WELCOME

UNIT-2
AIR POLLUTION

L-11/1 INTRODUCTION TO AIR POLLUTION

ATMOSPHERIC COMPOSITION-

- **The atmosphere is a**
- **blanket of gases & suspended liquids & solids**
- **that entirely envelops the earth.**

ATMOSPHERIC COMPOSITION…

- **Pure air is colourless odourless and taste less.**
- **It is transparent to many of the radiations and can absorb others.**

L-11/1 INTRODUCTION….

- **It absorbs most of the cosmic rays from outer space and**

  a major portion of the

- **Electromagnetic radiation (EMR) from the sun.**

L-10/1 INTRODUCTION….

It transmits only

- **near ultraviolet,**
- **Visible,**
- **near infrared radiations (300 to 2500 nm) and**
- **radio waves.**

L-11/1 INTRODUCTION…..

Atmosphere is divided into four layers

1. **Troposphere**
2. **Stratosphere**
3. **Mesosphere**
4. **Thermosphere**

L-11/1 INTRODUCTION……

TROPOSPHERE

- **It is nearest the earth surface.**
- **It extends up to 11 KM.**
- **The temperature decreases with Altitude.(15^{0+}C to -56^{0}C)**

L-11/1 INTRODUCTION…..

TROPOSPHERE

- **The change of temperature with height is called the "LAPSE RATE".**
- **End of Troposphere is known as "Tropopause".**
- **It has a positive LAPSE RATE.**

L-11/1 INTRODUCTION…..

STRATOSPHERE

- **Above Troposphere, Stratosphere starts.**
- **It extends from 11 to 50 KM.**
- **The temperatures increases with Altitude**
- **due to absorption of UV radiation from Sun by Ozone.**

i

L-11/1 INTRODUCTION…..

STRATOSPHERE

- **At the end of Stratosphere a narrow zone is found called "Stratopause".**

- **The Lapse Rate is negative.**

  (-56^0C to -2^0C)

L-11/1 INTRODUCTION….

MESOSPHRE

- **Above Stratopause, Mesosphere Starts.**
- **It extends up to 50 – 85 KM.**
- **The temperature decreases with Altitudes because the conc. of ozone decrease.**

i

L-11/1 INTRODUCTION….

MESOSPHRE

- **It extends up to 50 – 85 KM.**
- **The end of this layer is called "Mesopause".**
- **The Lapse Rate is negative. (-2^{0}C to -92^{0}C)**

L-11/1 INTRODUCTION….

IONOSPHERE

- **It is the region above the Mesopause.**
- **The Temperature – Altitudes curve exhibits a negative Lapse Rate.**
- **The temperature increases very rapidly with Altitude. (-92^0C to 1200^0C)**

i

L-11/1 INTRODUCTION….

IONOSPHERE

- **It is the region above the Mesopause.**
- **This region is characterized by**
- **low pressure and high temperature.**

- **Oxygen and nitric oxides absorb the UV radiations and undergo "Ionization"**
- **So this region is also called 'IONOSPHERE".**

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L-1/1 INTRODUCTION….

Name of region	Height above the earth surface (Km)	Temperatu- re (^oC)	Major Chemical species present
Troposphere	0-11	15 to -56	O_2, N_2, CO_2, H_2O
Stratosphere	11-50	-56 to -2	O_3
Mesosphere	50-85	-2 to -92	O_2^+, NO^+
Thermospher e	85-500	-92 to 1200	O_2^+ , O^+, NO^+

L-11/2 INTRODUCTION….

AIR POLLUTION

Air pollution is basically –

- **the presence of foreign substances in air**
- **in excessive concentration –**
- **which adversely affects the well being of an individual.**

L-11/2 INTRODUCTION….

Definition-

“Presence of one or more than one contaminants of-

- **dust, smoke different type of gases and vapours in the atmosphere-**
- **which affect the quality and property of air-**
- **which is injurious to human health, plant and animal life is called Air Pollution”.**

L-11/2 INTRODUCTION…..

OR

“Substances introduced in air

- **by the activities of mankind**
- **which cause serious effect on human health is called**

Air Pollution”.

L-11/2 INTRODUCTION….

- **The parameters of the atmosphere vary considerably with altitude.**
- **The density of atmosphere shows a**
- **sharp decrease with increasing altitude.**

L-11/2 INTRODUCTION….

Composition of Air-

The earth's atmosphere exceeds 200 km height.

The gases can be broadly divided into:

1. **Major**
2. **Minor and**
3. **Trace elements.**

L-11/2 INTRODUCTION…..

Compounds		Concentration in ppm	Volume %
Major	N_2	780900	7.809×10^{1}
	O_2	209400	2.094×10^{1}
Minor	Ar	9,300	9.3×10^{-2}
	CO_2	318.0	3.18×10^{-2}
Trace	Ne	18.0	1.8×10^{-3}
	He	5.2	5.2×10^{-4}
	CH_4	1.3	1.3×10^{-4}

L-11/2 INTRODUCTION…..

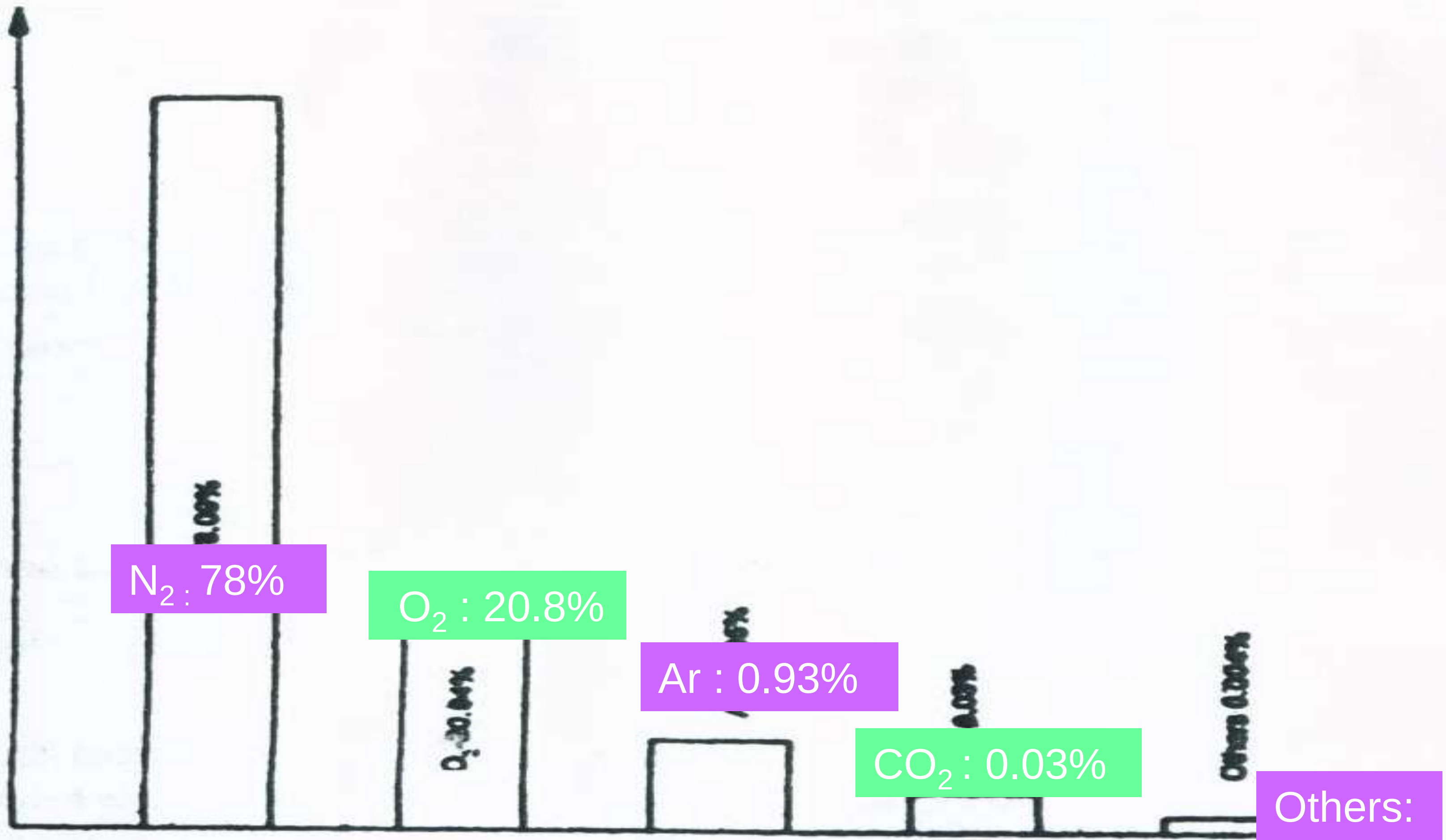

Fig. Composition of Air.

L-12/1 Energy Balance in Atmosphere

ENERGY BALANCE

OR

EARTH RADIATION BALANCE

AND

HEAT BUDGET

L-12/1 Energy Balance…..

- **Radiation is the means by which the solar energy reaches the earth &**
- **the earth loses energy to outer space.**

- **All objects that have temperature above absolute zero (0^0 k) radiate energy.**

L-12/1 Energy Balance…..

Radiations have two distinct temp. bands-

1. **Incoming radiation from the Sun which has an effective surface temperature of 6000^0K .**

2. **Outgoing radiation by the surface of the earth which has an effective surface temperature of 290^0K.**

L-12/1 Energy Balance….

- **The earth receives the radiation of 'shorter wave length' (in the near ultraviolet and visible region) from the Sun.**

- **And then emits (or re-radiate) it into the space in the longer wave (infrared) region.**

L-12/1 Energy Balance….

- **The solar beam is intercepted by a circular cross-section of the earth,**
- **while terrestrial radiation is emitted from the entire spherical surface.**

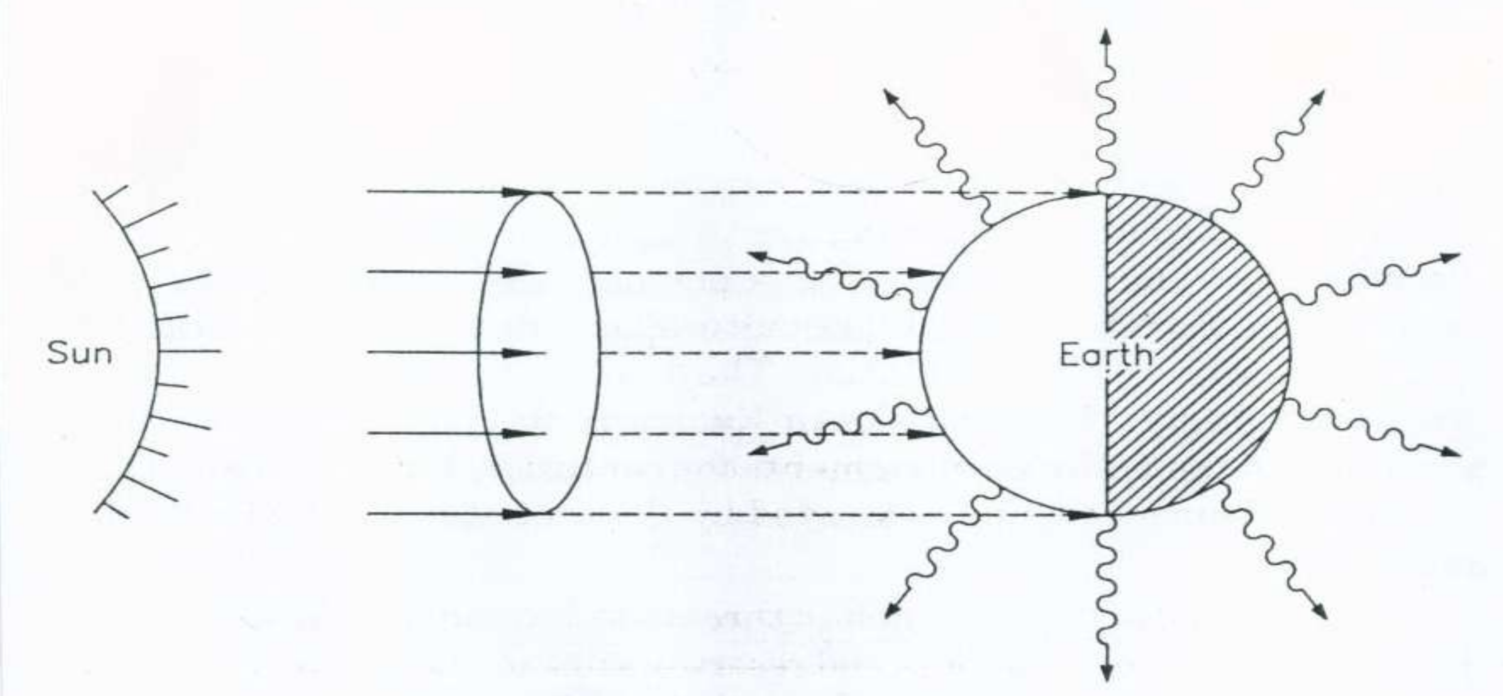

Fig. Contrast between global areas receiving and emitting radiation.

L-13/1 Classification of Air Pollutants:-

1. According to origin-

(i) Primary Pollutants.

(ii) Secondary Pollutant

2. According to chemical composition

(i) Organic pollutants

(ii) Inorganic Pollutants

3. According to state of matter –

a) Gaseous Pollutants:

b) Particulate matters:

L-13/1 Classification

1. According to origin-

(i) Primary Pollutants.

- **Which are directly emitted into the atmosphere and are found as such.**

- **Examples: CO, NO, SOx, HC and particulate matters.**

L-13/1 Classification….

2. Secondary Pollutant

- **Which are derived from the primary pollutants due to chemical or photochemical reaction.**

- **Examples: PAN (Per oxy – acetyl nitrate).**

L-13/1 Classification…

2. According to chemical composition

(i) Organic pollutants

- **Hydrocarbons,**
- **Aldehydes,**
- **Ketones &**
- **Amines**

(ii) Inorganic Pollutants

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L-13/1 Classification….

According to chemical composition

(ii) <u>Inorganic Pollutants</u>

- **Carbon Compounds,**

  (CO & Carbonates)
- **Nitrogen Compounds,**

  (NOx & NH_3)
- **Sulphur Compounds**

  (SO_2 , H_2 S and SO_3)

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mark@kyne.com.au

L-13/1 Classification….

3. According to state of matter –

a) Gaseous Pollutants:

which get mixed with air & don't normally settle out.

Examples: CO, NOx and SO_2 .

b) Particulate matters:

finely divided solids or liquids, e.g. Smoke, fumes, dust, fog and smog.

PRIMARY POLLUTANTS

L-14/1 PRIMARY POLLUTANTS (CO)

1. **Carbon Monoxide (CO)**

Properties –

- **It is colourless, tasteless, odourless and toxic gas.**
- **It is slightly lighter than air.**
- **Insoluble in water.**
- **It is chemically inert under normal condition**

L-14/1 Primary Pollutants (CO)

Carbon Monoxide (CO) –

Production-

(i) Incomplete burning of fuels.

$$2C + O_2 \rightarrow 2CO$$

(ii) Reaction between CO_2 and C at very high temperature in blast furnace.

$$CO_2 + C \rightarrow 2CO$$

(iii) Dissociation of CO_2 at higher temperature

$$CO_2 \rightarrow CO + O$$

Carbon Monoxide (CO) –

Sources:

(i) Natural Sources:-

- **Volcanic eruption,**
- **Natural gas emissions &**
- **Forest fires.**

(ii) Anthropogenic Sources:-

Almost 2/3rd of the CO emitted comes from internal combustion (IC) engines.

i

L-14/1 Primary Pollutants (CO)

Carbon Monoxide (CO) –

Sources:

(ii) Anthropogenic Sources:-

- **Motor vehicles, aircrafts, railways,**
- **Iron and steel industries,**
- **Petroleum and paper industries,**
- **Agricultural burning.**

L-14/1 Primary Pollutants - CO

Effects:-

It affects 'oxygen carrying capacity of blood'; due to high affinity for haemoglobin (Hb).

$$[HbO_2] + CO \leftrightarrow [HbCO] + O_2$$

Oxyhaemoglobin Carboxy haemoglobin

(stable complex)

L-14/1 Primary Pollutants (CO)

Conc.	Effects
10 ppm	Decreases visibility
100 ppm	Headache, vascular disorder
250 ppm	Loss of consciousness
750-1000ppm	Death of human beings.

Control:-

1. Modification of internal combustion engines.

2. Development of substitute fuels for gasoline.

3. The four basic technical control methods used for CO are:

i) adsorption, ii) absorption,

iii) condensation and iv) combustion.

i

L-14/1 Primary Pollutants (CO)

3.The four basic technical control methods used for CO are adsorption, absorption, condensation and combustion.

4.Transport sources are 2/3rd responsible for all CO emission which can be controlled by

- **controlling automobiles.**

L-14-2 Primary Pollutants (SO_x)

Oxides of Sulphur:-

- **They are presented by (SOx).**
- **In air pollution SO_2 and SO_3 are the two major pollutants.**
- **There are six types of oxides-**

L-14/2 Primary Pollutants (SO_x)

i) Sulphur monoxide (SO)

ii) Sulphur dioxide (SO_2)

iii) Sulphur trioxide (SO_3)

iv) Sulphur tetra oxide (S_2O_4)

v) Sulphur sesquioxide (S_2O_3) and

vi) Sulphur heptaoxide (S_2O_7).

L-14/2 Primary Pollutants (SO_x)

SO2:-

It is a colourless, non-flammable, suffocating pungent odour, highly soluble in water, is about twice as heavy as air.

Generation:-

It is produced from the combustion of any sulphur bearing materials.

