aromatic hydrocarbons (PAH) :**

- There are a large group of organic compounds with two or more benzene rings.
- They are formed mainly as a result“ of pyrolytic processes, especially the incomplete combustion of organic materials, as well as in natural processes such as carbonization.
- There are about 500 PAH in the air , the best known is BaP. [Benzo(a)pyrene]

## **Others...**

- Chlorofluorocarbons: (CFCs) - Peroxyacetyl nitrate (PAN)



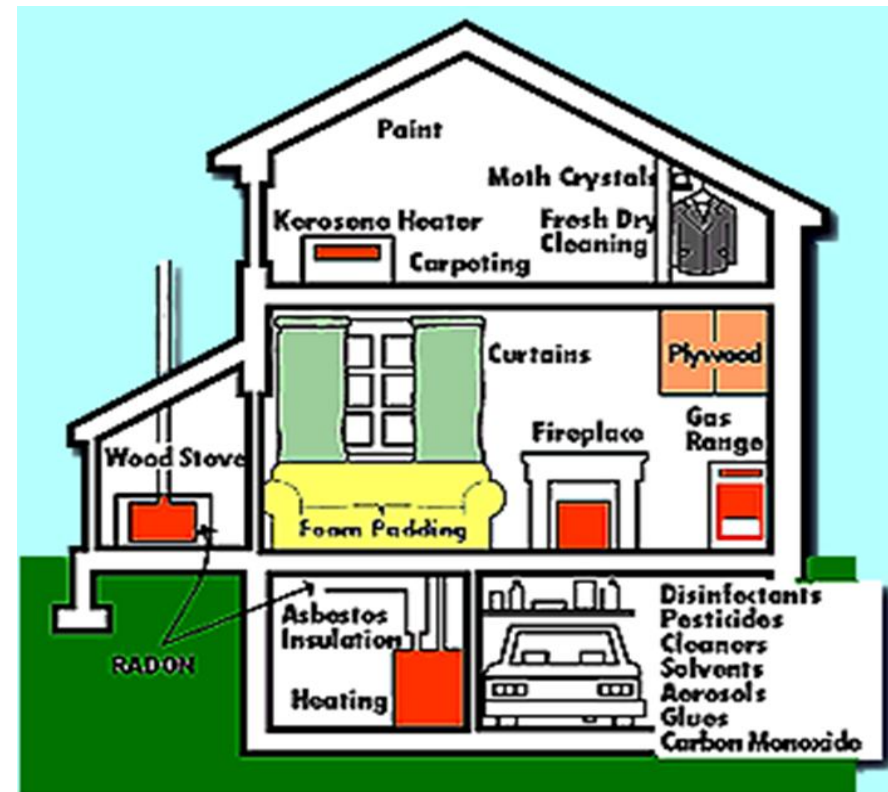
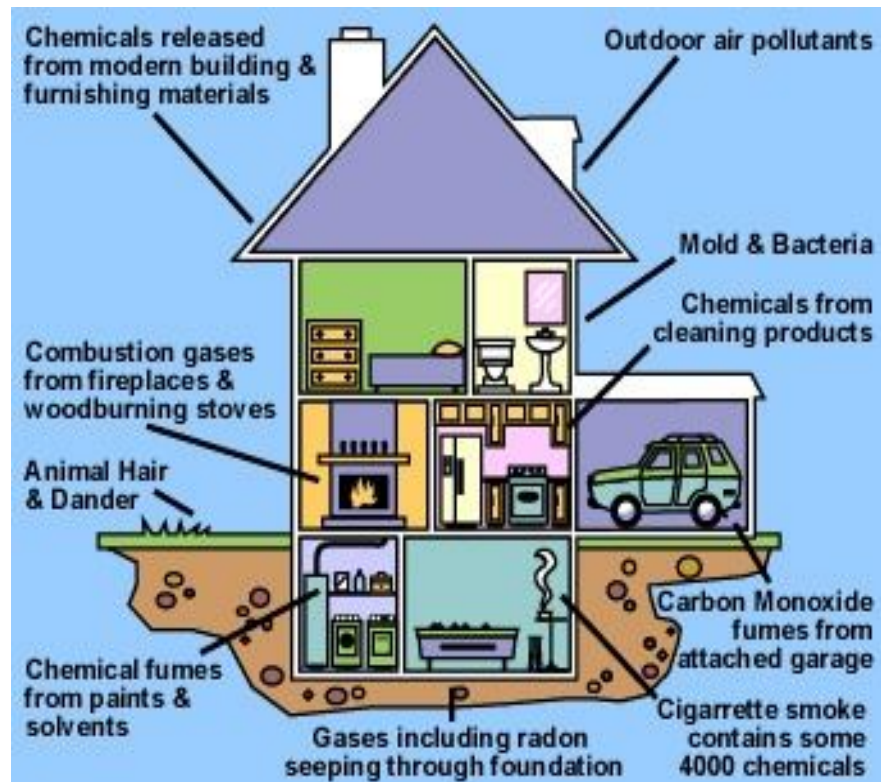
# Indoor Air Pollution

