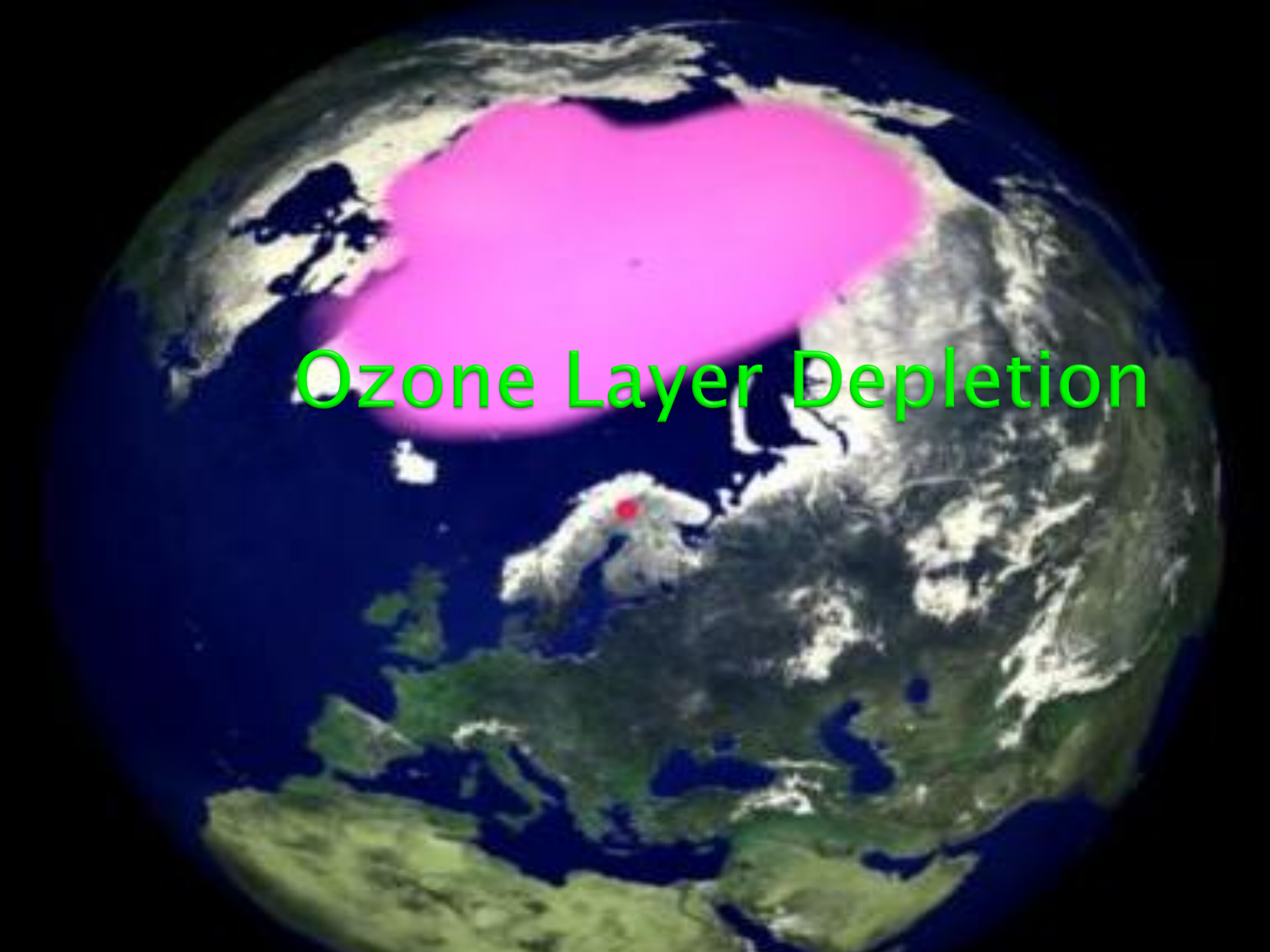
(Management Topic in Environmental St

B. Tech 7TH Semester

Ozone Layer Depletion and Acid Rain

Depart: Chemistry

Subject: MTES (CHM 2049)