L-14/2 Primary Pollutants (SO_x)

$$S + O_2 \leftrightarrow SO_2$$

$$2SO_2 + O_2 \leftrightarrow 2SO_3$$

$SO_2 + H_2O \rightarrow H_2SO_3$ **(Sulphurous acid)**

$SO_3 + H_2O \rightarrow H_2SO_4$ **(Sulphuric acid)**

L-14/2 Primary Pollutants (SO_x)

Sources –

(i) Natural Sources:-

67% of SOx are emitted by natural agencies from:

a) **volcanic eruption,**
b) **decomposition of fossil fuels and**
c) **bacterial decomposition of organic substance.**

(ii) Anthropogenic Sources:- [33%]

L-14/2 Primary Pollutants (SO_x)

(ii) Anthropogenic Sources:-

33% from anthropogenic sources.

- **Combustion of S containing coal and fuel.**
- **Roasting of sulphide ore in smelting industries.**

$$Cu_2S + O_2 \rightarrow 2Cu + SO_2$$

(Copper pyrite)

L-14/2 Primary Pollutants (SO_x)

Harmful effects – These affect human as well as plants.

- **H_2SO_4 and SO_3 irritate the mucous membrane and respiratory tract.**

- **It causes bronchitis.**

- **The SO_2 particulate combination (smog) has been cited as cause of death.**

L-14/2 Primary Pollutants (SO_x)

In plants:-

SO_2 if present only 0.03 ppm conc. shows :

1. **Damage of chlorophyll and stop photosynthesis in green plants called 'chlorosis disease'.**

2. **Falling of leaves called 'Narcosis'.**

L-14/2 Primary Pollutants (SO_x)

3. **Crops such as soybeans, cotton, spinach, sensitive to sulphur dioxide.**

4. **Due to formation of $H_2 SO_4$, (acid rain) it damages marbles, buildings.**

$CaCO_3 + H_2SO_4 \rightarrow$

L-14/2 Primary Pollutants (SO_x)

Effects of SO2 on human health .

Conc.ppm	Effects
1.0 - 2.0	Cardio respiratory response
1.0 - 5.0	Chest pain
5.0 - 10.0	Choking and increased lung resistance to air flow.
10.0 - 20.0	Nose bleeding
> 20.0	Digestive tract affected, eye irritation
400 to 500	Fatal

L-14/2 Primary Pollutants (SO_x)

<u>Control:-</u>

(i) Removal of SOx from fuel gases.

(ii) Use of low sulphur fuels.

(iii) Converting coal by liquefaction or gasification.

(iv) Using chemical scrubbers like CaCO3.

L-14/3 Primary Pollutants (NO_x)

(3) Oxides of Nitrogen (NOx)

These are represented as NOx.

There are seven types of NO_x present.

(i) NO (nitric oxide)

(ii) Nitrous oxide (N_2O)

(iii) Nitrogen dioxide (NO_2)

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L-14/3 Primary Pollutants (NO_x)

Oxides of Nitrogen (NOx)

(iv) Nitrogen tri oxide (NO_3)

(v) Nitrogen sesquioxide (N_2O_3)

(vi) Nitrogen tetraoxide (N_2O_4) and

(vii) Nitrogen pentaoxide (N_2O_5)

L-13/3 Primary Pollutants (NO_x)

Properties:

i) NO: It is a colourless, odourless, paramagnetic gas, produced by rapid combustion of fuels.

ii) NO_2 : is red brown in colour, pungent, suffocating in odour.

L-14/3 Primary Pollutants (NO_x)

Generation:-

The formation of NO and NO_2 is as follows:-

$$N_2 + O_2 \xrightarrow{1210 - 1765^0C} 2NO$$

$$2NO + O_2 \longrightarrow 2NO_2$$

This is formed at high temperature.
NO_2 is produced by "photolytic reaction" also.

L-14/3 Primary Pollutants (NO_x)

Sources:-

1. Natural sources –

- **Bacterial decomposition of organic matter.**
- **by lightening and forest fire.**
- **NOx is also produced in upper atmosphere which diffuses to lower atmosphere.**

2. Anthropogenic sources :

L-14/3 Primary Pollutants (NO_x)

2. Anthropogenic sources :

- **Combustion of fossil fuel, coal, natural gases.**
- **Power plants produce high concentration of NOx at high temperature.**
- **HNO_3 is end product of NOx. HNO_3 is formed as follows-**

L-15/3 Primary Pollutants (NO_x)

- HNO_3 is end product of NOx. HNO_3 is formed as follows-

  $NO_2 + O_3 \rightarrow NO_3 + O_2$

  $NO_3 + NO_2 \rightarrow N_2O_5$

  $N_2O_5 + H_2O \rightarrow 2HNO_3$

- NOx is 10-100 times greater in urban area due to industrialization and automobiles.

L-14/3 Primary Pollutants (NO_x)

Harmful Effects:-

- **NO_2 is more harmful than NO.**
- **NO_2 is a toxic gas causing damage to respiratory system.**
- **Increased concentration causes 'Bronchitis'.**
- **It disturbs some 'cellular enzyme system'.**

L-14/3 Primary Pollutants (NO_x)

Nitric oxide

- **NO is an inert gas.**
- **Nitric oxide like CO can combine with haemoglobin and-**
- **reduces oxygen carrying capacity of the blood.**

L-14/3 Primary Pollutants (NO_x)

Nitrous Oxide

- **N_2O – Nitrous oxide or laughing gas**
- **is often used as a dental anaesthetic**
- **is an important green house gas.**
- **One N_2O molecule is about 200 times as effective as one CO_2 molecule, as a green house gas.**

L-14/3 Primary Pollutants (NO_x)

NOx are responsible to damage

textile material like

- **cotton,**
- **Rayon, and**
- **nylon and**

these start fading.

L-14/3 Primary Pollutants (NO_x)

Effect of NO_2 on health

ppm	Effect
0.7 to 2.0	Increased resistance of the lung's airways
5 to 20	Eye and nasal irritation.
20 to 50	Pulmonary discomfort
50 to100	Inflammation of lung tissues
100 to 150	Bronchitis

L-14/3 Primary Pollutants (NO_x)

Control-

- **The use of catalytic converter for the control of automotive emissions.**

- **Fuel burn out at a relatively low temperature in excess air-**

  - under these conditions NO will not be formed.

L-14/4 Primary Pollutants (HC)

(iv) HYDROCARBONS (HC)

- Hydrocarbons are organic compounds which contain only C and H like CH_4 ,
- they represent unburnt and waste fuel.
- The major chemicals in gasoline and petroleum products are hydrocarbons.

L-14/4 Primary Pollutants (HC)

HYDROCARBONS

Aromatic **Aliphatic**

Alkane **Alkene** **Alkyne**

L-14/4 Primary Pollutants (HC)

1. **Alkanes – Saturated HCs e.g. CH_4 are inert and not active in photo chemical reactions.**

2. **Alkenes – or "Olefines" are unsaturated and highly reactive.**

3. **Alkynes – e.g. ethylene.**

L-14/4 Primary Pollutants (HC)

3. Alkynes –

Ethylene, in the presence of sunlight,

- **react with NO_2 at high conc. to form secondary pollutants such as PAN and ozone.**

4. Aromatic hydrocarbons are biochemically and biologically active.

L-14/4 Primary Pollutants (HC)

Sources of Hydrocarbon:-

1. Natural Sources:

- **Some HC come from geothermal areas, coal fields, natural gas from petroleum fields and natural fires.**

- **HC are also produced by plants and trees (terpenes, isoprene)**

- **contd……….**

L-14/4 Primary Pollutants (HC)

Sources of Hydrocarbon:-

1. Natural Sources:

- **CH_4 is the major component HC emitted in the atmosphere.**

- **It is produced by the anaerobic decomposition of organic matter in water or soil**

L-14/4 Primary Pollutants (HC)

2. Anthropogenic Source:-

It is estimated that human activities contribute about 15% of HC.

- **Industrial sources.**
- **Transportation,**

L-14/4 Primary Pollutants (HC)

2. Anthropogenic Source:-

- **HC emissions from solid waste disposal,**
- **agricultural burning and**
- **coal waste fires- also contribute to anthropogenic sources.**

L-14/4 Primary Pollutants (HC)

Harmful Effects of HC –

- **HC are generally non toxic, but their role in the formation of**

---- 'Photochemical Smog' is important.

- **Ethylene, produced in automobile exhaust cause plant damage even at low concentrations.**

L-14/4 Primary Pollutants (HC)

Harmful Effects of HC –

- **Tomato and pepper plants and orchids can be severely damaged if they are exposed to ethylene for longer duration.**

L-14/4 Primary Pollutants (HC)

Control Methods – HC are controlled by physical and chemical method –

- **Through adsorption.**
- **Through substitution.**
- **Through condensation method.**

L-14/5 Primary Pollutants - Particulates

5. **Particulate Matter or ‘Aerosols’-**

Small, solid particles and liquid droplets

are collectively termed as ‘Particulates’.

L-14/5 Primary Pollutants - Particulates

Natural particulates include

- **pollen, viruses,**
- **bacteria, fungi,**

- **spores, fibres,**
- **volcanic dust etc.**

L-14/5 Primary Pollutants - Particulates

Anthropogenic particulates include

- **smoke, fly ash,**
- **acid droplets,**
- **inorganic dusts.**

L-14/5 Primary Pollutants - Particulates

Anthropogenic particulates

There are various types of particulates –

1. **Dust**
2. **Smoke**
3. **Fumes**
4. **Mist**
5. **Fog**
6. **Aerosol**

L-14/5 Primary Pollutants - Particulates

1. **Dust – Dispersion aerosols**

   with solid particles are called dusts.

- **They are heterogeneous in composition.**

L-14/5 Primary Pollutants - Particulates

2. **Smoke – Condensation aerosols**

with a solid and a solid dispersed phase

or

- **a liquid and a liquid dispersed phase are called smokes.**

L-14/5 Primary Pollutants - Particulates

3. Fumes – Solid particles of the size 0.1 to 1mm –

- **which are released from chemical or metallurgical process.**

L-14/5 Primary Pollutants - Particulates

4. **Mist – It is made up of liquid droplets generally smaller than 10 mm**

- **formed by condensation in the atmosphere or**
- **are released from industrial operation.**

L-14/5 Primary Pollutants - Particulates

5. **Fog – It is mist in which the liquid is water and is dense to observe vision.**

6. **Aerosol – all air borne suspensions either solid or liquid , smaller than 1cm.**

Sources of Particulates-

L-14/5 Primary Pollutants - Particulates

Sources of Particulates-

- **About 2000 million tonnes of particulate matter**
- **per year released from natural agencies e.g.**
- **'volcanic eruption', wind, dust, storms etc.**

L-14/5 Primary Pollutants - Particulates

Sources of Particulates-

Man made activities such as

- **burning of wood, coal, oil and gaseous fuels.**
- **Any ash emissions from power plants, forest fires,**
- **burning of coal refuse and**
- **agricultural refuse etc.**

L-14/5 Primary Pollutants - Particulates

- **Aerosols cause allergies to sensitive persons.**

- **The sprays of insecticides and pesticides affect the central nervous system.**

Control – Various types of equipments are used for the removal of particulate matter from gas streams.

SECONDARY POLLUTANTS

OZONE

L-15/1 Secondary Pollutants (O_3)

Secondary Pollutants – (O3, Acid Rain, Smog)

Ozone –

- **Ozone is a bluish gas with an pungent odour.**
- **Water soluble, unstable, sweetish odour.**

L-15/1 Secondary Pollutants (O_3)

Ozone –

- **It can be produced by passing a high voltage through dry air between two electrodes.**
- **It is unstable and breaks down to O_2 and nascent oxygen**

(a powerful oxidizing agent).

L-15/1 Secondary Pollutants (O_3)

Occurrence –

- **Natural ozone mainly occurs in the stratosphere where-**

- **it serves a vital biological role in absorbing high energy photons of UV rays.**

L-15/1 Secondary Pollutants (O_3)

Natural O_3 is also present in troposphere.

"Ozone is a life saviour, if present in Stratosphere but a pollutant in troposphere".

L-15/1 Secondary Pollutants (O_3)

Sources –

1. Mainly it is present in stratosphere
but small concentration diffuses downwards.

2. Also small amount is produced by lighting, forest fires.

L-15/1 Secondary Pollutants (O_3)

3. The emission of hydrocarbons, CO and NOx mainly from vehicles

is responsible for higher ozone concentration in the troposphere.

L-15/1 Secondary Pollutants (O_3)

- **NO (nitric oxide) present in atmosphere reacts with ozone and is thus,**

- **responsible for the depletion of ozone.**

L-15/1 Secondary Pollutants (O_3)

Effects –

- **Ozone is a smelly and poisonous gas.**
- **At higher concentration**
- **Ozone is a major component of photochemical smog along with PAN.**

L-15/1 Secondary Pollutants (O_3)

Effects –

- **It is an irritant. In the respiratory tract reaches much deeper into lungs than SO_x.**
- **Causes coughing,**
- **breathing problems,**
- **headache,**
- **altered red blood cells,**
- **eye, nose and throat irritation.**

L-15/1 Secondary Pollutants (O_3)

- **Effect of ozone on plants include**
- **premature aging,**
- **suppressed growth,**
- **nacrosis (killing of tissues).**

- **The cracking of tyres has become a serious economic problem.**

L-15/1 Secondary Pollutants (O_3)

Control –

tropospheric ozone conc. can be reduced by controlling –

the emission of the anthropogenic precursors of ozone which are HC's, NOx and CO for this-

L-15/1 Secondary Pollutants (O_3)

Control –

- **Reduce NOx emissions from power stations and vehicle exhausts.**

- **Reduce volatile organic compounds (VOC) emissions from vehicle exhausts, fuel system.**

- **Reduce CO emissions from vehicles.**

SECONDARY POLLUTANTS
ACID RAIN

L-15/3 Secondary Pollutants (Acid rain)

Definition **– (by Robert Angus in 1872).**

"Presence of excessive acid in rain water is called acid rain."

Acid rain is a mixture of ***H_2SO_4 and HNO_3*****.**

L-15/3 (Acid rain)

Acid rain is in fact cocktail (mixing) of mainly H_2SO_4 and HNO_3, where the ratio two acids vary according to the quantities of S And N_2,

- **H_2SO_4 is about 60 – 70%,**
- **HNO3 is 30 - 40% and**
- **HCl is 0 – 5%.**

L-15/3 (Acid rain)

Sources

- **Human activities- gaseous emissions from Cars, homes,**
- **factories and Power Station.**
- **Volcanoes,**
- **Burning of fossil fuels.**
- **Industrialization,**
- **Automobiles.**

L-15/3 (Acid rain)

$SOx + O_2 + H_2O \longrightarrow H_2SO_3$ or H_2SO_4

Sulphurous acid Sulphuric acid

$NOx + O_2 + H_2O \longrightarrow HNO_2$ or HNO_3

Nitrous acid Nitric acid

$CO_2 + H_2O \longrightarrow H_2CO_3$

Carbonic acid

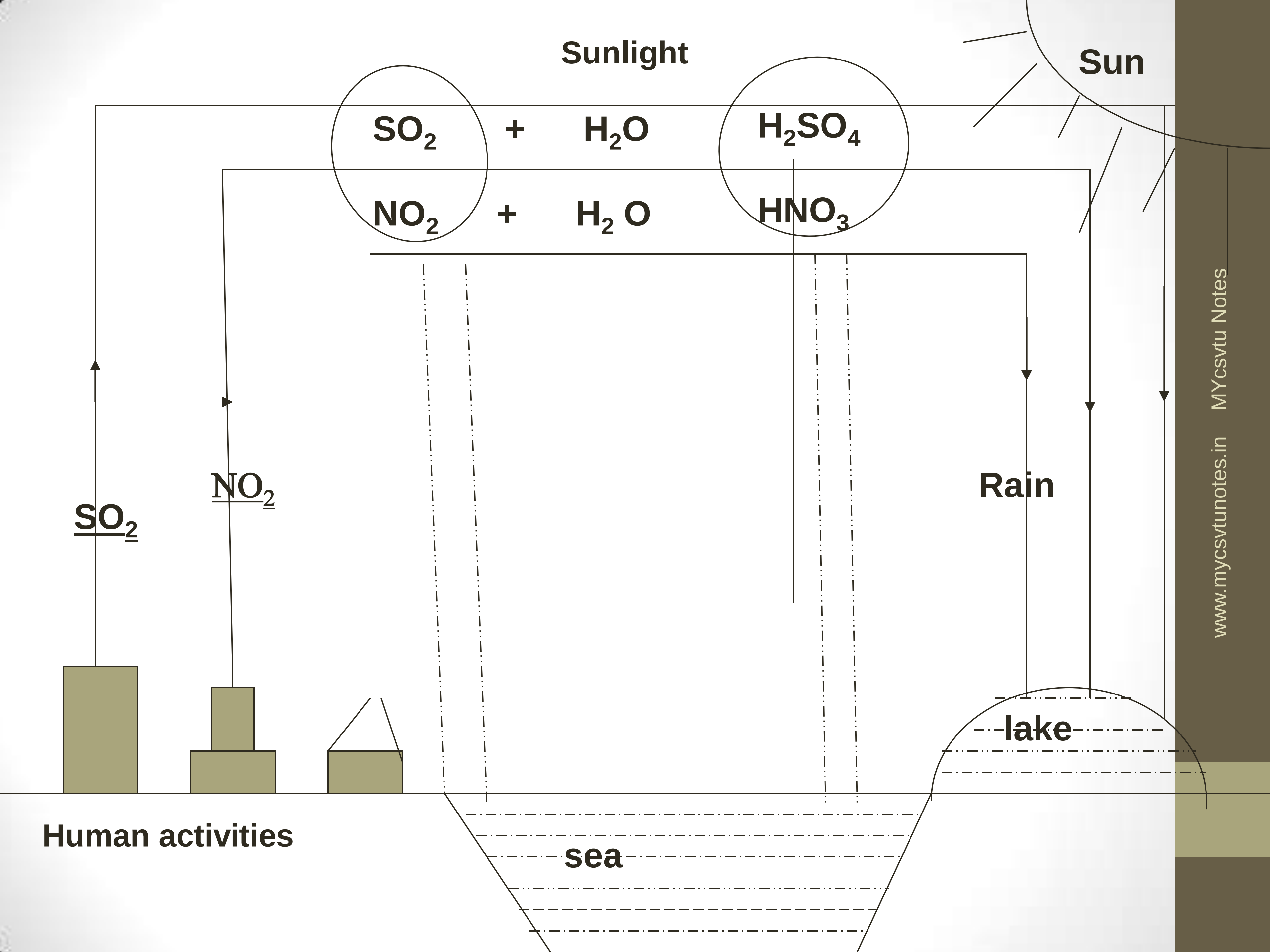
$NOx + VOC \xrightarrow{\text{sunlight}} O_3$ (Ozone)