## Fact related to Air Pollution:

- Indoor air pollution is one of the most critical global environmental problems,
- Probably exposes more people worldwide to important air pollutants than does pollution in outdoor air.
- Rural people in developing countries may receive as much as two-thirds (2/3) of global exposure to particulates.
- According to WHO.....
  - Around 3 billion people still cook and heat their homes using solid fuels in open fires and leaky stoves.
  - About 2.7 billion burn biomass (wood, animal dung, crop waste) and a further 0.4 billion use coal.
  - Such cooking and heating produces high levels of air pollution with a range of health-damaging pollutants.
- In poorly ventilated dwellings, indoor smoke can be 100 times higher than acceptable levels for small particles.
- Exposure is particularly high among women and young children, who spend the most time near the domestic hearth

## Major Sources of Indoor Air Pollution

- Kerosene, wood stoves
- Room and water heaters
- Open fire cooking stoves produce heavy smoke containing
- Smoking
- Mosquito Coils
- Solvents and Volatile Organic Compounds
- Biological Pollutants



Different Sources of Indoor Air Pollution

## Major Pollutant in Indoor Air Pollution

- ❖ Fine particles
- ❖ Carbon monoxide (CO)
- ❖ Polycyclic aromatic hydrocarbons (PAHs)
- ❖ Smog
- ❖ SO<sub>x</sub>
- ❖ NO<sub>x</sub>

# Adverse health effect of indoor air pollutants

- ❖ Irritation of the mucous membranes (eyes, nose, throat)
- ❖ Cough, wheeze, chest tightness
- ❖ Increased airway responsiveness to allergens
- ❖ Increased incidence of acute respiratory illness:
  - ❖ Cold, pneumonia, otitis media Tracheobronchitis Exacerbation of asthma
- ❖ Chronic: Long-term exposure decreases lung growth
- ❖ Impairment of pulmonary function
- ❖ Increased susceptibility to chronic obstructive lung diseases, including asthma

# Outdoor air pollution

## Facts

- Worldwide it is estimated that 1.3 million people -- more than half of them in developing countries -- die every year from urban outdoor air pollution.
- Urban outdoor air pollution is a major environmental health problem affecting people in both developed and developing countries
- significant decreases in lung function, inflammation and pain when breathing.
- chronic bronchitis and emphysema, as well as people with heart disease. Exposure can trigger asthma attacks and cause wheezing, coughing, and respiratory irritation in individuals with sensitive airways.
- irritate the lungs and lower resistance to respiratory infections such as influenza. effects on breathing, respiratory illness, changes in the lung's defenses, and aggravation of existing heart disease.
- Acid Rain or Acid Deposition a form of precipitation that contains high levels of sulfuric or nitric acids, can contaminate drinking water and vegetation, damage aquatic life, and erode buildings

# Effects of outdoor air pollution

## 1. Health aspects:

The health effects of air pollution are both immediate and delayed. The immediate effects are borne by the respiratory system, the resulting state is acute bronchitis.