Ozone Layer Depletion

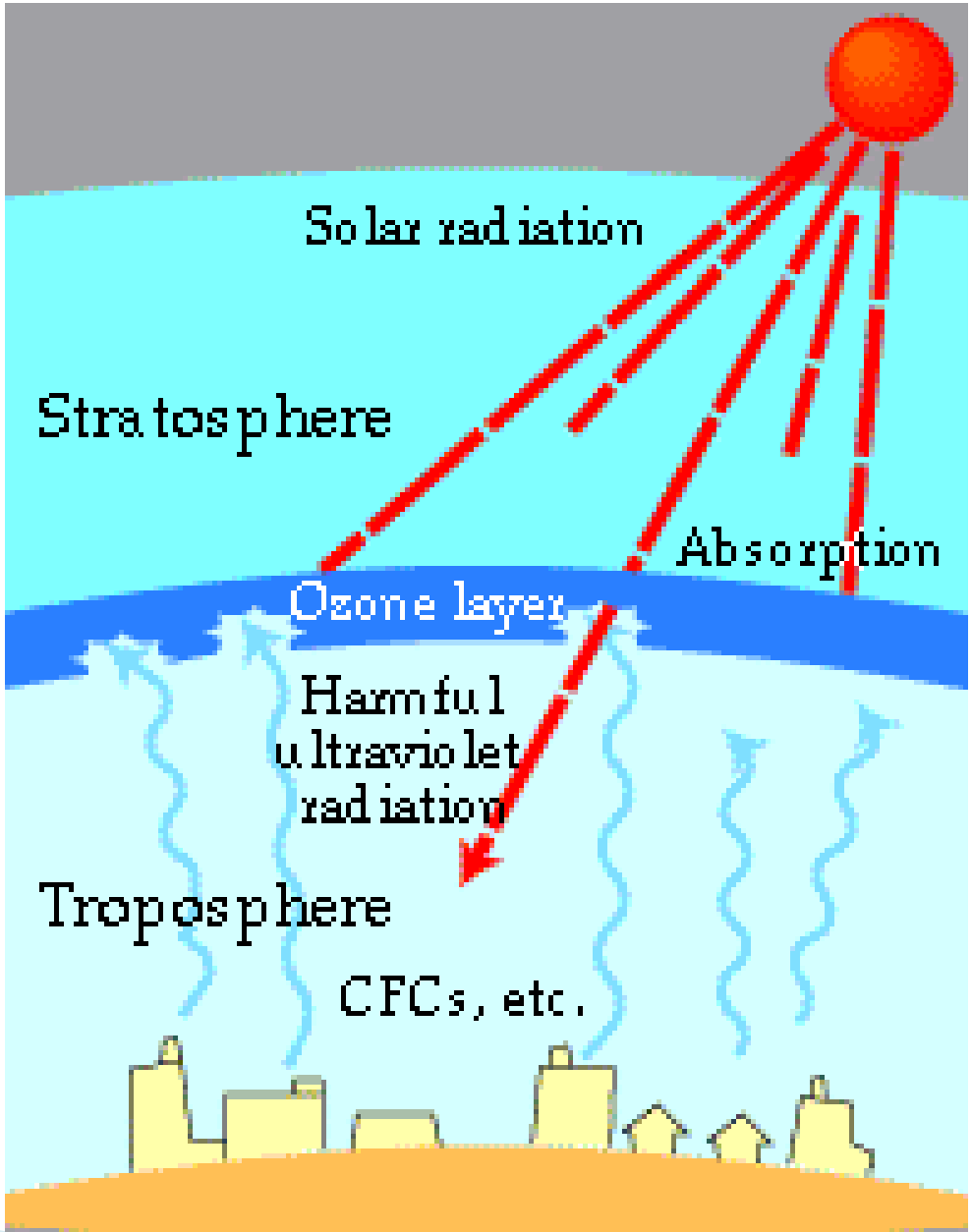
Content

- Introduction to ozone
- Types of ozone depleting chemicals
- Mechanism of Ozone depletion
- Chapman cycle
- Impact of Ozone depletion
- Preventive measure

Introduction to Ozone

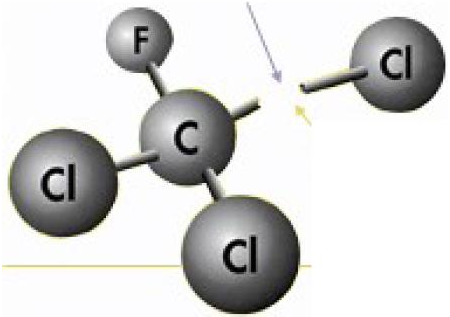
The ozone layer

- Ozone is a triatomic form of oxygen (O_3) found in Earth's upper and lower atmosphere.
- The ozone layer, situated in the stratosphere about 15 to 30 km above the earth's surface.
- Ozone protects living organisms by absorbing harmful ultraviolet radiation (UVB) from the sun.
- The ozone layer is being destroyed by CFCs and other substances.



www.epcc.pref.osaka.jp/apec/ eng/earth/**ozone**_layer_depletion/susumu.html

What is CFCs?



- Chlorofluorocarbons (CFCs)
- Composed of elements chlorine, fluorine, and carbon
- CFCs were welcomed by industries:
  - Low toxicity
  - Chemical stability
  - Cheap
- Usage:
  - As refrigerants. Air conditioning
  - As cleaning agents
  - As propellants

CFCs are used in aerosol sprays

CFC-11 (trichlorofluoromethane - $CFCl_3$),
CFC-12 (dichloro-difluoromethane - CF_2Cl_2),
CFC-113 (trichloro-trifluoroethane - $C_2F_3Cl_3$),
CFC-114 (dichloro-tetrfluoroethane $C_2F_4Cl_2$),
CFC-115 (chloropentafluoroethane - C_2F_5Cl)