Control of Acid Rain:-

1. **The simplest solutions to the problem is to neutralize the acid with time.**

2. **To reduce the emissions of SOx and NOx from industries.**

3. **Desulphurisation and denitrification.**


Sunlight
Sun
SO_2 + H_2O
H_2SO_4
NO_2 + H_2 O
HNO_3
NO_2
SO_2
Rain
lake
Human activities
sea

L-15/3 (Acid rain)

4. Energy conservations:- Reduce fuel consumption.

5. Substitution for fossil fuels by other alternative energy forms.

L-15/3 (Acid rain)

Harmful Effects of Acid Rain-

- **On Terrestrial Ecosystem.**
- **On Buildings.**
- **On Aquatic Biota.**

L-15/3 (Acid rain)

(Harmful Effects)

- **Effects on aquatic systems such as acidification, decreased alkalinity and mobilization of metals like Al.**
- **Biological effects on aquatic biota decline the productivity of fish and amphibians.**

L-16/3 (Acid rain)

- **Many bacteria and blue green algae are killed due to acidification.**

(Effects of Acid Rain on Terrestrial Ecosystem)

- **Acid rain damages leaves of plants and trees and retards the growth of plants.**

L-15/3 (Acid rain)

Acid rain retards the growth of crops such as

Pea, **Beans,**

Radish, **Potato, etc.**

- **It destroys the fertility of the soil.**

L-15/3 (Acid rain)

(Effects of Acid Rain On Buildings)

- **Extensive damage of buildings and rapid attack of materials of marble limestone.**

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2S + CO_2$$

- **The attack on marble is termed as 'Acid Leprosy'.**

L-15/3 (Acid rain)

- **Due to acidity, Al, Mn, Pb, Cd, Cu and Cr conc. in water**
- **increases beyond the safe limit which affects the buildings.**
- **The Taj Mahal of Agra is also suffering at present due to SO_2 and H_2SO_4 fumes.**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L-15/4 Photochemical Smog

Photochemical Smog (Secondary Pollutant):-

- **The majority of the harmful effects of hydrocarbon pollution**
- **is not due to the hydrocarbons,**
- **but the products of photochemical reactions in which these are involved.**

L-15/4 Photochemical Smog

Photochemical Smog (Secondary Pollutant):-

…….

- **‘Smog’ originally means an odd combination of ‘Smoke’ and ‘Fog’.**

L-15/4 Photochemical Smog

- **The condition for the formation of chemical smog are-**

(a) Stagnant air masses,

(b) Abundant sunlight,

L-15/4 Photochemical Smog

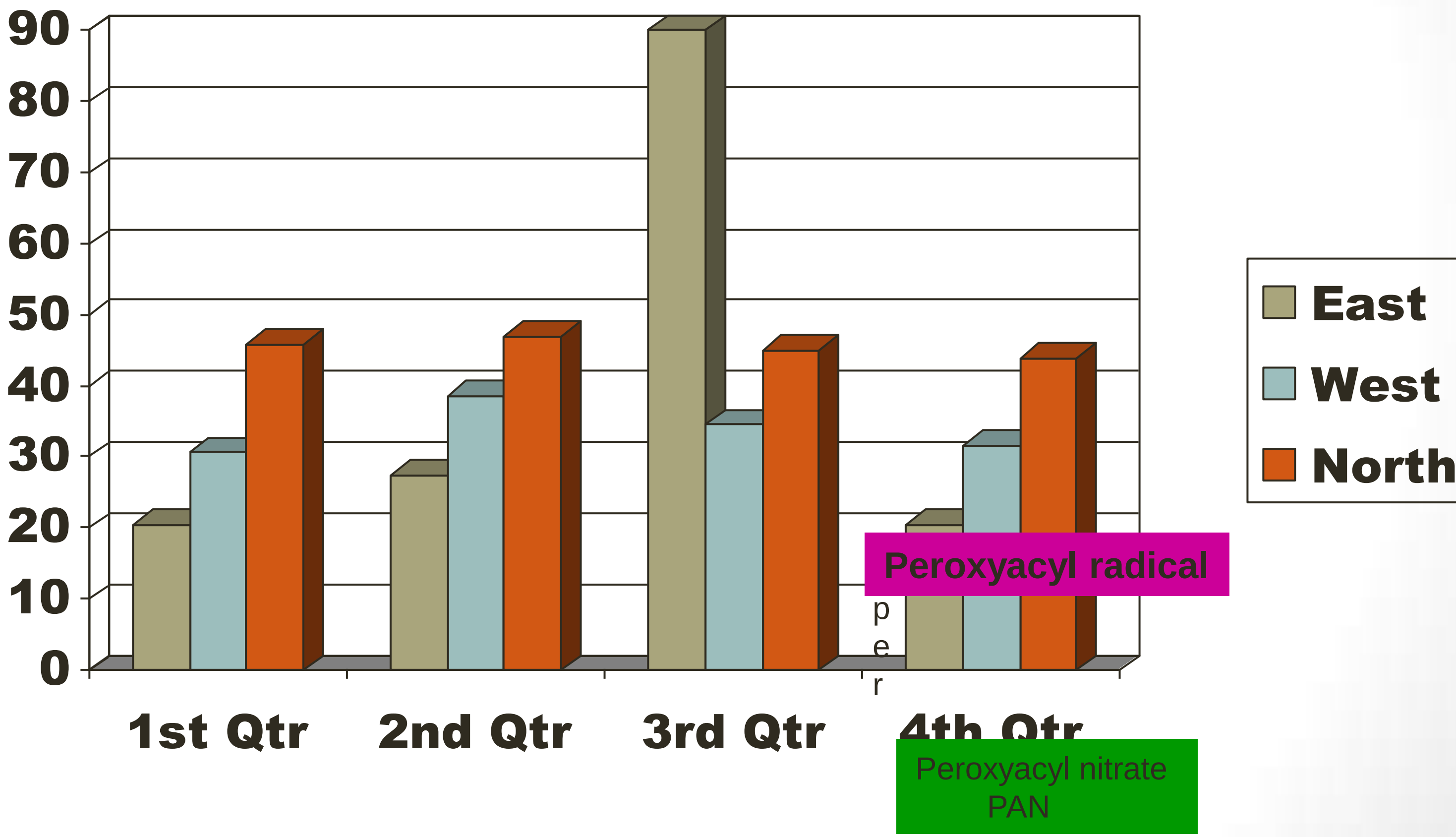
- **The condition for the formation of chemical smog are-**

(c) High concentration of hydrocarbon and NOx pollutants.

Photochemical smog is characterized by Brown, hazy fumes which-

- **irritates the eyes and lungs.**

Reactive hydrocarbon



Photochemical smog cycle

L-15/4 Photochemical Smog

- **Lead to the cracking of rubbers and**
- **cause extensive damage of plants life.**

- **This is an oxidising smog and it has high concentration of oxidants.**

L-15/4 Photochemical Smog

Reactions Involved in Photochemical Smog:-

- **Reactive hydrocarbons from automobile exhaust interact with O_3 to form a free radical RCH_2 .**

Reactive HC + O_3 $\rightarrow$ $RCH_2\cdot$

L-15/4 Photochemical Smog

Reactions Involved in Photochemical Smog:-

- **$RCH_2\cdot$ reacts with O_2 to form another free radical.**

$$RCH_2\cdot + O_2 \rightarrow RCH_2O_2\cdot$$

L-15/4 Photochemical Smog

$$RCH_2\cdot + O_2 \rightarrow RCH_2O_2\cdot$$

- $RCH_2O_2\cdot$ reacts with NO to produce NO_2 and the free radical $RCH_2O\cdot$.

$$RCH_2O_2\cdot + NO \rightarrow RCH_2O\cdot + NO_2$$

L-15/4 Photochemical Smog

- **This new free radical with O_2 to yields a stable aldehyde, RCHO and hydroperoxyl radical HO_2.**

$$RCH_2O^{\cdot} + O_2 \longrightarrow RCHO + HO_2^{\cdot}$$

L-15/4 Photochemical Smog

- **$HO_2\cdot$ then reacts with another molecule of NO to give NO_2 and HO.**

$$HO_2\cdot + NO \rightarrow HO\cdot + NO_2$$

L-15/4 Photochemical Smog

- **HO· is extremely reactive and**
- **rapidly reacts with a stable RCH_3 to yield**
- **H_2O and regenerate the free radical $RCH_2\cdot$.**

$$RCH_3 + HO\cdot \rightarrow RCH_2\cdot + H_2O$$

L-15/4 Photochemical Smog

- **One complete cycle yields**
- **two molecules of NO_2**
- **one molecule of RCHO and regenerates the**
- **free hydrocarbon radical $RCH_2\cdot$ to start all over again.**

L-15/4 Photochemical Smog

- **RCHO interacts with the HO· radical and form acyl radical RC = 0·**

$$\mathbf{RCHO + HO^{\cdot} \rightarrow RC = O^{\cdot} + H_2O}$$

L-15/4 Photochemical Smog

- The aldehyde RCHO interacts with the HO· radical and form acyl radical RC = 0·

$$RCHO + HO^{\cdot} \rightarrow RC=O^{\cdot} + H_2O$$

- Acyl radical further change into peroxyacyl radical by the absorption of O_2 and-

$$RC=O^{\cdot} + O_2 \rightarrow RC(=O)OO^{\cdot}$$

acyl radical peroxyacyl radical

L-15/4 Photochemical Smog

Peroxyacyl radical

- **finally changes into the RCO_3NO_2 peroxyacyl nitrate (PAN)**

$$RC(=O)OO\cdot + NO_2 \longrightarrow R\text{-}C(=O)OONO_2 + HO\cdot$$

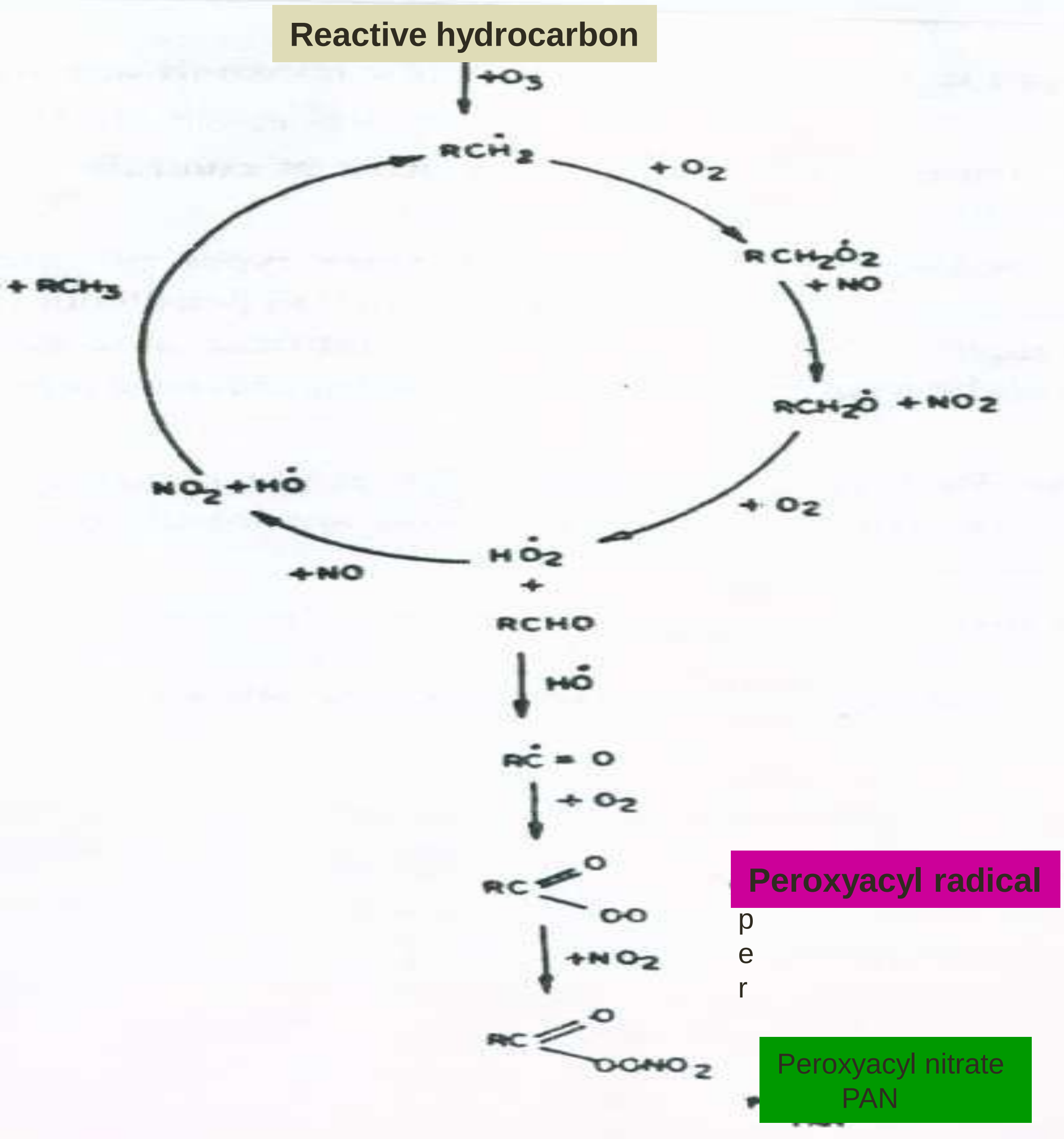


Fig. Photochemical smog cycle

L-15/4 Photochemical Smog

- **PAN is one of most potent eye irritant found in smog.**
- **The primary pollutants in photochemical smog are**

- **nitric oxide and hydrocarbons-**
- **which convert rapidly in to the secondary pollutants like ozone and PAN.**

GLOBAL WARMING

(GREEN HOUSE EFFECT)

L-16/1 Green House Effect &..

- **The heating up of the earth's surface due to absorption of**

- **heat radiation and retention is called as Global Warming.**

L-16/1 Green House Effect &..