- ✓ If the air pollution is intense, it may result even in immediate death by suffocation.
- ✓ The delayed effects most commonly linked with air pollution are chronic bronchitis, lung cancer, bronchial asthma, emphysema, and respiratory allergies.
- ✓ Lead poisons many systems in the body and is particularly dangerous to children developing brain and nervous system.
- ✓ Elevated lead levels in children have been associated with impaired neuropsychological development as measured by loss of IQ, poor school performance and behavioural difficulties.
- ✓ The elderly, children, smokers and those with chronic respiratory difficulties are most vulnerable.

## 2. Social and economic aspects :

- ✓ These comprise destruction of plant and animal life; corrosion of metals; damage to buildings; cost of cleaning and maintenance and repairs and aesthetic nuisance: Air pollution also reduces visibility in towns. It can soil and damage clothing.

# Control of Air Pollution

WHO has recommended the following procedures for the prevention and control of air pollution:

## 1. Eliminate or control the sources of pollution:

- Improved stoves
- Clean fuels (kerosene, gas)
- Venting stoves for cooking and heating
- Regular maintenance of cooking, heating and cooling systems

## 2. Ventilation – building design

- Dilute and remove pollutants through ventilation with outdoor air

## 3. Air cleaning –

- Natural air fresheners
- Air filters and ionizers may remove some airborne particles
- Gas adsorbing material is used to remove gaseous contaminants

## 4. Education of-

- Children /Family and community
- Health care providers

## 5. Environment policymaking:

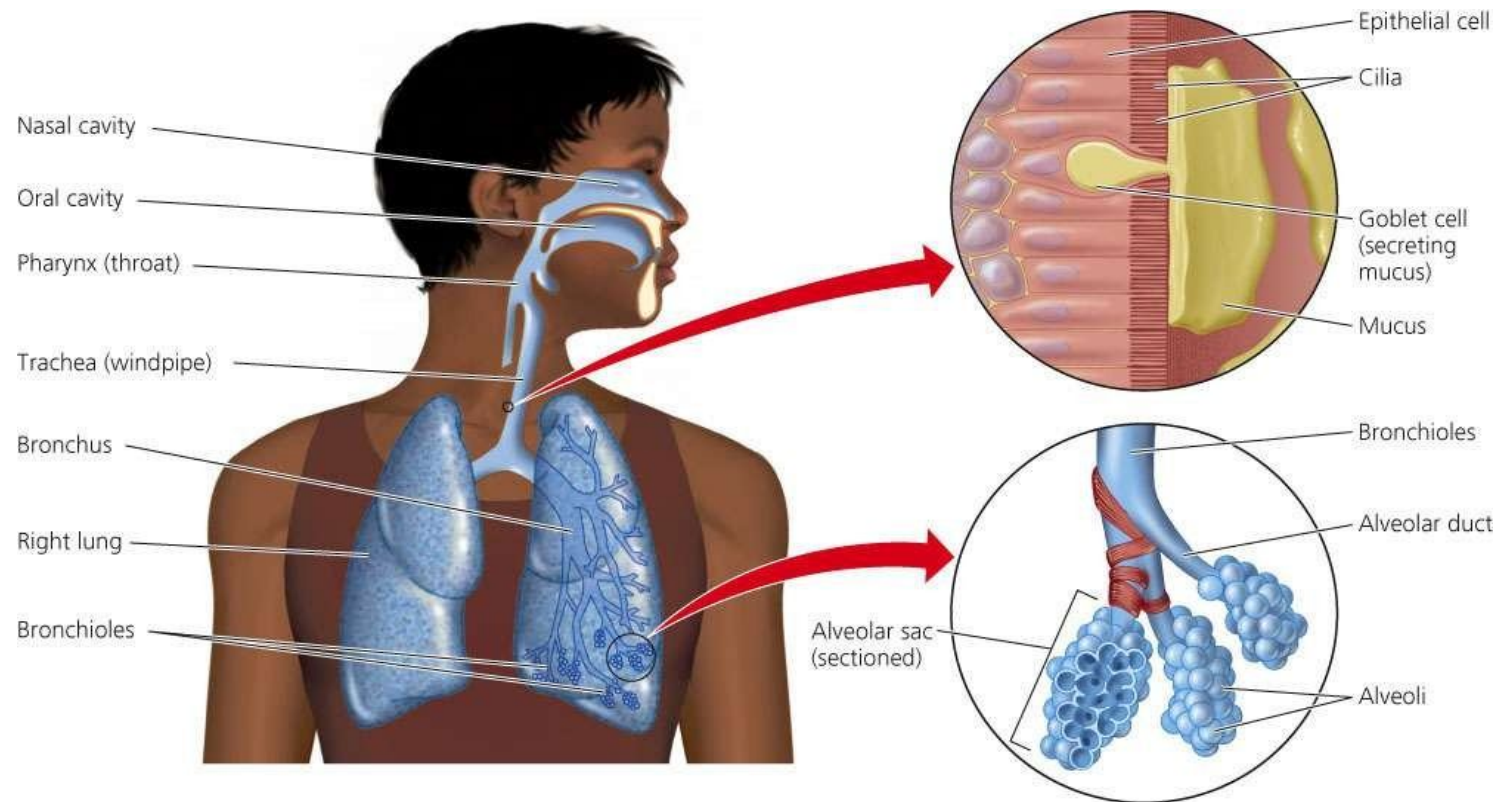
- Framework Convention on Tobacco Control
- Clean indoor/outdoor air regulations
- Community actions Research