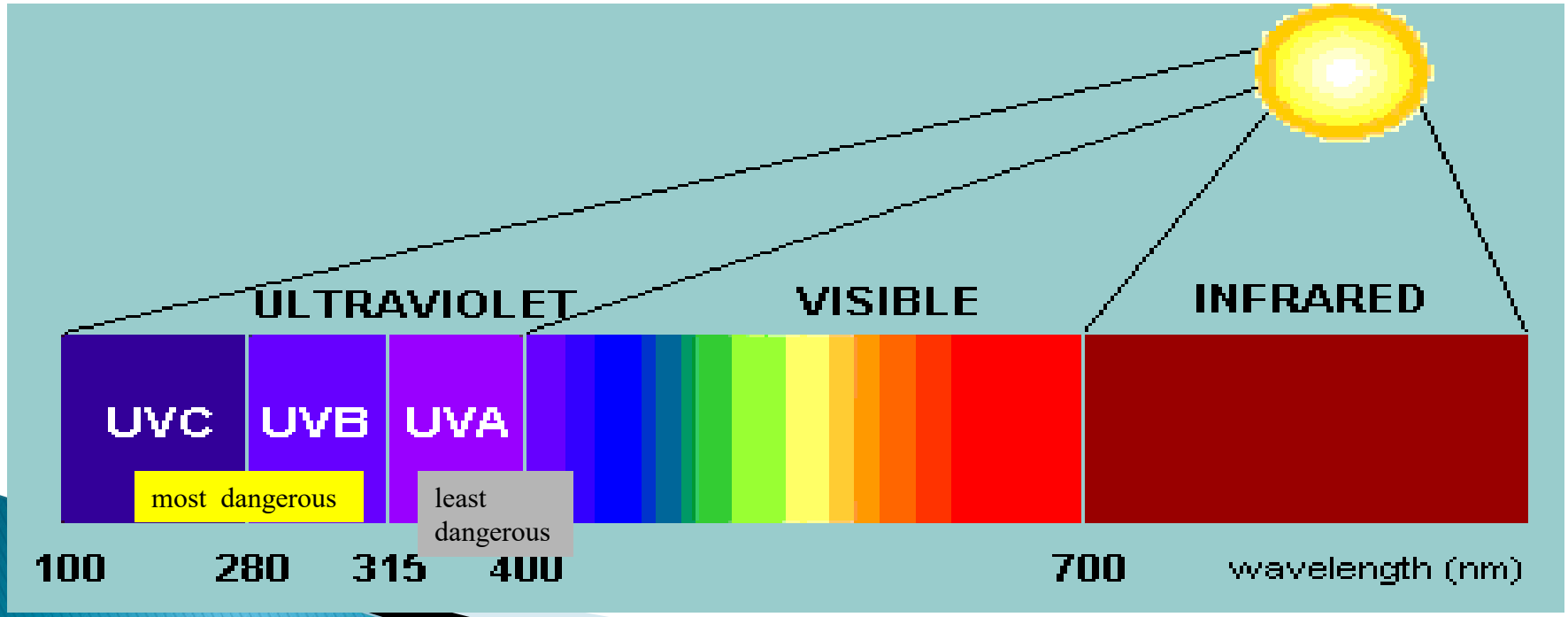
Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Halon
CH_3CCl_3 (Methyl chloroform)
CCl_4 (Carbon tetrachloride)
Chlorofluorocarbons
Methyl bromide

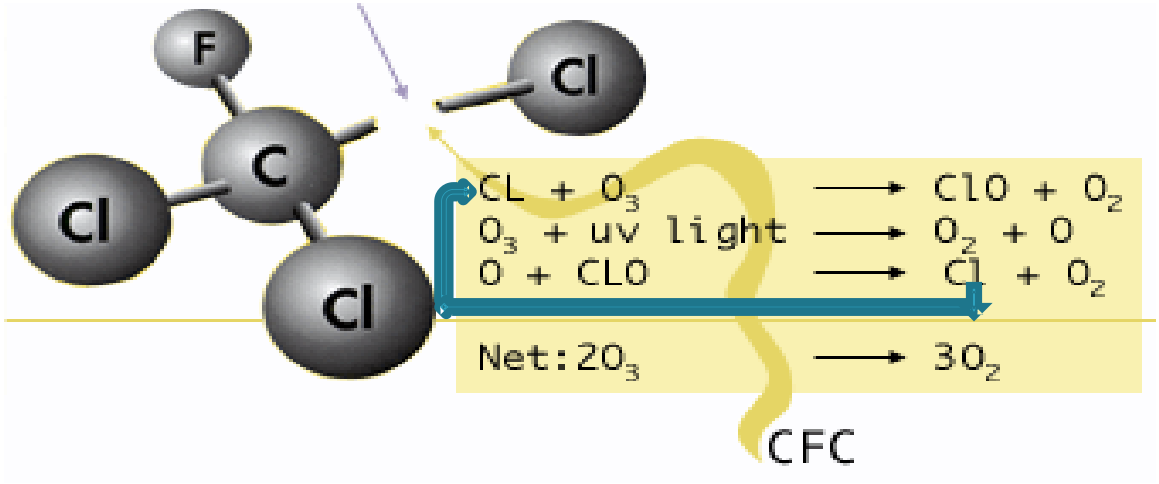
Stratospheric Ozone and Ultraviolet Radiation (UVR)

- **Ultra-violet radiation (UVR)** high energy electromagnetic wave emitted from the sun. It is made up of wavelengths ranging from 100nm to 400nm.

- **UV radiation includes** **UV-A**, the least dangerous form of UV radiation, with a wavelength range between 315nm to 400nm, **UV-B** with a wavelength range between 280nm to 315nm, and **UV-C** which is the most dangerous between 100nm to 280nm. UV-C is unable to reach Earth's surface due to stratospheric ozone's ability to absorb it. (Last, 2006)



Chemical Mechanism of Ozone Depletion



chlorine monoxide (ClO).