- **Water vapour and radioactively active gases (RAG's) or**
- **green house gases (GHG) in the atmosphere-**
- **absorb a large part of long wave radiation and the temperature**
- **raises from 2550^0K to 2900^0K.**

From fig 2. (next-)

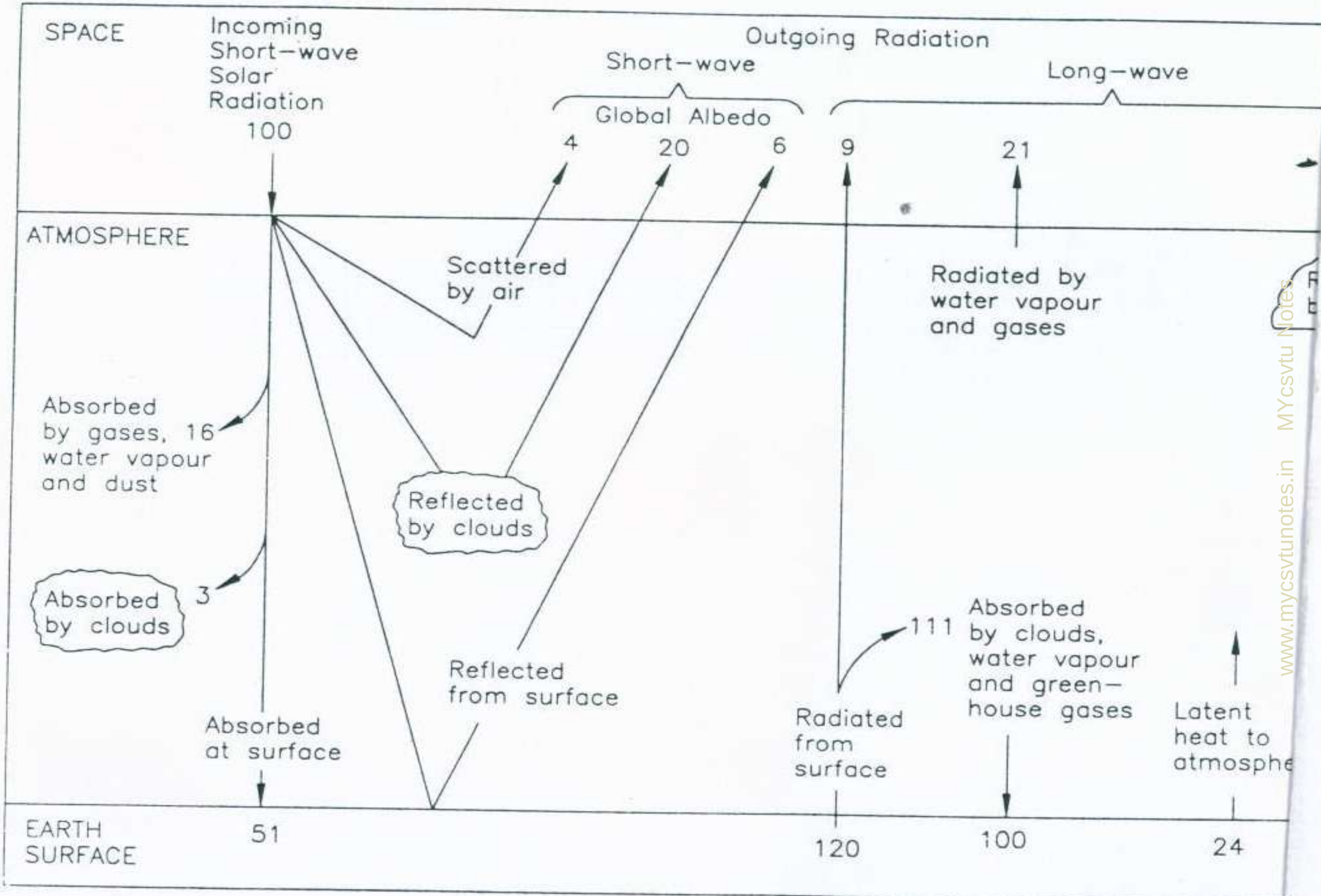
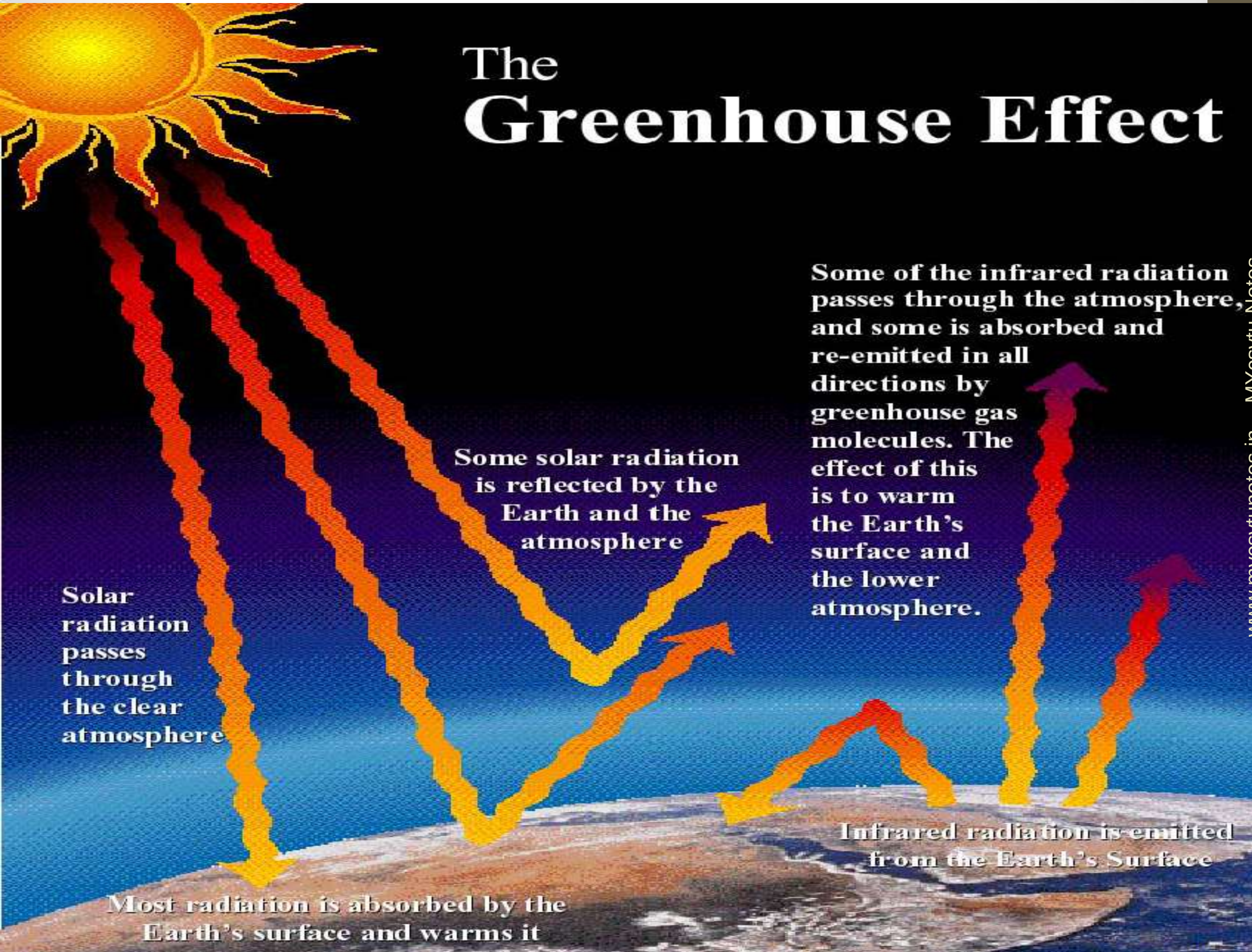


Fig. Main components of the earth's radiation balance.


The Greenhouse Effect
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Some solar radiation is reflected by the Earth and the atmosphere
Solar radiation passes through the clear atmosphere
Infrared radiation is emitted from the Earth's Surface
Most radiation is absorbed by the Earth's surface and warms it

L-16/1 Green House Effect &…

- **120 units of long wave energy emitted from the earth's surface,**
- **111 units are absorbed by clouds, water vapour and GHG's in the atmosphere.**

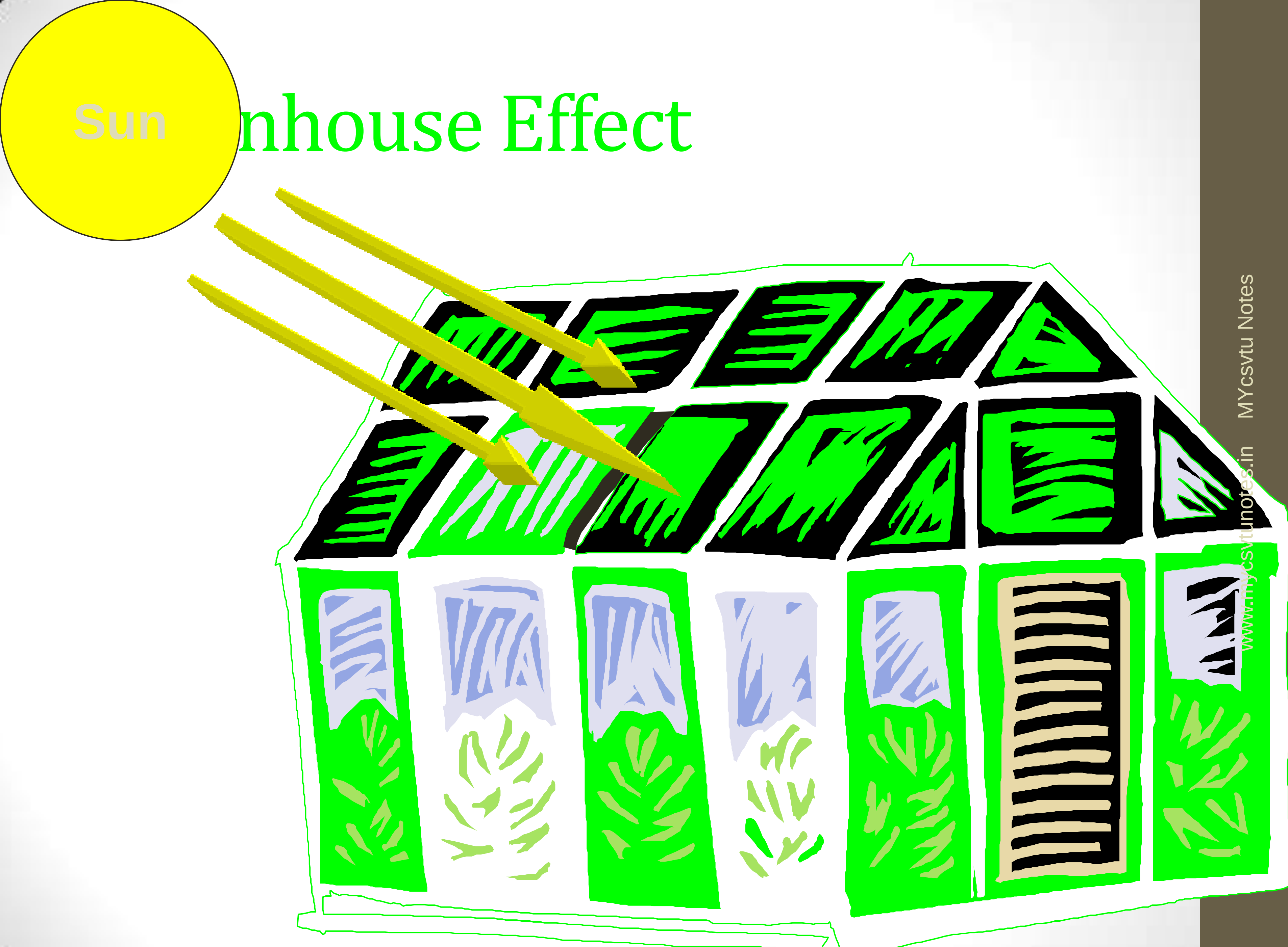
L-16/1 Green House Effect &…

- **40 units are radiated by clouds,**
- **21 units are radiated by water vapour and gases.**
- **100 units return to the earth.**

L-16/1 Green House Effect &…

- **Thus, this ability to retain the longer wave radiation from earth's surface is commonly known as "Green house effect".**

nhouse Effect

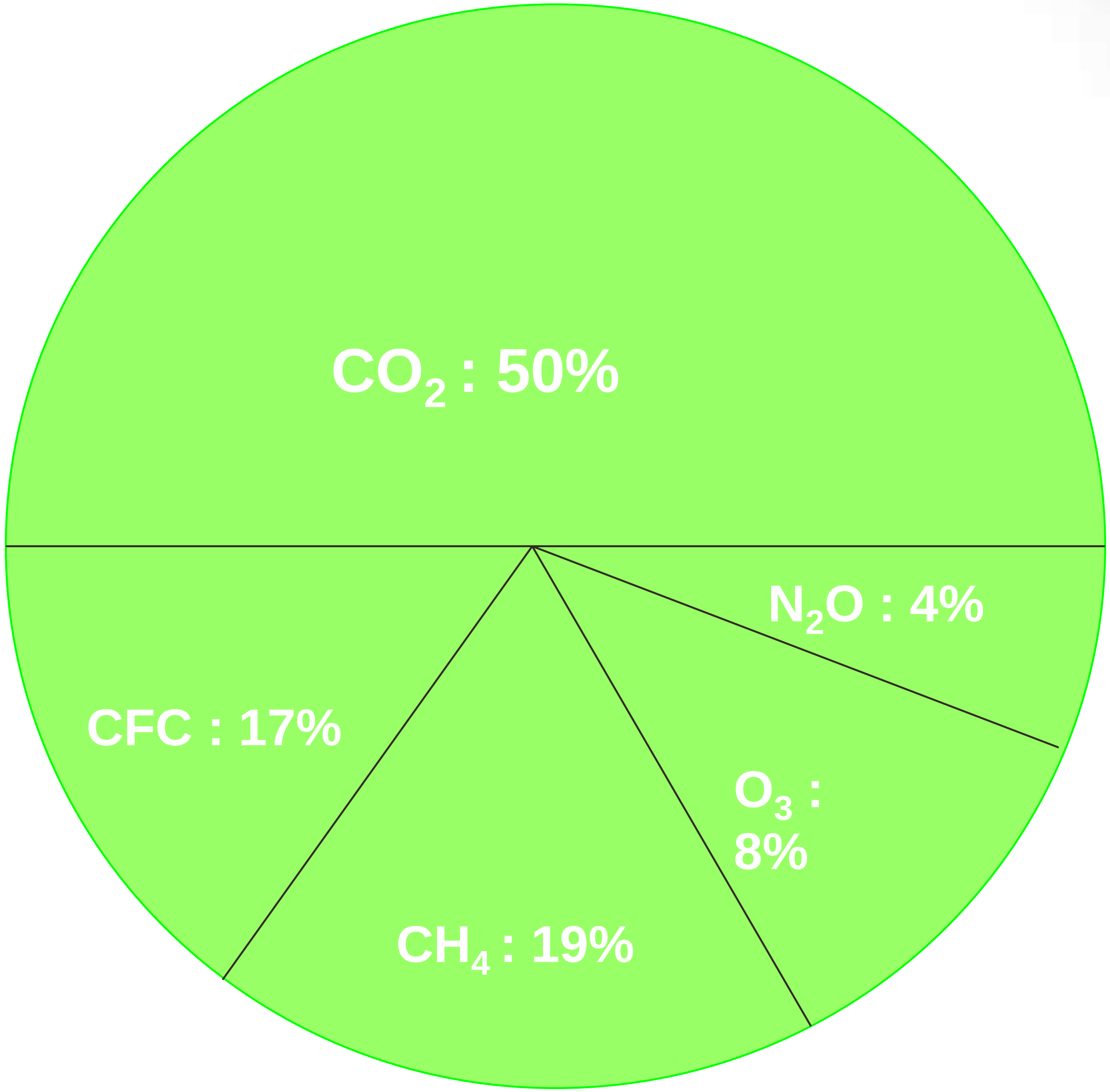


L-16/1 Green House Effect &…

Global Warming:-

Some Green House Gases

- **CO_2 50%** **Burning of fossil fuels coal, oil, petroleum,**
- **CFC (chlorofluoro carbon)17%** **Through refrigeration, insulation,**



Green House Gases

L-16/1 Green House Effect &…

- **aerosols.**
- **CH_4 19% Agriculture**
- **N_2O 4% from fossil fuels**
- **O_3 8% By photochemical reaction of NO_2.**

L-16/1 Green House Effect &…

GLOBAL WARMING
AND GREEN HOUSE EFFECT

Global Warming:- The average global temperature is increasing day by day.

- **30^{o} C – 40^{o} C rise is harmful.**

- **The energy of sun is emitted as 'red radiation'.**

L-16/1 Green House Effect &…

- CO_2 and water vapour absorb in red radiation and block a large fraction of the earth emitted radiation.

GREEN HOUSE EFFECT:-

The term 'Green house effect' first given by J. Fourier in 1827.

- The effect is also called as 'Atmospheric effect' and 'Global warming'.

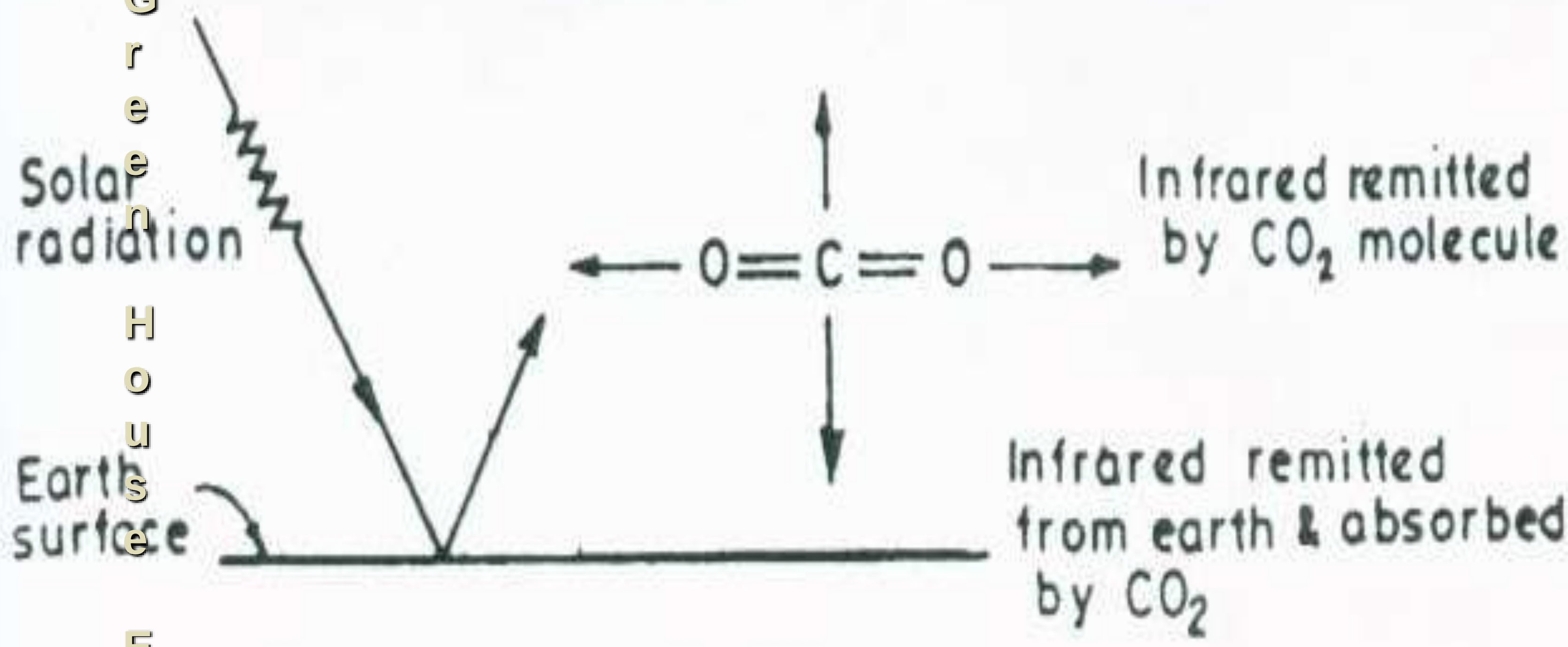
L-16/1 Green House Effect &...