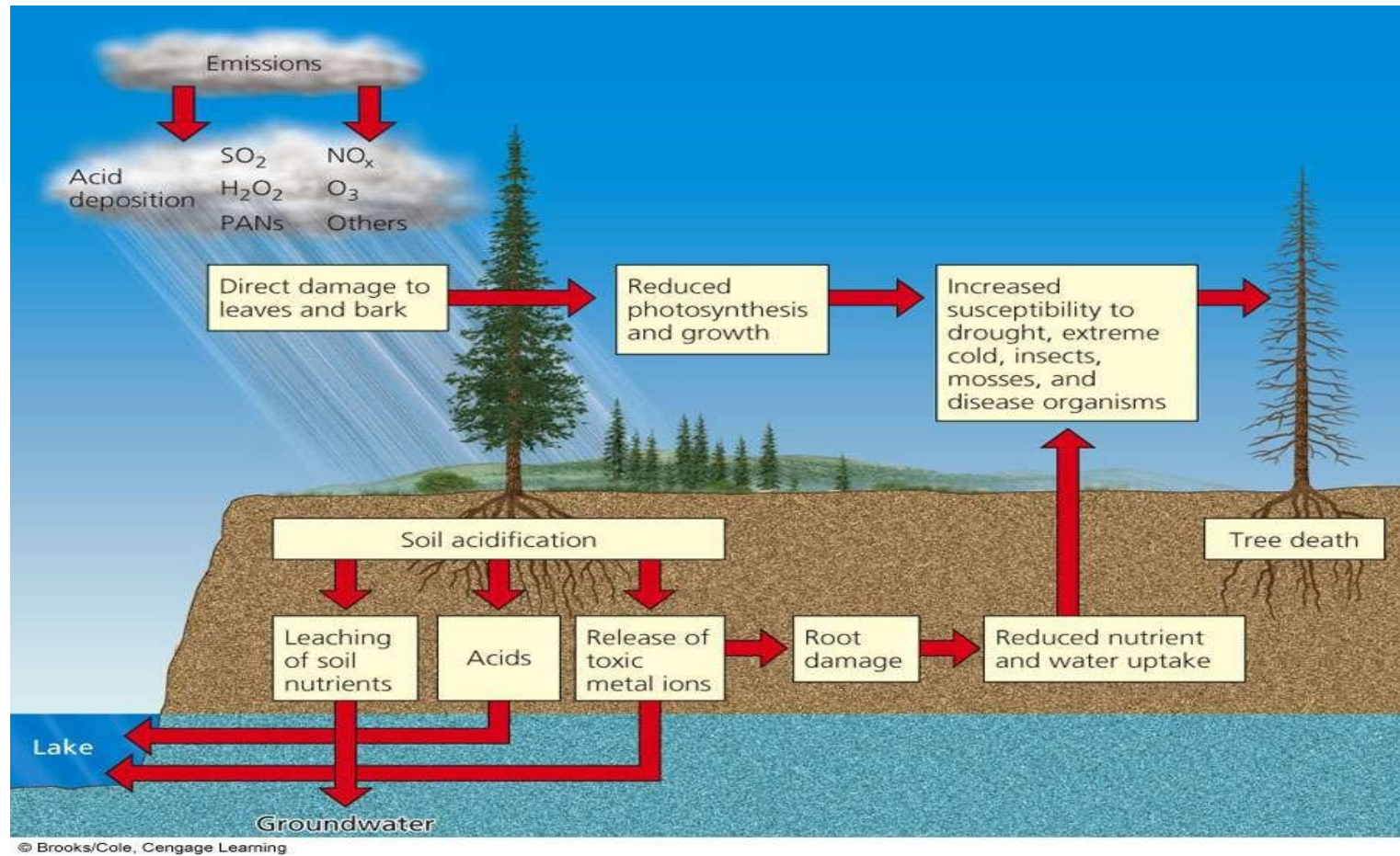
## Factor Affecting Human Health:

1. Nature of the pollutants
2. Concentration of the pollutants
3. Duration of exposure
4. State of health of receptor
5. Age group of the receptor

# EFFECTS OF AIR POLLUTION ON HUMAN



# EFFECTS OF AIR POLLUTION ON PLANT



## EFFECTS OF AIR POLLUTION ON MATERIALS

1. Corrosion of metals due to  $\text{SO}_2$  in presence of oxygen and moisture is converted into  $\text{H}_2\text{SO}_4$  acid.
2.  $\text{H}_2\text{SO}_4$  acid react with limestone, marble and other building materials to cause deterioration.
3. Soiling and eroding of building materials.
4.  $\text{SO}_2$ ,  $\text{O}_3$ ,  $\text{H}_2\text{S}$  and aerosols damage protective coating and paints of the surface.
5.  $\text{O}_3$  and PAN (Peroxyacetyl nitrate) causes cracking of rubber and various electrical insulations.
6. Deterioration of art work due to SPM.

## Air Pollution Control Equipment's:

- Scrubbers
- Air Filters
- Cyclones
- Electrostatic Precipitators
- Mist Collectors
- Incinerators
- Catalytic Reactors
- Biofilters

## National Ambient Air Quality Standards

Pollutants	Time weighted average	Concentration in ambient air		
		Industrial Area	Residential, Rural & other Areas	Sensitive Area
1	2	3	4	5
Sulphur Dioxide(SO <sub>2</sub> )	Annual Average*	80 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	15 µg/m <sup>3</sup>
	24 hours****	120 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>
Oxides of Nitrogen as NO <sub>2</sub>	Annual Average*	80 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	15 µg/m <sup>3</sup>
	24 hours****	120 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m <sup>3</sup>	140 µg/m <sup>3</sup>	70 µg/m <sup>3</sup>
	24 hours****	500 µg/m <sup>3</sup>	200 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>
Respirable Particulate Matter (RPM) (size less than 10	Annual Average*	120 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	50 µg/m <sup>3</sup>
	24 hours****	150 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	75 µg/m <sup>3</sup>



## National Ambient Air Quality Standards

Pollutants	Time weighted average	Concentration in ambient air		
		Industrial Area	Residential, Rural & other Areas	Sensitive Area
1	2	3	4	5
Lead	Annual Average*	1.0 µg/m <sup>3</sup>	0.75 µg/m <sup>3</sup>	0.50 µg/m <sup>3</sup>
	24 hours*****	1.5 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	0.75 µg/m <sup>3</sup>
Ammonia <sup>1</sup>	Annual Average*	0.1 mg/m <sup>3</sup>	0.1 mg/m <sup>3</sup>	0.1 mg/m <sup>3</sup>
	24 hours*****	0.4 mg/m <sup>3</sup>	0.4 mg/m <sup>3</sup>	0.4mg/m <sup>3</sup>
Carbon Monoxides	8 hours**	5.0 mg/m <sup>3</sup>	2.0 mg/m <sup>3</sup>	1.0 mg/m <sup>3</sup>
	1 hours	10.0 mg/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	2.0 mg/m <sup>3</sup>
*	Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.			
**	24 hourly/ 8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days. Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week at uniform interval.			

Thank You