The chlorine atom is free to destroy up to 100,000 ozone molecules

- Different chemicals are responsible for the destruction of the ozone layer
- Topping the list :
  - chlorofluorocarbons (CFC's)
  - In the stratosphere, Ozone are photolysed, releasing reactive chlorine atoms that catalytically destroy ozone

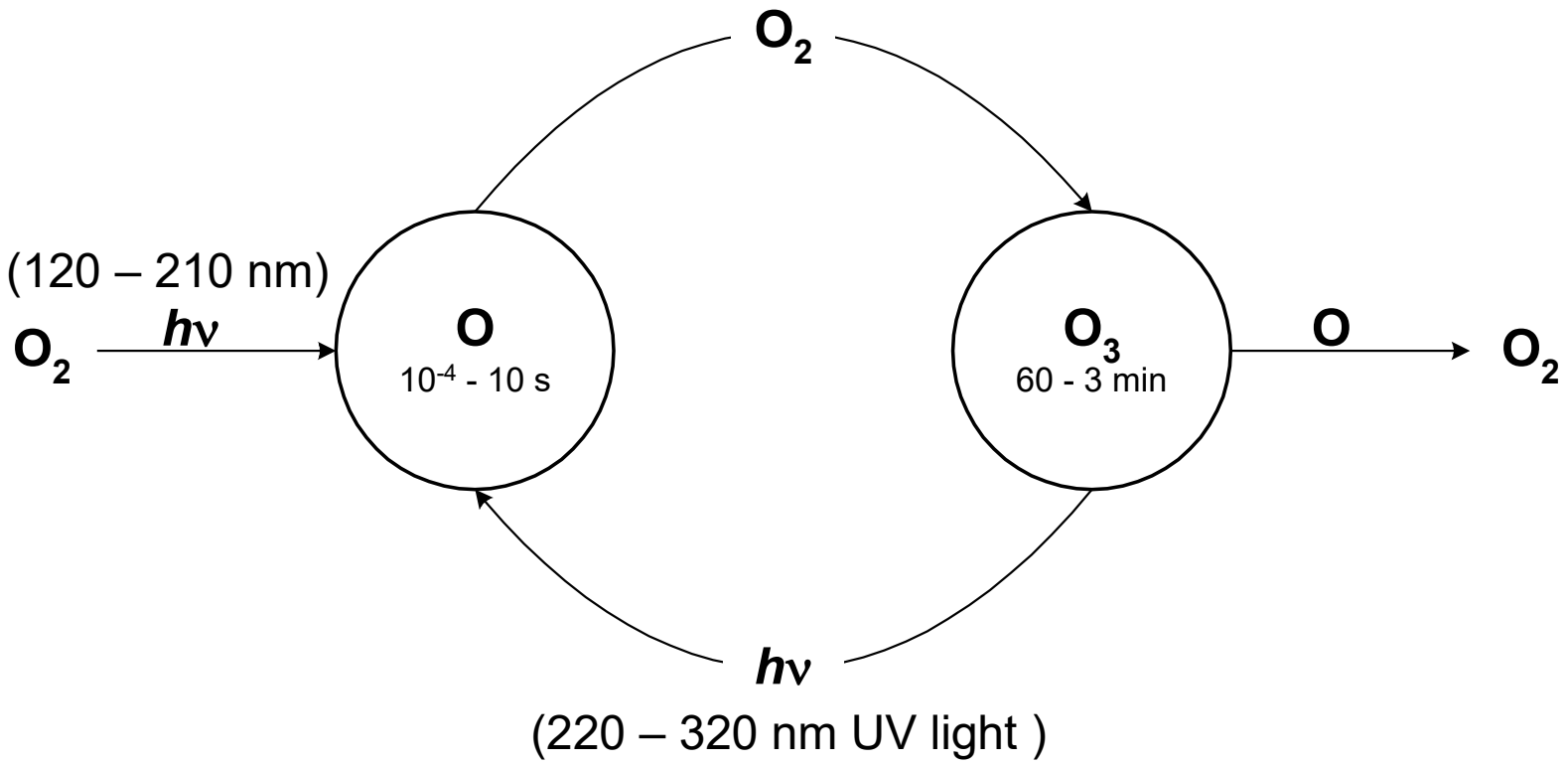
The Chapman Cycle

- 1930
  - Chapman (Australian scientist) proposed a series of reactions to account for the ozone layer known as *the Chapman Cycle*
  - The *Chapman Cycle* explains how the ozone layer is formed and maintained.
  - *Chapman Cycle :* Four chemical reactions
    - *Initiation* $O_2 + \text{light} \rightarrow 2O$ (120 – 210 nm)
    - *Propagation* (cycling)

      $O + O_2 + M \rightarrow O_3 + M^*$ (generates heat)

      $O_3 + \text{light} \rightarrow O_2 + O$ (220 – 320 nm UV light)
    - *Termination* $O_3 + O \rightarrow 2O_2$