- **Incident solar energy is absorbed by earth's surface and emitted into space as long wave radiation.**

- **Some gases like CO2 and water vapour are transparent to the incoming shortwave radiations.**

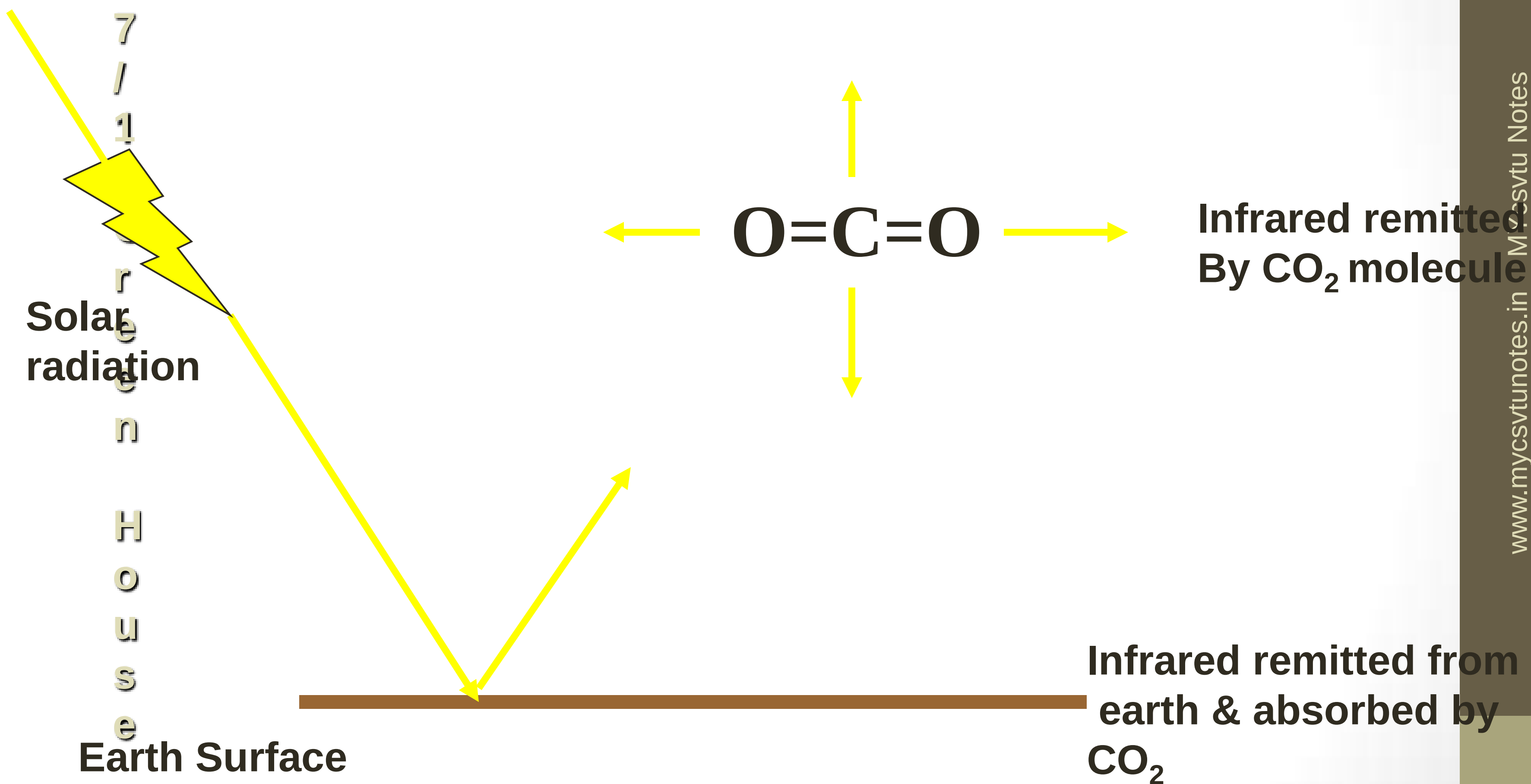
L-17/1 Green House Effect &…

L-17/1 Green House Eff



L-16/1 Green House Effect &…

L-17/1 Green House Eff



L-16/1 Green House Effect &…

- **CO_2 and water vapour are transparent to the incoming shortwave radiations but-**
- **are nearly opaque to the reflected longer radiation. This gives warming.**
- **This phenomenon is known as Green House Effect. And such gases called Green House Gases.**

L-16/1 Green House Effect &…

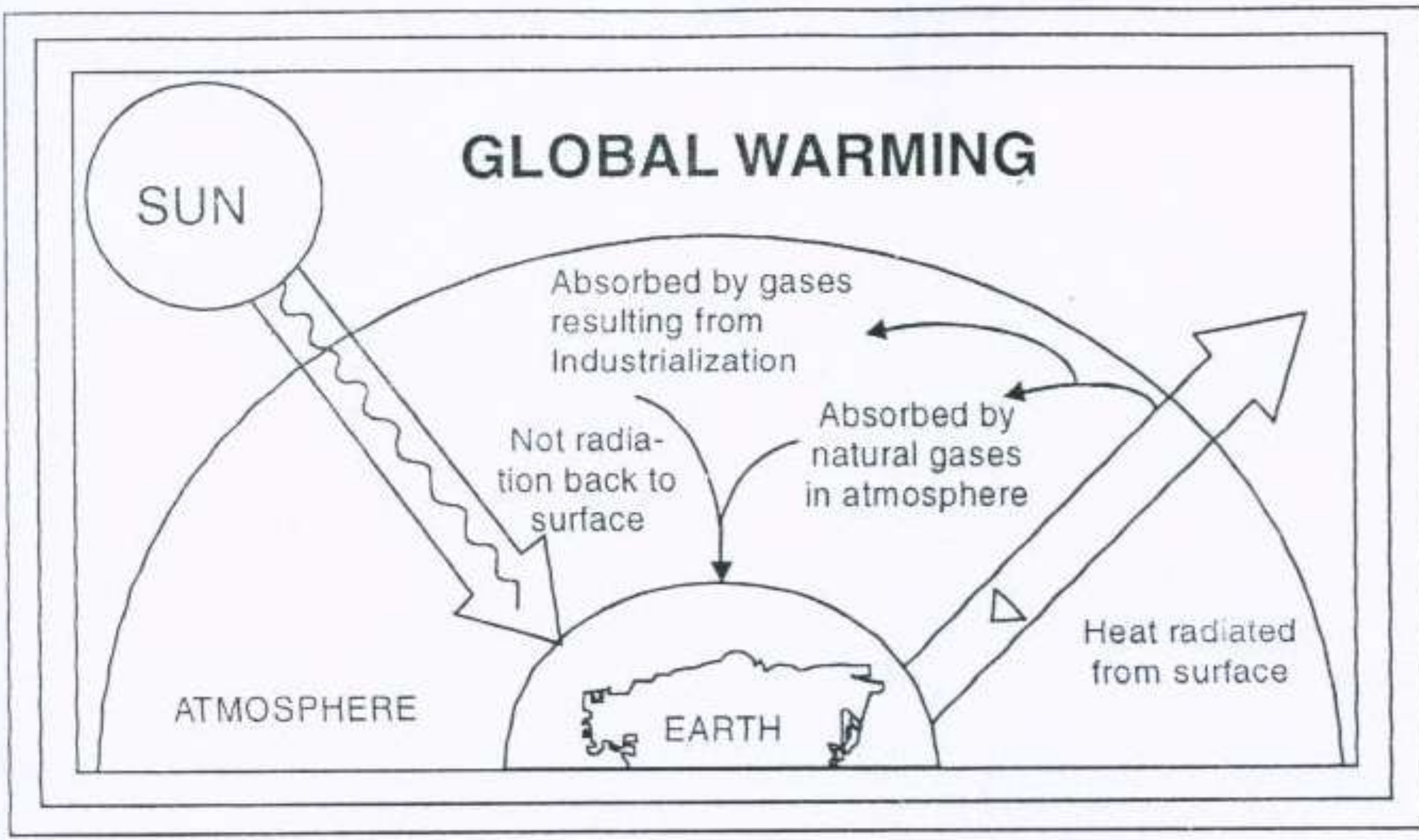
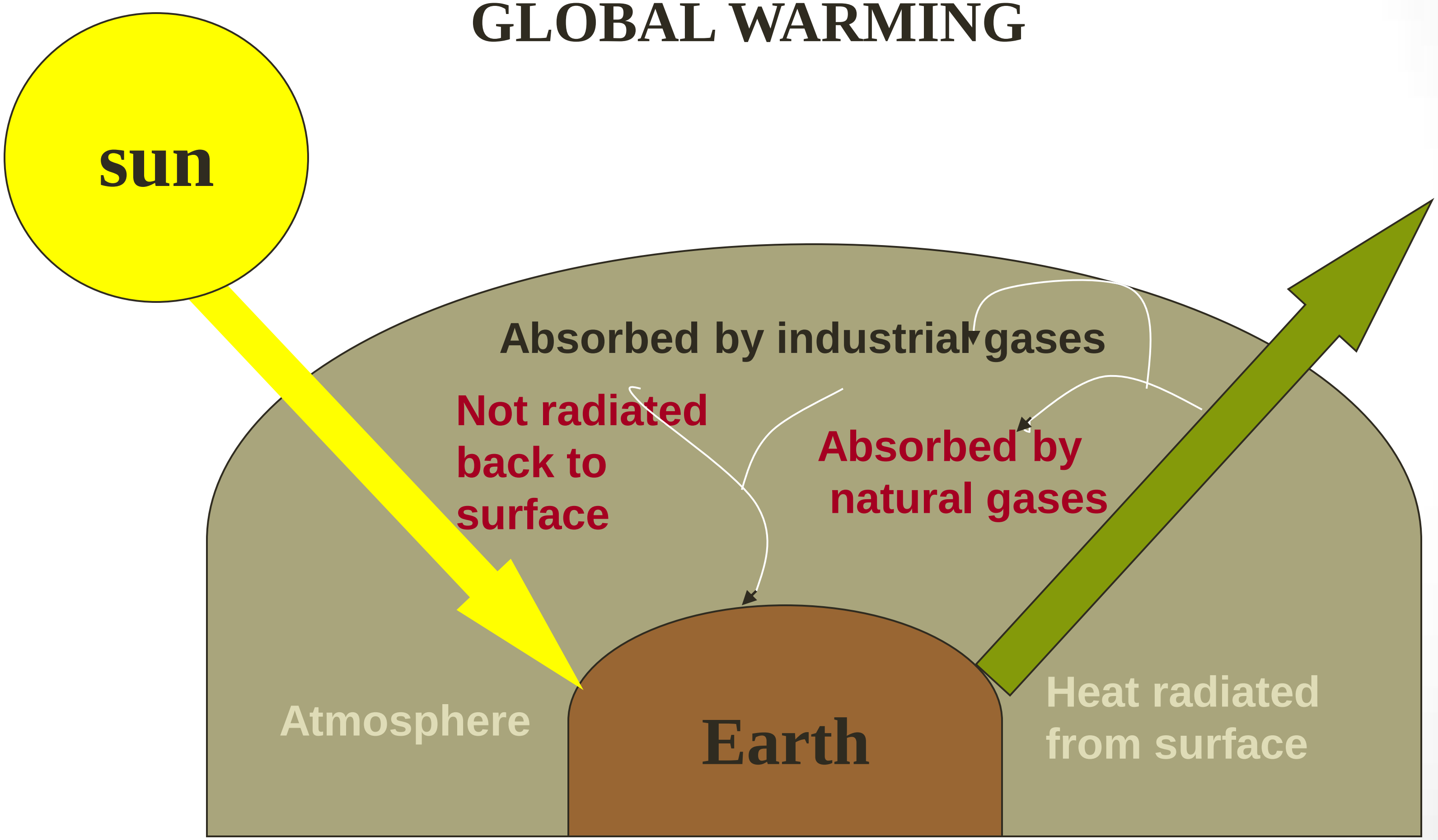


Fig. Global Warming.

L-16/1 Green House Effect &...

GLOBAL WARMING



L-16/1 Green House Effect &…

Definition:-

“ The progressive warming up of the earth surface due to blanketing effect CO2 in the atmosphere”.

- **The pollutants from human activities are increasing**
- **the global conc. of heat trapping gases, which act like a blanket.**

L-16/1 Green House Effect &…

- **It reminds of the heat trapping effect of the glass wall in a horticultural green house.**

- **In a green house, visible light passes through the glass and heats up the soil and warms up the plants.**

L-16/1 Green House Effect &…

- **The warm soil emits radiations of longer wavelength (I.R.). This mechanism keeps the green house warmer.**

- **Thus a green house is a body which allows the shorter wavelengths from SUN to come in but does not allow the longer wave radiations (IR) to escape.**

L-16/1 Green House Effect &…

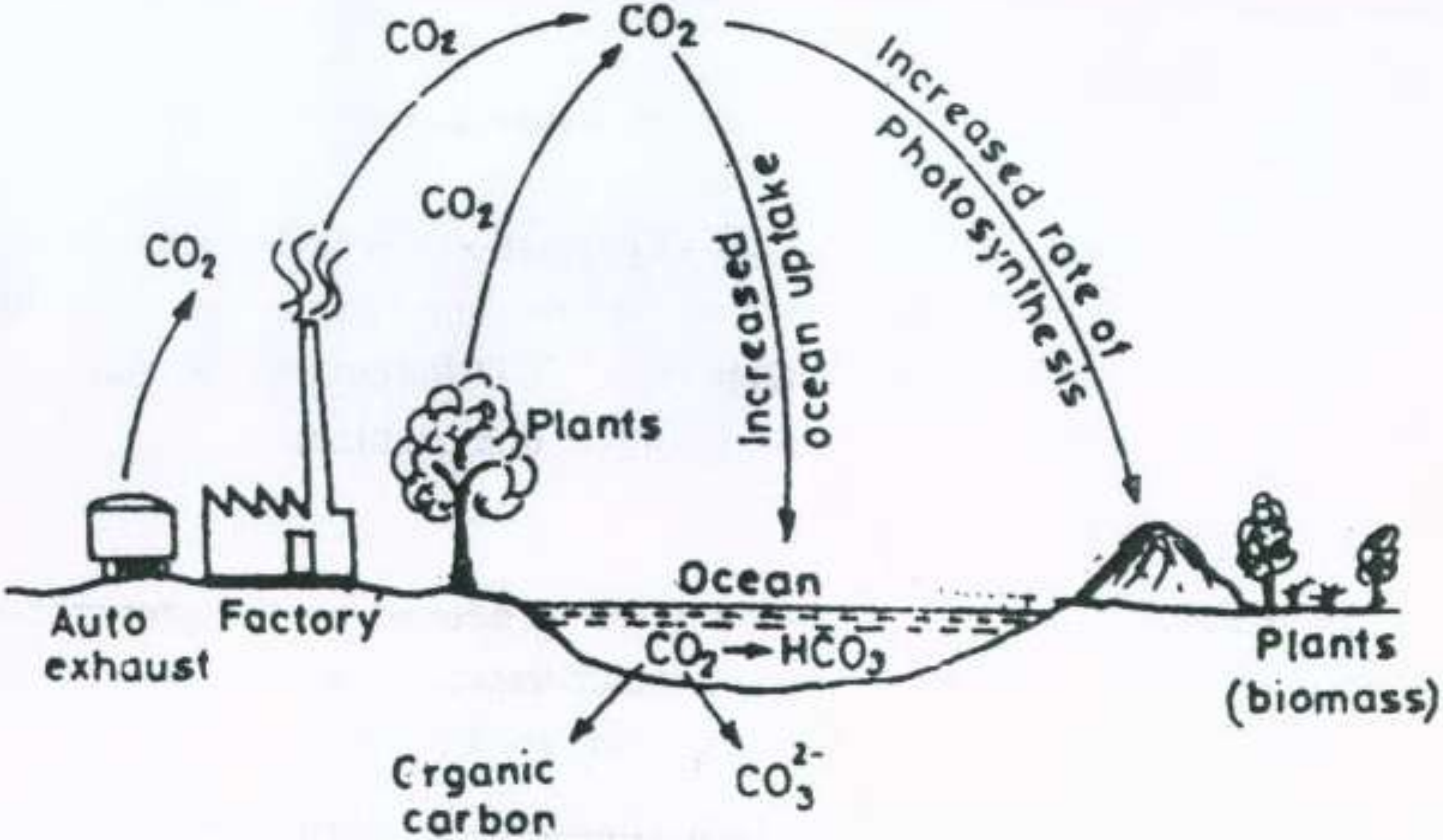
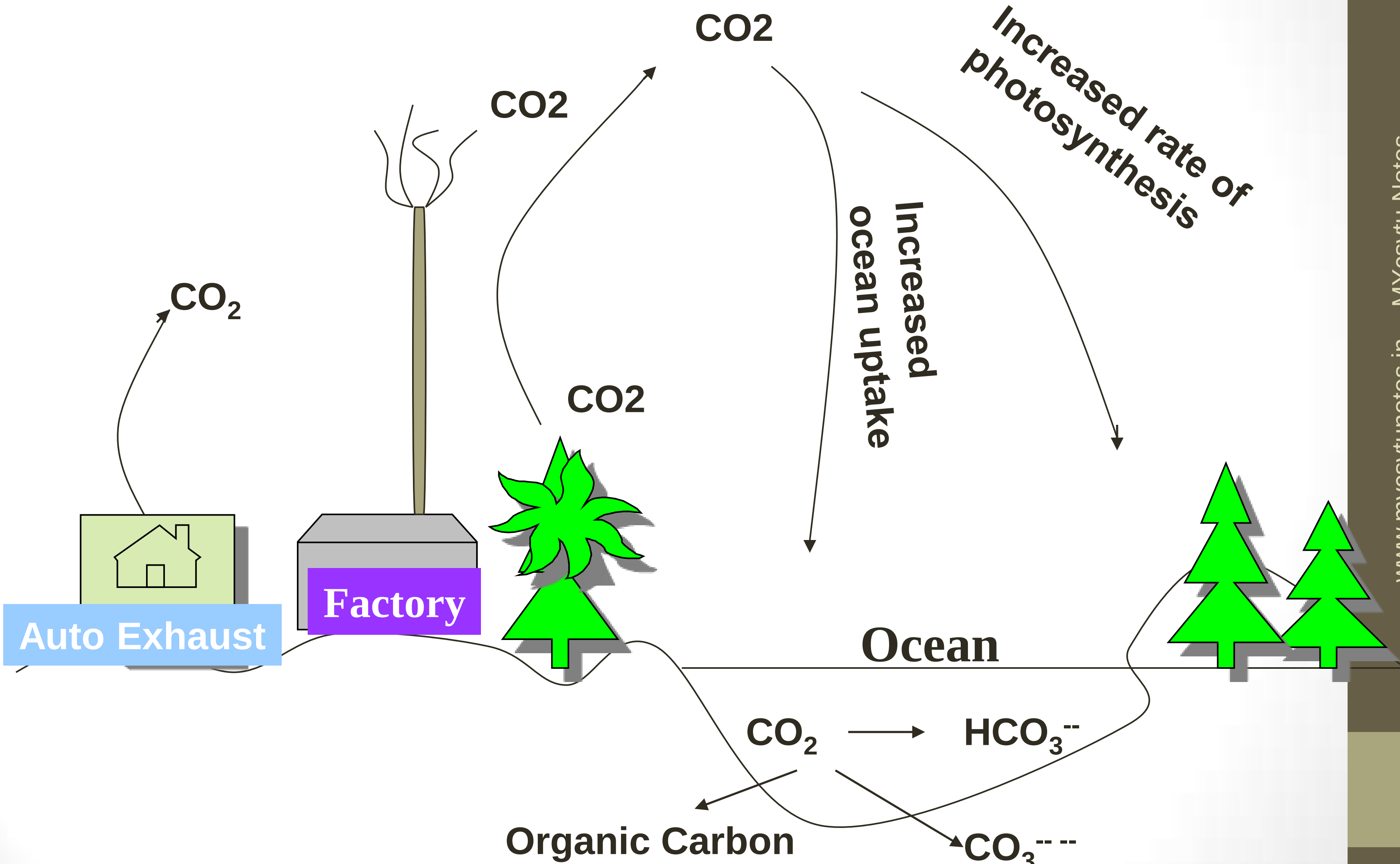


Fig. Sources and sinks of carbon dioxide.

L-16/1 Green House Effect &...



L-16/1 Green House Effect &…

Sources of Green House Gases.

Major sources are:-

(i) Factories,

(ii) Fossil fuels

(iii) automobile, railways, air craft

(iv) Burning of fossil fuel

(v) Deforestation

L-16/1 Green House Effect &…

Sources of Green House Gases.

(vi) Halogenated gases (CFC)

(vii) Forest fire

(viii) Bacteriological decomposition of dead organic compounds.

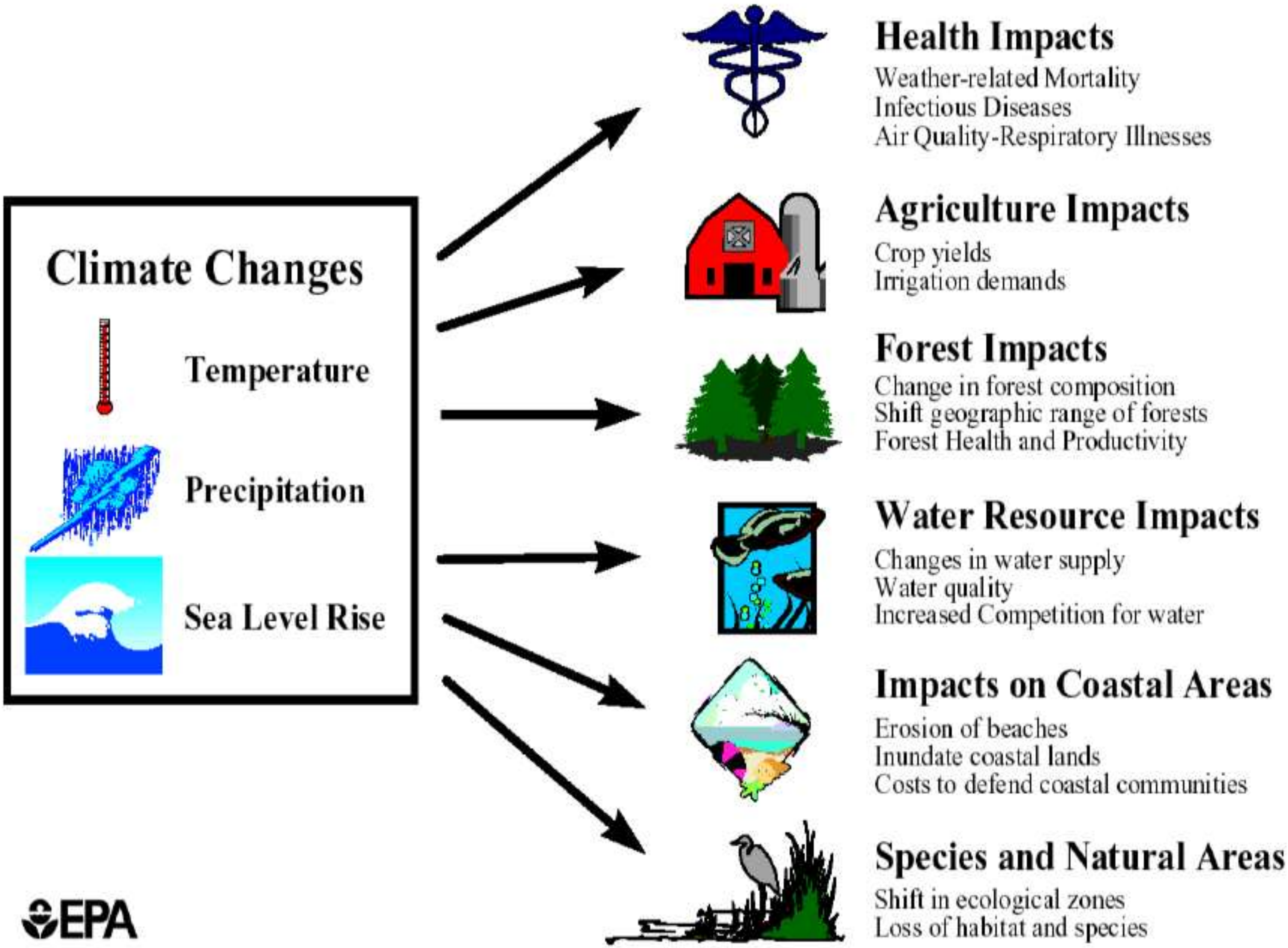
L-16/1 G H Effect & Global warming

Effect of Green House gases:-

- **Rise in temperature will result in melting the ice masses in the Arctic and Antarctica region.**

- **In temperate regions the summers will be longer and hotter whereas in the winters will shorter and warmer.**

Potential Climate Change Impacts



Direct Weather related Mortality

- **Climate change is expected to increase the frequency of very hot days.**

- **During heat waves deaths from cardio-vascular and respiratory illness also increase.**

- **Winter mortality may decrease, but not expected to offset the summer mortality increase.**

- **The elderly, particularly those living alone and children are in greatest danger during heat waves.**

L-16/1 G H Effect & Global warming

- **Due to increased conc. of CO_2 the growth and yield of plants will increase.**
- **Global warming will also lead to dislocation of suitable land for agriculture.**

L-16/1 G H Effect & Global warming

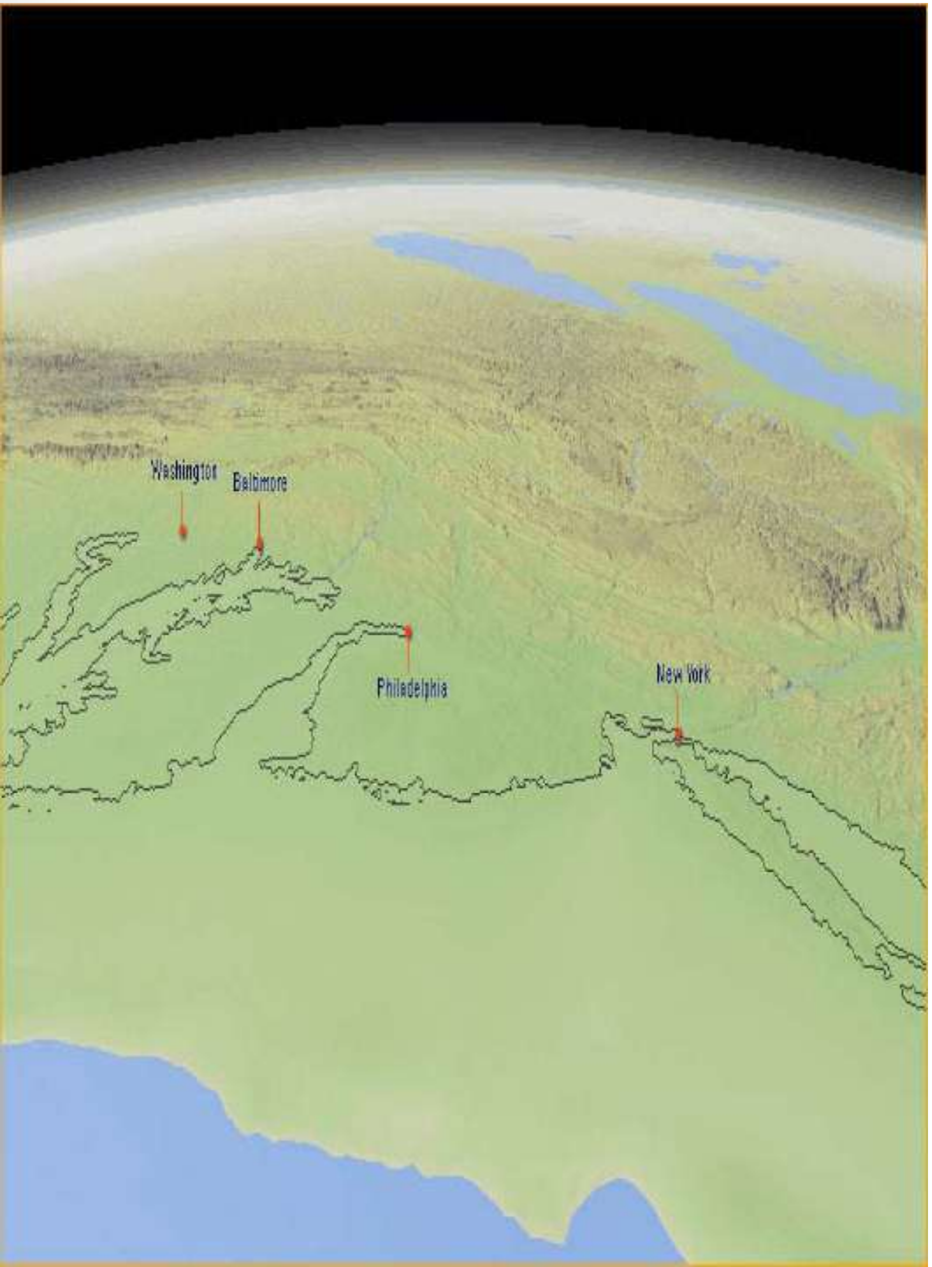
Impact of Green House Effect
On Global Climate:-
The changes in the climate due to the green house effect can be:

- **In temperature region, the winter will be shorter and warmer and the summer will be longer and hotter.**

L-16/1 G H Effect & Global warming

- **Industrialization and deforestation will create a layer of impenetrable gases.**
- **Plants will be less rich in nitrogen and hence more susceptible to pests.**

Ice Age Shorelines



Current Shorelines

Prevention of Global Warming:-

- **Drastic cut in the consumption of fossil fuels.**
- **Technical alteration in industrialization and transportation.**

- **Use of methanol in automobile.**
- **Use of solar energy, Biogas.**
- **Forestation.**

Mitigation of Global Warming

- Conservation
  - Reduce energy needs
  - Recycling
- Alternate energy sources
  - Nuclear
  - Wind
  - Geothermal
  - Hydroelectric
  - Solar
  - Fusion

L-16/2 Depletion of Ozone Layer

- **Ozone is present at all altitudes in the atmosphere mainly in the stratosphere extending from 10 kms to 30 kms.**

- **This upper layer of the atmosphere is commonly known as Ozonosphere.**

L-16/2 Depletion of Ozone Layer

- **Its conc. at tropopause is < 1.0ppm and then starts**
- **increasing to a maximum value of 8.0 ppm at 30 km.**
- **and then again decreases to a value of 2.0ppm at 40 km.**
- **Its value reaches 0 ppm at 100 k.m.**

L-16/2 Depletion of Ozone Layer

Formation of Ozone Layer:-

- In stratosphere, O_3 is formed naturally when oxygen is dissociated by UV solar radiations.

$$O_2 + h\nu\ (242\ nm) \rightarrow O + O$$

$$O + O_2 + M \rightarrow O_3 + M$$

- Where M denotes energy and momentum balance
- produced by the collision of different molecules.

L-16/2 Depletion of Ozone Layer

Cause of Depletion of Ozone Layer:-

1. **Water vapour and nitrogen oxides released by high attitude aircrafts.**

2. **Nitrous oxides (N_2O) produced by the bacteria in soil.**

L-16/2 Depletion of Ozone Layer

3. Chlorofluoro hydrocarbons which are widely used in refrigeration.

4. So depletion of ozone takes place and result in increase in u v rays reaching the earth.

L-16/2 Depletion of Ozone Layer

Mechanism of Ozone Depletion:-

It includes :

(1) The natural process.

(2) The anthropogenic process.

L-16/2 Depletion of Ozone Layer

1.The Natural Process:-

- **The atmospheric oxygen absorbs UV radiation at < 240 nm. And photo dissociate into two oxygen atoms.**
- **This nascent oxygen combine with oxygen molecule and form ozone (O3).**

L-16/2 Depletion of Ozone Layer

- **This ozone again react with nascent oxygen and dissociates into molecular oxygen.**

$$O_2 + n\mu \xrightarrow{240 - 260\ nm} O + O$$

$$O_3 + O \longrightarrow O_2 + O_2$$

- **Ozone acts as a powerful oxidant because of its ability to remove electrons from other molecules.**

L-16/2 Depletion of Ozone Layer

- **The CFC' s (like chlorofluoro methane or freon) are inert in normal and physical reactions but –**

- **they get accumulated in greater amounts at higher altitudes of stratosphere.**

- **Release chlorine atoms under the influence of UV radiations.**

L-16/2 Depletion of Ozone Layer

$$CF_2Cl_2 + h\nu \rightarrow Cl + CF_2Cl \quad \text{---- (1)}$$

$$CF_2Cl + O_2 \rightarrow CF_2O + ClO \quad \text{----- (2)}$$

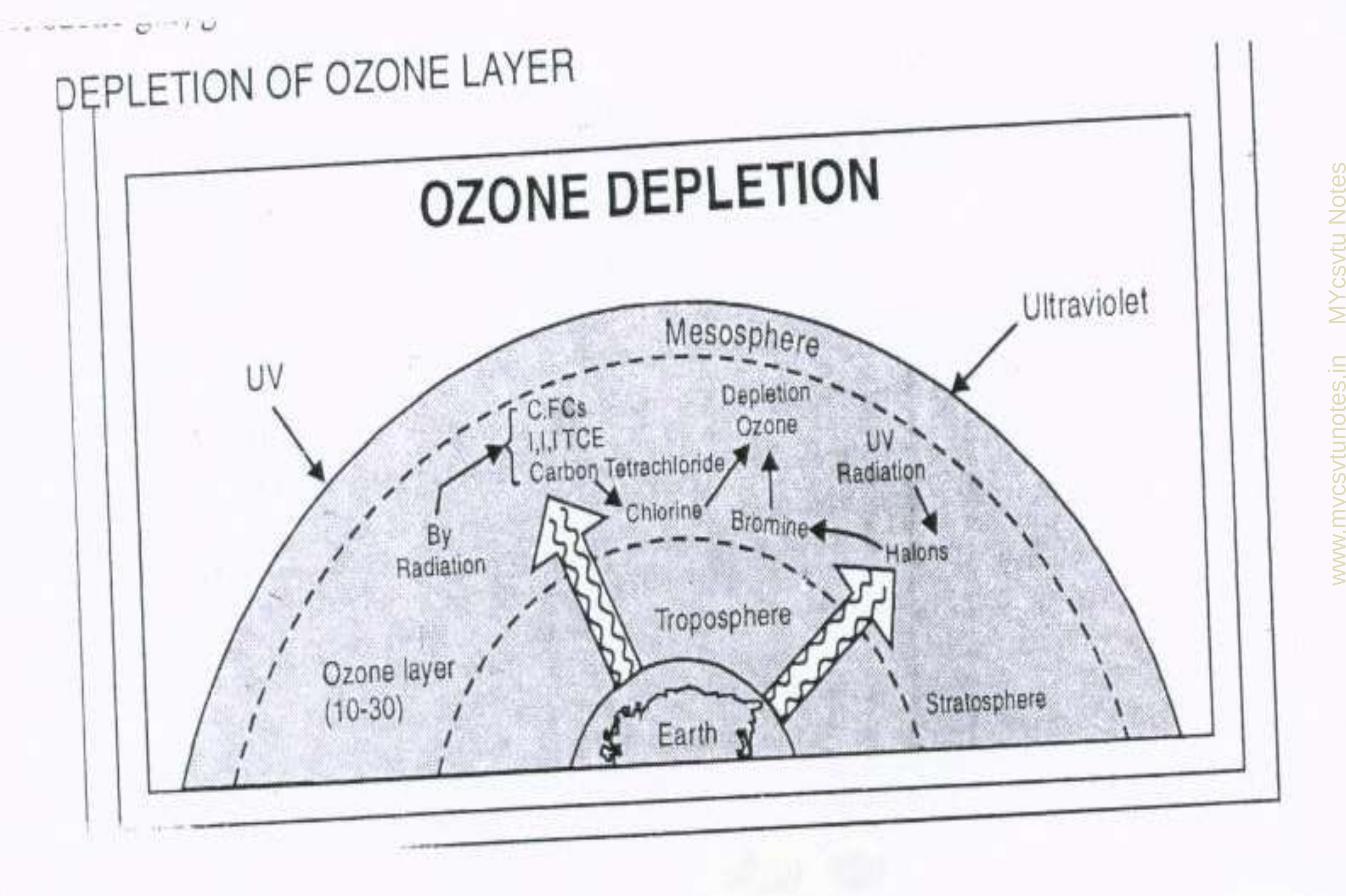
$$ClO \rightarrow Cl + O \quad \text{--------- (3)}$$

$$Cl + O_3 \rightarrow ClO + O_2 \quad \text{------(4)}$$

$$ClO + O_3 \rightarrow Cl + 2O_2 \quad \text{---------(5)}$$

- **Here Cl atom acts as a catalyst, and two O_3 molecules are destroyed.**

L-16/2 Depletion of Ozone Layer



L-16/2 Depletion of Ozone Layer

- **CFCs and halons (bromochlorofluoro carbon) remain inactive in the troposphere and**