The Chapman Cycle



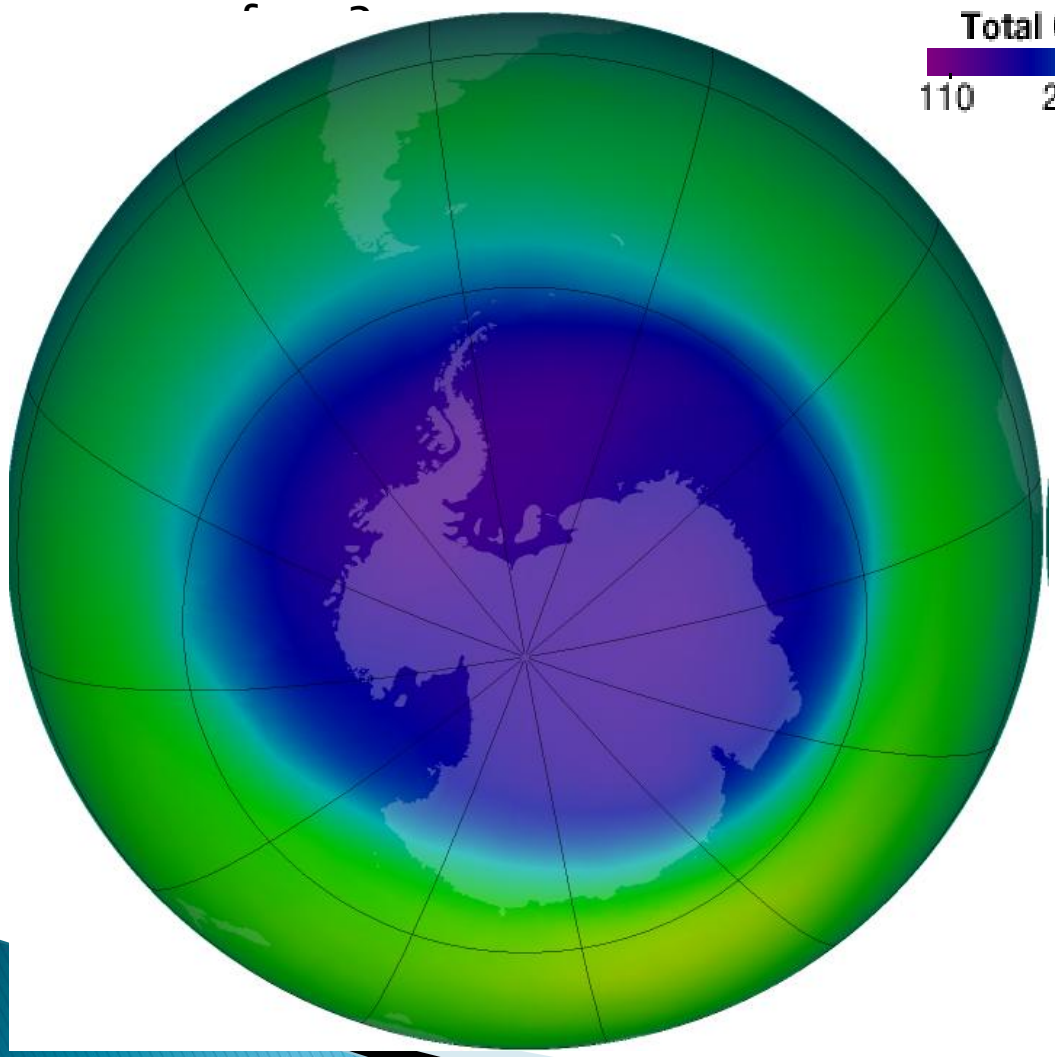
"odd-oxygen" species (O_x) are rapidly interconverted

$$O_x = O + O_3$$

The "Ozone Hole"

Levels of ozone are measured in Dobson units (DU), where 100 DU is equivalent to a 1 millimeter thick layer of pure ozone

- What is the "ozone hole?" When did it first appear? How does it



The ozone hole is the region over Antarctica with total ozone 220 Dobson Units or lower. (The avg total column ozone in the atmosphere is about 300 DU.)

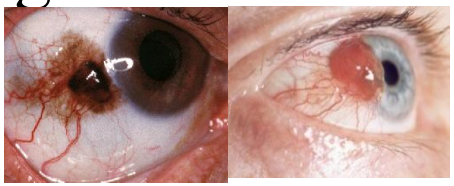
These conditions have led to ozone hole formation in Antarctica.

Ozone hole in Sept 2005. Source: NASA

Toxicity Effect

over exposure to UV-B

- Skin cancer
- Eye damage such as cataracts leading to blindness



- Immune system damage
- Reduction in phytoplankton
- Damage to the DNA in various life-forms form pyrimidine dimer lead to cancer

Over Exposure

- Suppress immune system
- Accelerate aging of skin due high exposure
- Cause an outbreak of rash in fair skinned people due to photo allergy – can be severe

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What Is Being Done to Counter the Effects of Ozone Depletion?

- **Montreal Protocol (adopted in 1987)** – panel of experts was formed to investigate substances responsible for hole formation
  - Established policies that prevent future use of certain types of chemicals
  - Stipulated that the production and consumption of compounds contributing towards depletion of ozone in the stratosphere were to be phased out by the year 2000

Acid Rain

Acid Rain

Learning objectives

- What is acid rain?
- How is it formed?
- What effects does it have on people and the environment?
- How to reduce it?

Acid Rain

- **Acid Rain:** the deposition of different acidic mainly H_2SO_4, HNO_3 and H_2CO_3 along with rain water or particulate mater/dust/smoke of air called acid rain.