- **it takes about 20 -40 years for these chemicals to travel to reach the stratosphere,**

L-16/2 Depletion of Ozone Layer

- **but after that their intermediate product (chlorine atom) remains active for more than 100 years.**

2. Anthropogenic Process :-

L-16/2 Depletion of Ozone Layer

Anthropogenic Process :-

- **Supersonic air crafts (SST),**

- **nuclear explosions produce large quantities of NOx**
- **which directly enter into stratosphere.**

- **Reaction between ozone and NOx is given below.**

L-16/2 Depletion of Ozone Layer

Reaction between ozone and NOx is given below.

$$NO + O_3 \xrightarrow{h\nu} NO_2 + O_2$$

$$NO + O_2 \rightarrow NO_2 + O$$

$$NO_2 + O_3 \rightarrow NO_3 + O_2$$

$$NO_2 + O \rightarrow NO + O_2$$

L-16/2 Depletion of Ozone Layer

$$H_2O \xrightarrow{h\nu} \cdot OH + H\cdot$$

$$\cdot OH + O_3 \rightarrow HO_2 + O_2$$

$$H\cdot + O_3 \rightarrow \cdot OH + O_2$$

- **The net result is that NOx increase the rate of O_3 destruction.**

L-16/2 Depletion of Ozone Layer

Effects of Ozone Depletion:-

On Human Body:-

1. **Ozone at low conc. also accumulate in the inflammatory cells at the site of lung injury causing severe damage to the lung.**

2. **Exposure of ozone causes lung cancer, DNA breakage and cell death.**

L-16/2 Depletion of Ozone Layer

3. **Dizziness and visual impairment, damage of central nervous system, enlargement of spleen.**

4. **Photochemical smog is the major cause of ozone – exposure causing urban air pollution.**

L-16/2 Depletion of Ozone Layer

Concentration PPm	Effect
O.2	No adverse effect.
O.3	Nose and throat irritation
1.0 to 3.0	Extreme fatigue after shown
9.0	Severe pulmonary oedema

L-16/2 Depletion of Ozone Layer

- **Ozone is a strong irritant and reaches the lungs and respiratory tract**

much faster than SO_x .

Even at low conc. causes pulmonary oedema.

L-16/2 Depletion of Ozone Layer

- **Increase in UV radiation have damaging effects on the DNA of exposed cells of organisms and cause 'Skin Cancer'.**

Effect on Biotic Community:-

- **Many micro – phytoplankton and zoo planktons would die because of their exposure to UV solar radiation**

L-16/2 Depletion of Ozone Layer

(Effect on Biotic Community)

- **The marine animals, fishes etc. will starve in the absence of sufficient supply of food.**

- **The loss of fish population would directly affect the inhabitants of coastal area.**

L-16/2 Depletion of Ozone Layer

Effect on Plants:-

- **Ozone flecking is observed with the plants of grape, citrus, tobacco.**
- **It damages tomato, pea, pine and other plants.**
- **Plant proteins are also susceptible to UV injury.**

L-16/2 Depletion of Ozone Layer

Effect on Plants:-

- **Chlorophyll reduction have been observed.**
- **Ozone along with other pollutants**
- **like SO_2 and NO_2 affects loss of crops over 50%.**

L-16/2 Depletion of Ozone Layer

- **O_3 level can reduce yields of bean, potato and poplar.**
- **In plants O_3 enter through stomata.**
- **It cause visible damage to leaves and reduce their photosynthetic rate.**

L-16/2 Depletion of Ozone Layer

Effect on Climate:-

- **By absorbing UV radiations the ozone layer heats the temperature.**
- **Ozone reduction in stratosphere may drastically change the weather elements like temperature, wind pattern, acid rains.**

L-16/2 Depletion of Ozone Layer

Ozone Depletion Create Ecological Disbalance:-

- **The depletion of ozone if not controlled would effect the ecosystem productivity, ecological stability and environmental equilibrium.**
- **This also cause certain physiological changes in man and animals. Change in energy balance and radiation would affect type, density and stability of vegetation.**

STABILITY

FEATURES

- **LAPSE RATE.**
- **TEMPERATURE INVERSION.**

- **WIND SPEED &WIND DIRECTION.**

L-17/1 Atmospheric Stability &…

Atmospheric Stability

and Temperature Inversion

- **The degree to which air pollutants, from various sources concentrate in a particular area depends on**

- **Meteorological conditions or parameters i.e.**

a) Wind speed & wind direction.

- **Degree of pollution depends on diffusion of wind (speed& direction).**
- **Higher the wind speed at or near the point of discharge dilution is high.**
- **Lower the wind speed at or near the point of discharge dilution is less.**

L-17/1 Atmospheric Stability &…

- **wind speed,**

- **wind direction;**

- **temperature inversion and**

- **atmospheric stability.**

b) Temperature inversion.

- **When the temperature of the ambient air increases instead of decrease,**

- **the lapse rate is negative or inverted from the natural state and is called as an INVERSION**

- **In this state warmer air blankets colder air.**
- **This shows a high degree of stability.**

Temperature inversion.

INVERSION

- **This shows a high degree of stability.**

- **Vertical air movement is stopped**
- **pollutants don’t spread-**

- **very little turbulence.**
- **Frequent in Autumn and Winter seasons**

Temperature inversion.

- **Change of lapse rate from negative to positive or vice versa is called Temperature inversion.**

- **There are two types of lapse rates**

  ALR (Adiabatic lapse rate)

  ELR (Environmental lapse rate)

L-17/1 Atmospheric Stability &…

ELR:-

- **In the troposphere ,the temperature of the ambient air**
- **usually decreases with an increase in altitude.**
- **This is called the**
- **‘Environmental or ambient lapse rate’.**

L-17/1 Atmospheric Stability &…

ALR:-

" The temperature change of a hot parcel of air against altitude gain under adiabatic conditions is called Adiabatic lapse rate".

- **For dry air ALR is 0.98^{0}C per 100m.**
- **While for wet air it is 0.6^{0}C per 100m.**

Atmospheric Stability

ELR and ALR are measure of atmospheric stability.

Stable Atmosphere – The dispersion rate of pollutants will be very less.

OR

- **When rising parcel cools faster means ALR is greater.**

L-17/1 Atmospheric Stability &…

Unstable Atmosphere:-

The dispersion rate of pollutants will be very large.

OR

- **When as long as a rising parcel of air remains warmer means ALR is less.**

Relation of ALR & ELR.

Relation between ALR&ELR tells about the status of atmosphere.

- **When ALR>ELR the condition is**
- **sub- adiabatic atmosphere is stable.**

- **When ALR<ELR the condition is**
- **super adiabatic atmosphere is highly unstable.**

Relation of ALR & ELR.

- **When ALR=ELR the condition is**

  Dry adiabatic atmosphere is neutral.

- **When the temperature is constant then**

  ELR=0 the condition is isothermal & atmosphere is stable.

- **When ever we observe temperature inversion condition atmosphere is stable.**

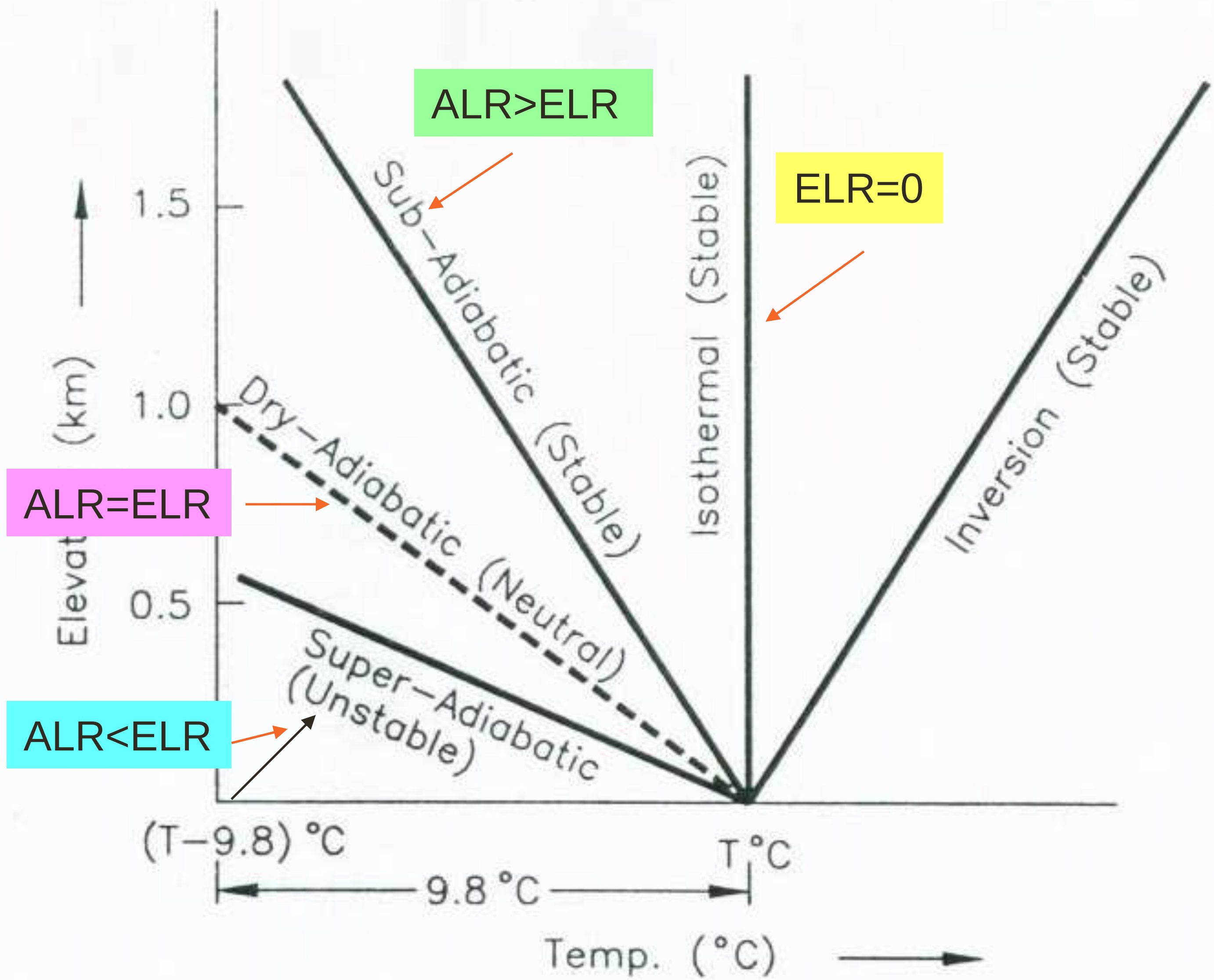


Fig. Relationship of the Ambient or Environmental Lapse Rate (ELR)

Summary behind stability

- **If ALR is equal or higher than ELR then atmosphere is said to be stable.**

(dry adiabatic or neutral)

- **If ELR is 0 then it is isothermal.**

- **Only when ELR is greater than ALR the atmosphere is unstable.**

Plume Behavior

- **Plume refers to path and extent of the gaseous effluents, released from a stack, in the atmosphere (>300m above ground level)**

- **Observation of smoke plumes is important to locate the sample spots.**

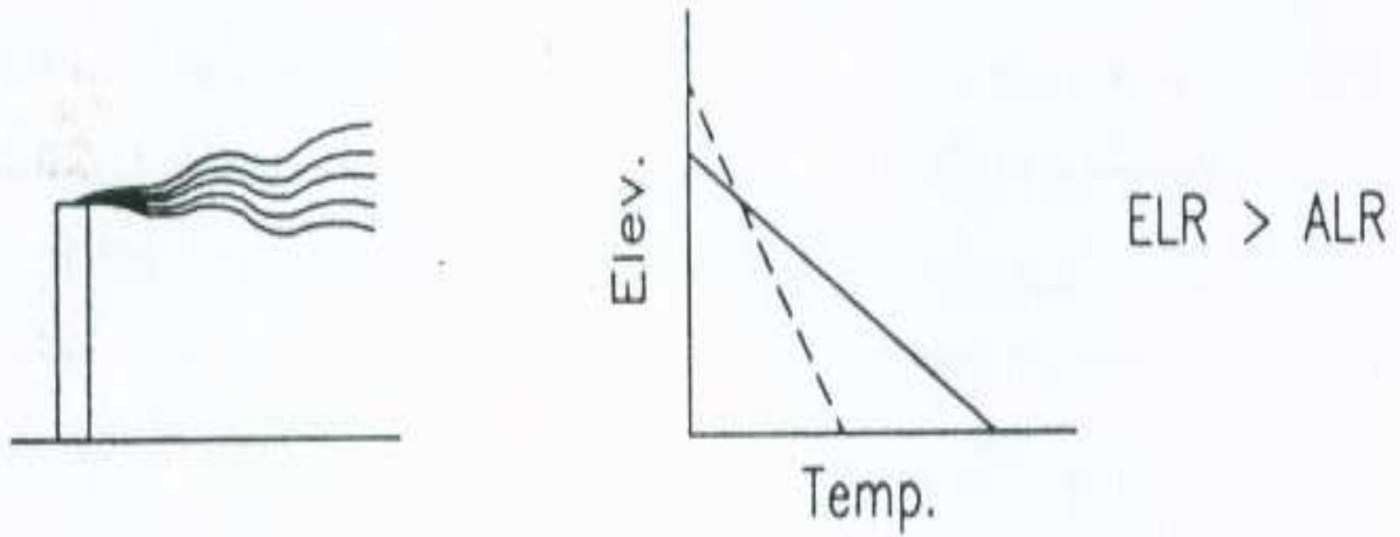
- **This also helps to find the invisible pollutants.**

L-17/1 Atmospheric Stability &…

Looping :- This type of plume has a

(a) wavy shape and occurs in super adiabatic manner. (ELR>ALR) or ALR<ELR

(b) Looping plume produces highly unstable atmosphere due to rapid mixing.



(a) Looping

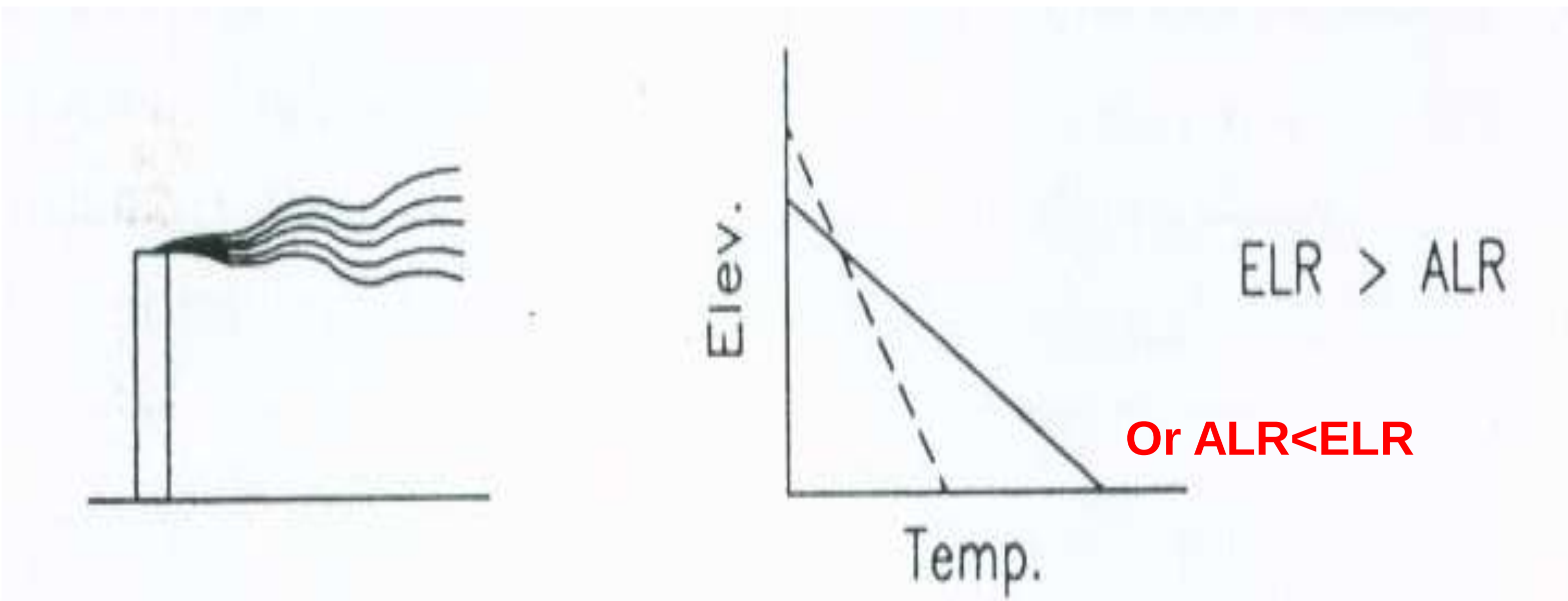
Unstable

L-17/1 Atmospheric Stability &…

Looping :-

© Dispersion of plume will be rapid if high degree of turbulence is present.