Types:

- **Wet deposition:** along with rain water
- **Dry deposition**: with particulate mater/dust/smoke etc of air
- Normally rain water pH is 5.6 due water reacting with carbon dioxide in the air to form carbonic acid

$CO_2(g)+H_2O(l) \rightarrow H_2CO_3(aq)$ $2SO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(aq)$

The Formation of Acid Rain

$2NO_2(g)+H_2O(l) \rightarrow HNO_2(aq)+HNO_3(aq)$

The rest reacts with sunlight and ozone in the atmosphere; nitric (HNO_3), and sulphuric acid (H_2SO_4) are produced

Burn fossil fuels in

Transport, Industry, Homes, power stations

NO_2 SO_2

Some falls back to Earth close to the source as dry particles, gas and aerosols (NO_x and SO_2)

(dry deposition)

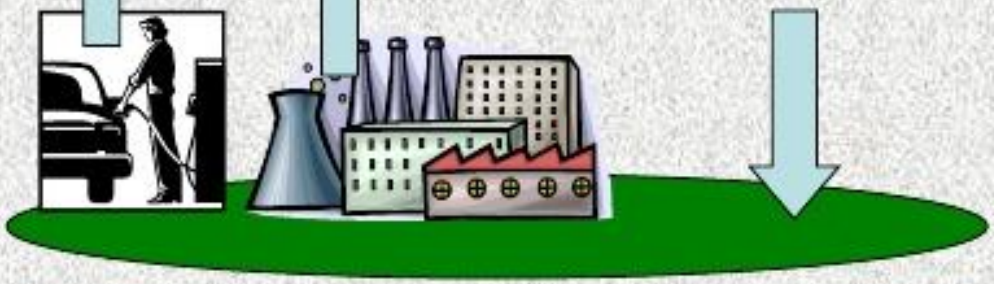
It is dissolved in the moisture in the atmosphere making

$2H^+$ and SO_4^{2-}

and can be carried large distances before falling as rain or snow

(wet deposition)

H^+ NO_3^- SO_4^{2-}



Gas, Oil, Coal

TRANSBOUNDARY POLLUTION

Causes Of Acid Rain

- **NATURAL CAUSES:-**
  - Volcanic emissions.
  - Biological processes.
  - Lightning.

Sulfur dioxide (SO_2) is emitted from the combustion of sulfur-containing fuels (coal and oil) and from the smelting of sulfur-containing ores (mostly copper, lead, and zinc). In the atmosphere, SO_2 is oxidized by OH to produce H_2SO_4:

$$HSO_3 + O_2 \rightarrow SO_3 + HO_2$$

$$SO_3 + H_2O + M \rightarrow H_2SO_4 + M$$

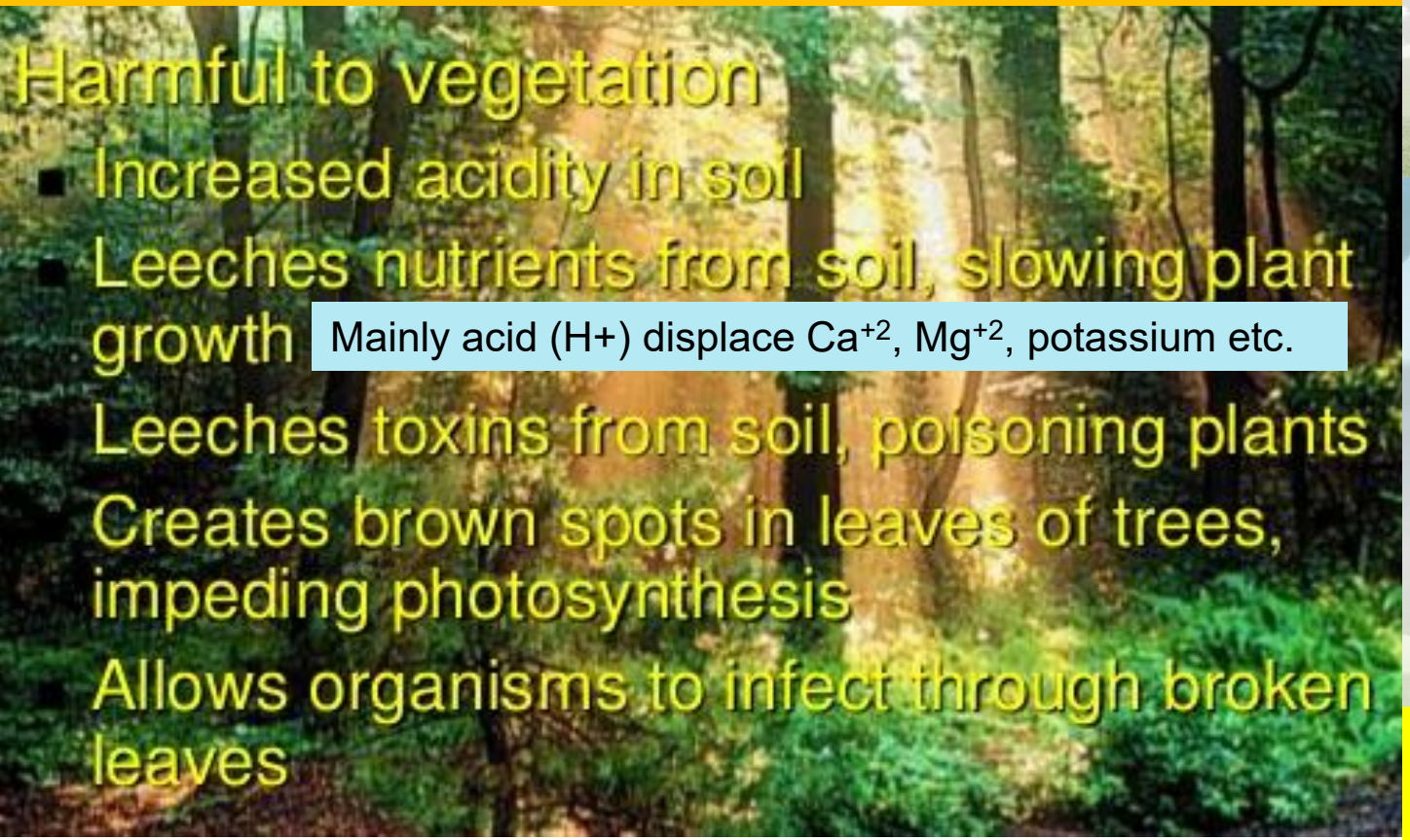
$$SO_2 + OH + M \rightarrow HSO_3 + M$$

- **ANTHROPOGENIC CAUSES:-**
  - Factories (industrialization)
  - Motor vehicles, automobile exhaust.
  - Coal based power plants.
  - Domestic fires.
  - Smelters.

- Which discharges huge amount of CO_2, SO_2, NOx to atmosphere.

Harmful impact of Acid Rain

Effect on plant and soil



Yellowish plant leave, chlorophyll damage(Chlorosis)

- Microbes not able to tolerate low pH and die
- Upper fertile layer of soil is affect as essential nutrients are leached away from soil

- Leeching of toxins from the soil by acid rain can be absorbed by plants and animals. When consumed, these toxins affect humans severely.
- Brain damage, kidney problems, and Alzheimer's disease has been linked to people eating "toxic" animals/plants.

e. Effect On Buildings

Metallic structure archeological structure

- Causes extensive damage to buildings, structural materials of marble ,limestone, slate etc.

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$$

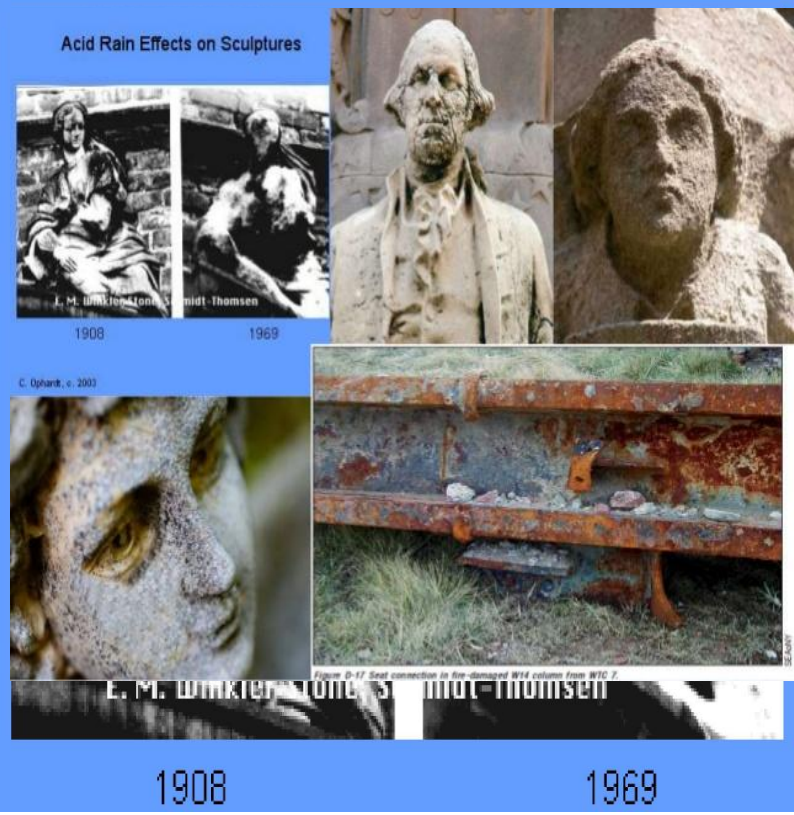
insoluble

soluble

- In Greece and Italy invaluable stone statues have been partially dissolved by acid rain.

- Taj Mahal in Agra is also suffering due to acid fumes from Mathura refinery.

Acid rain dissolves the stonework and mortar of buildings that can be washed away by rain.



Cause corrosive damage/oxidation of metallic structure by acid rain

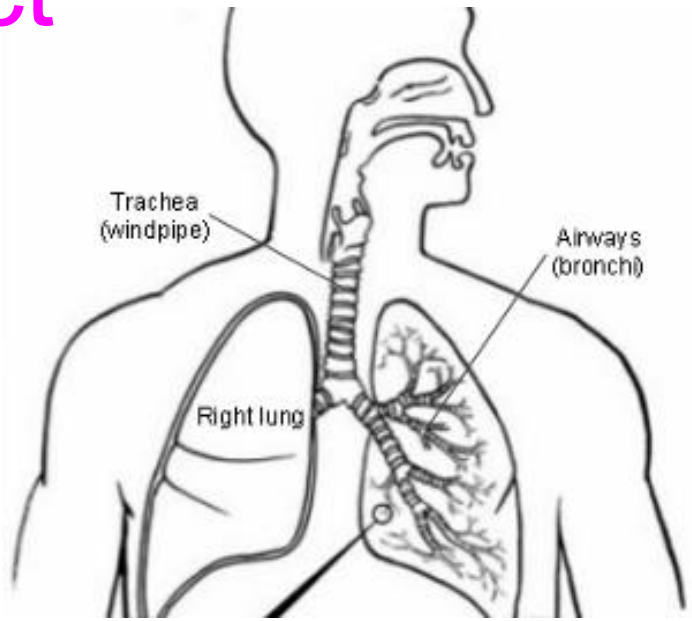
Effect of Acid rain to aquatic system

- Fish die off, and that removes the main source of food for birds. Also low pH ≤ egg will not hatch and fish and lose their ability to reproduce
- Chronic acidification reduce level of nutrient availability for fish

Also, birds can die from eating "toxic" fish and insects.

Human health effect

- Sulfur dioxide (SO2) and nitrogen oxides (NOx) gases turn in to particles that can be inhaled deep into people's lungs.
- In high levels of the fine particles there is an increase in illnesses, a key component of urban smog, cause inflammation and damage to tissues, and premature death from respiratory diseases such as:
- Asthma and Bronchitis.



Affects human health

- Respiratory problems, asthma, dry coughs, headaches and throat irritations
- Leeching of toxins from the soil by acid rain can be absorbed by plants and animals. When consumed, these toxins affect humans severely.
- Brain damage, kidney problems, and Alzheimer's disease has been linked to people eating "toxic" animals/plants.

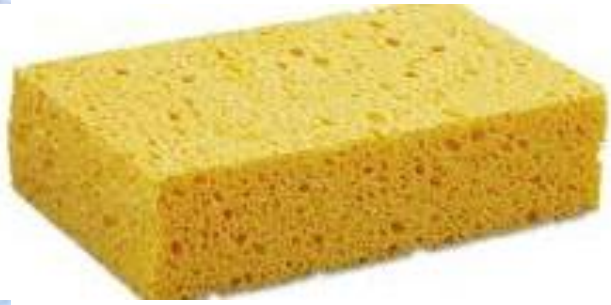
Control measures

- **Clean combustion technologies**
- **Using pollution control equipments**
- **Replacement of coal by natural gas or renewable energy resources**

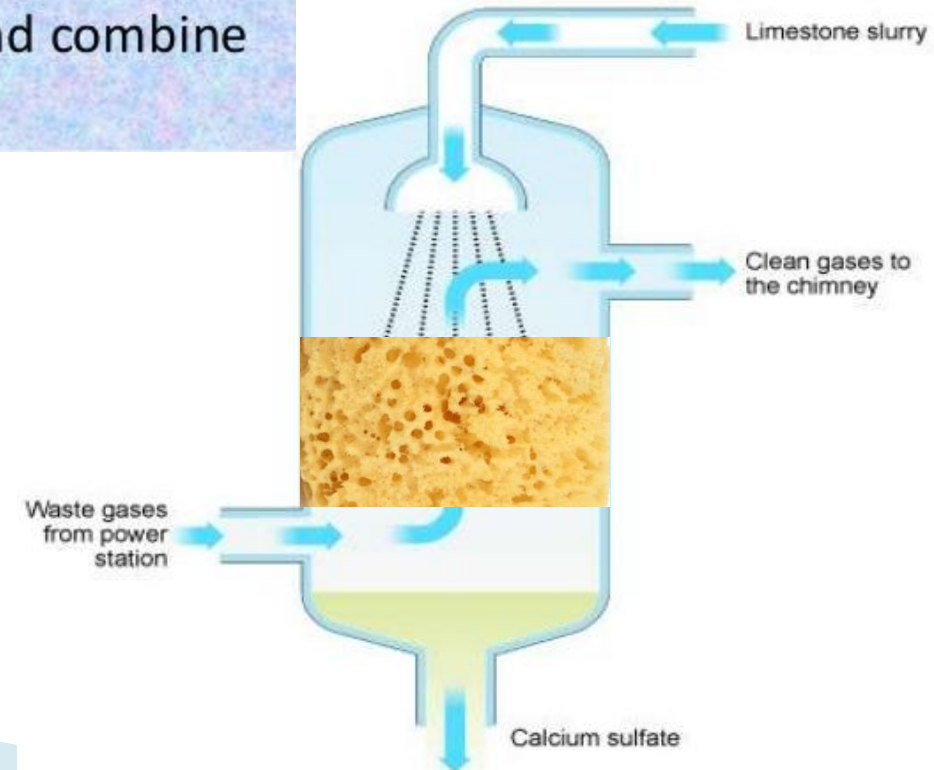
  Wind power, solar panels, tidal power, hydropower and geothermal energy.
- **Liming of lakes and soils**
- **Formulate the policy framework for reduction of sulfur dioxide and other acid rain causing gas emissions.**
- **Support a set of subproject that promote cleaner production, reduce acid rain and air pollution, improve the environment.**
  - Uses of catalytic converters to vehicle exhausts which remove the nitrogen oxides.

Control Measure

- Fluidized bed combustion also reduces the amount of sulfur emitted by power production.
- A wet scrubber is basically a reaction tower equipped with a fan that extracts hot smoke stack gases from a power plant into the tower.
- Lime or limestone in slurry form is also injected into the tower to mix with the stack gases and combine with the sulfur dioxide present.



- **Remove oxides of sulphur and oxides of nitrogen before releasing**
  - **Flue gas desulphurization**
  - **Catalytic Converters**



$Ca(OH_2) + SO_{2+}O_2 = CaSO_4 + H_2O$

Gas solid


Measure consumption of environmental resources
Calculate emissions
Report consumption and emissions externally
Identify reduction
Reduce consumption
Reduce emissions
Environment Sustainability

THANK YOU


MASS EXTINCTION
BUSH FIRES
SEVERE DROUGHT
NEXT 100 YEARS