(d) Due to turbulence high concentration occurs near the ground.



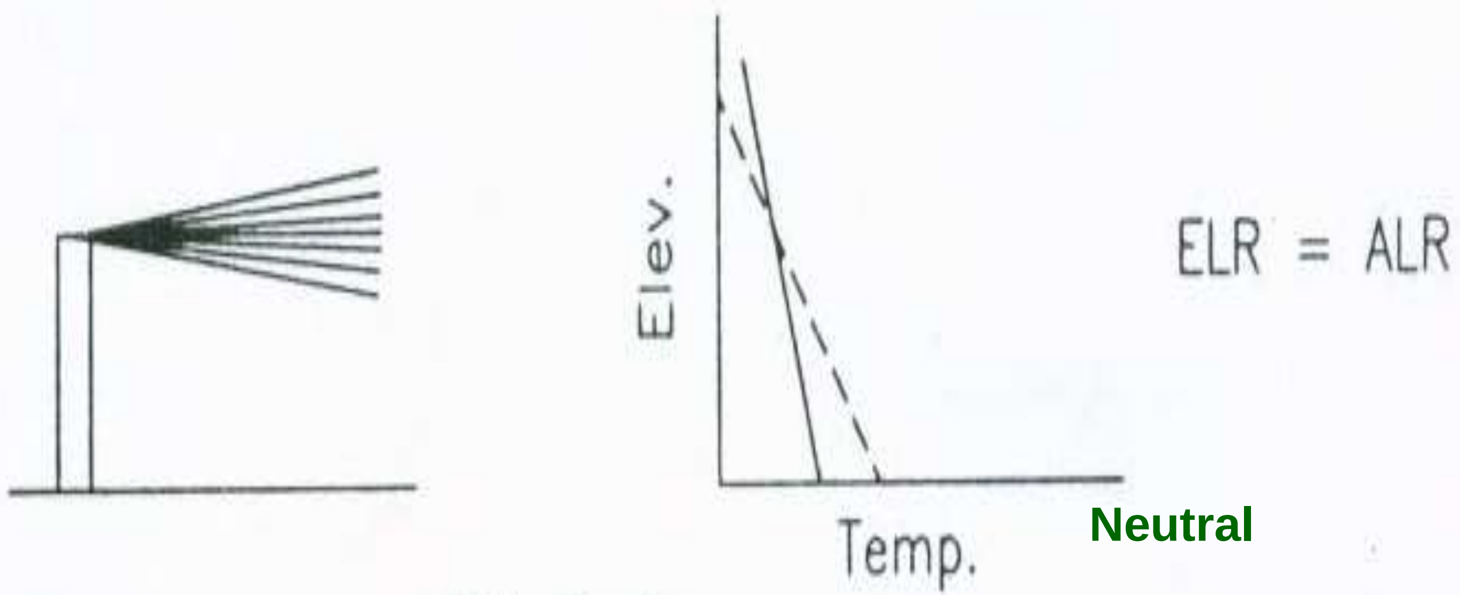
(a) Looping

Unstable

L-17/1 Atmospheric Stability &…

Coning :- This type of plume has a cone shape and occurs in dry adiabatic or neutral manner.

- **It occurs when wind velocity is greater than 32 km/hr.**

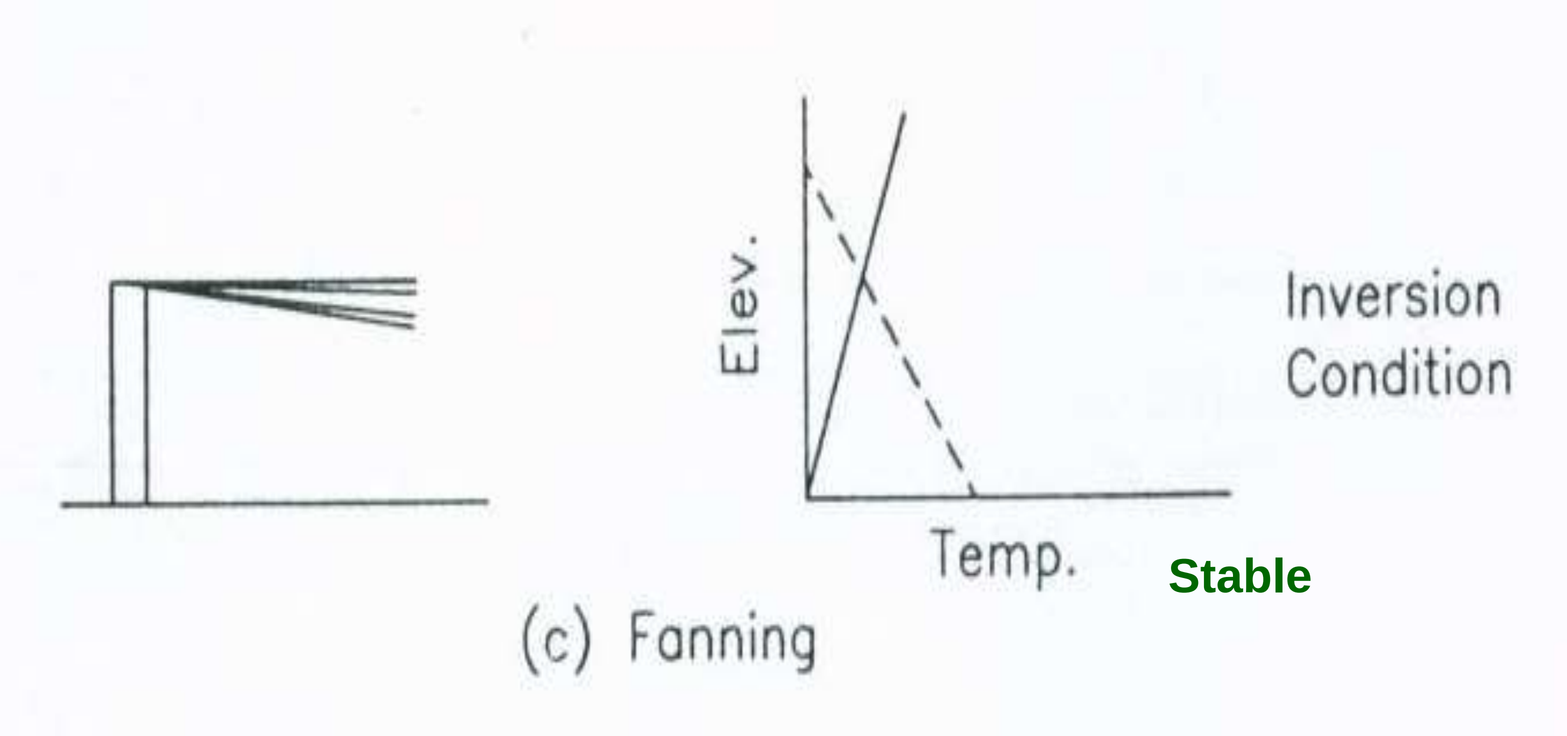


(b) Coning

L-17/1 Atmospheric Stability &…

Fanning: - This type of plume is emitted under extreme inversion conditions. The plume spreads horizontally.

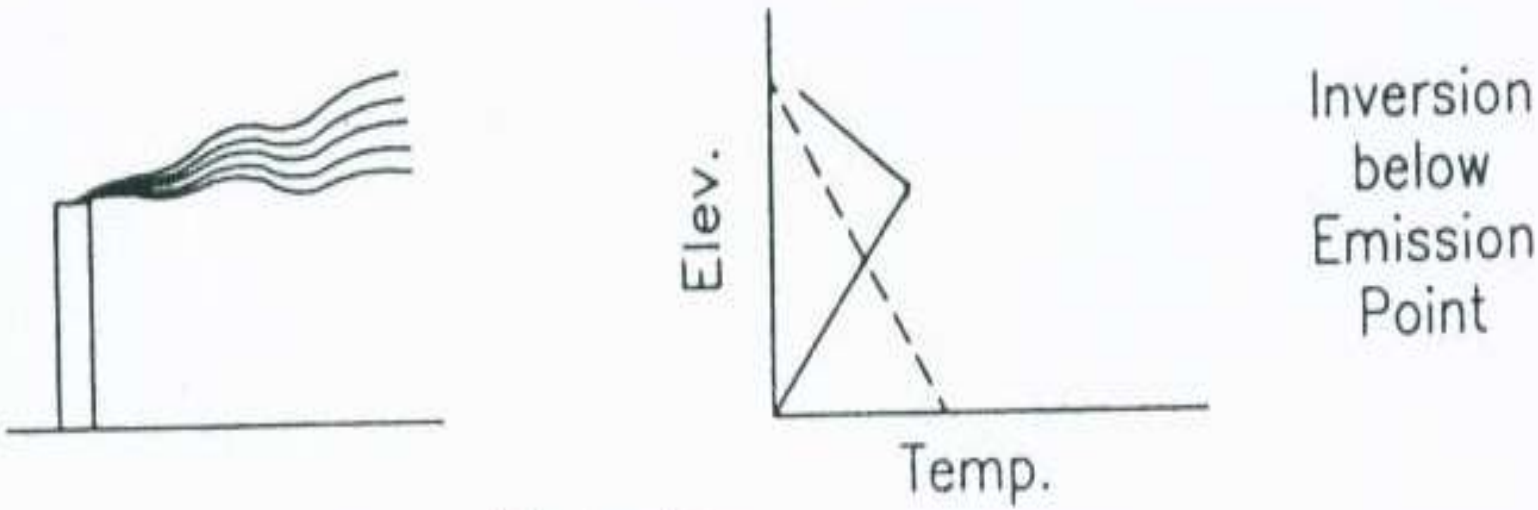
- **It is fan shaped and there is very little vertical spreading. It is dispersed very slowly.**



Stable

L-17/1 Atmospheric Stability &…

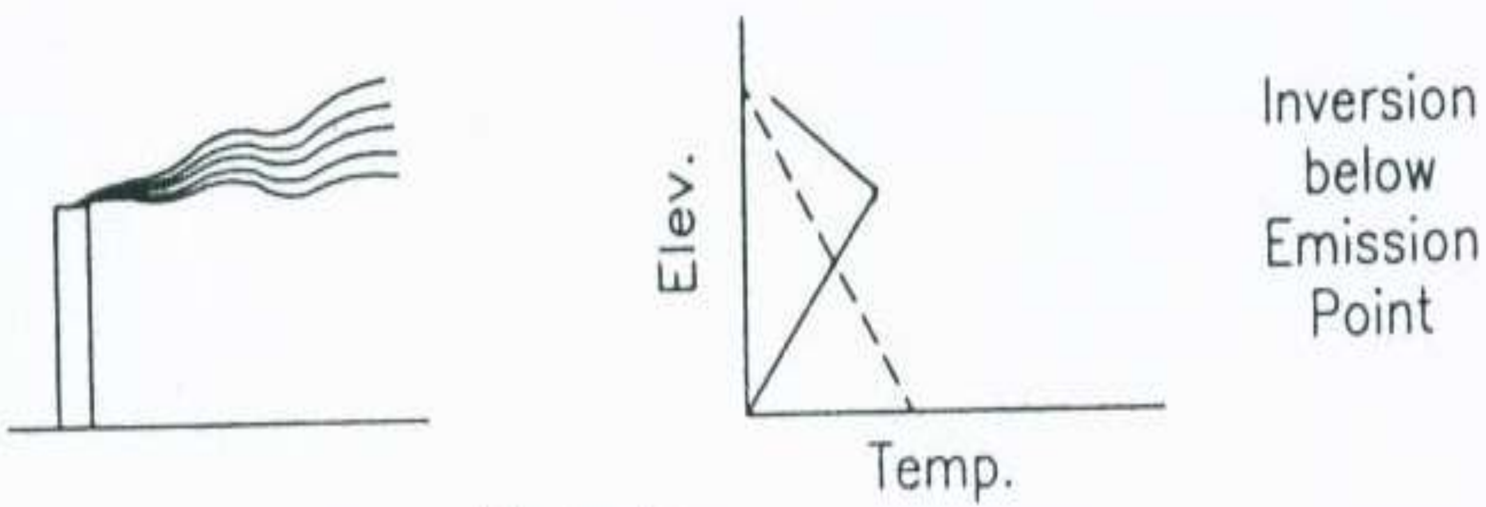
- **Lofting:- This is in the form of loops.**
- **Lofting occurs when there is a strong lapse rate above a surface inversion.**
- **diffusion is rapid upward does not penetrate the inversion layer.**



(d) Lofting

L-17/1 Atmospheric Stability &…

- **It is the best condition for dispersion because the pollutants are dispersed in upper air with very little in ground contact.**



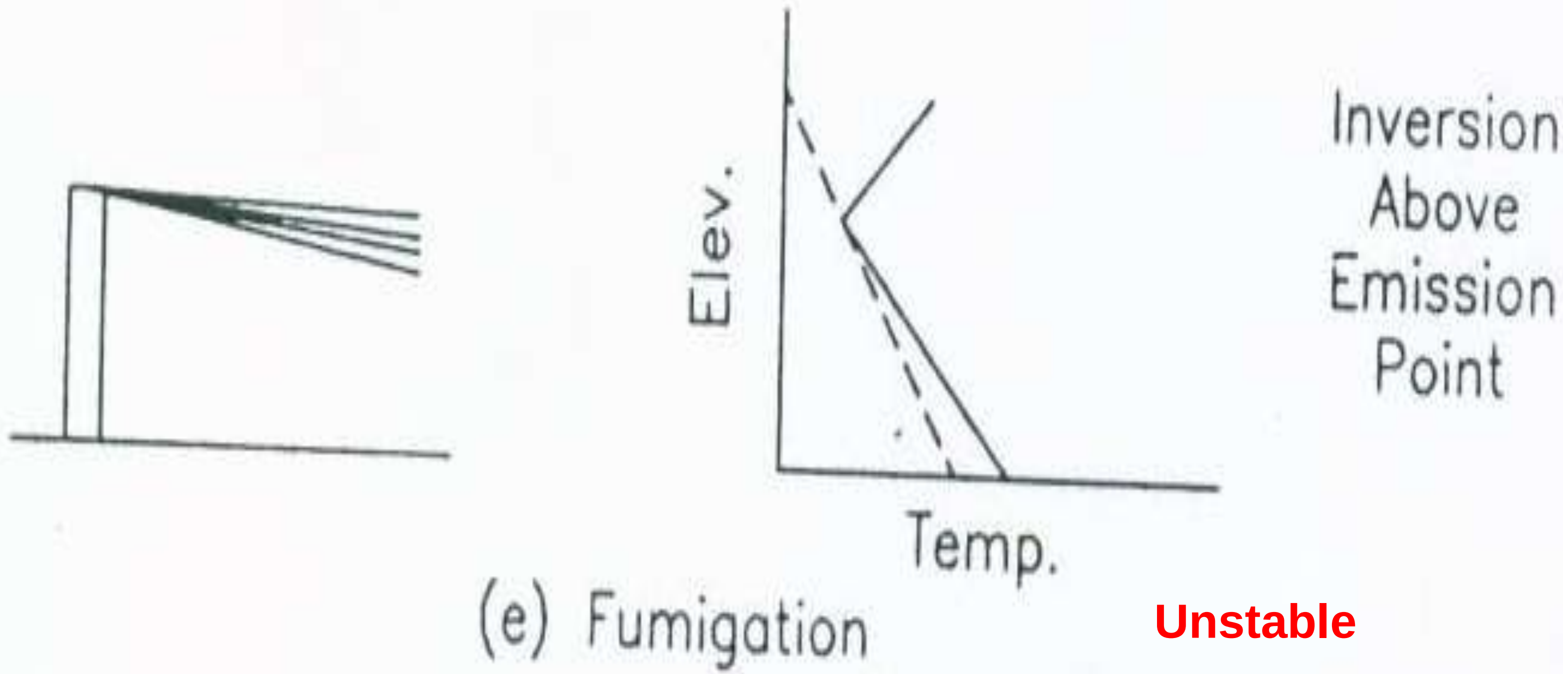
(d) Lofting

NOTE

- ECOLOGY IS A BEST SUBJECT.

L-17/1 Atmospheric Stability &…

- **Fumigation :- When an inversion layer occurs at a short distance above the top of the stock (plume) and super adiabatic conditions prevail below the stock, then it is called fumigation plume.**

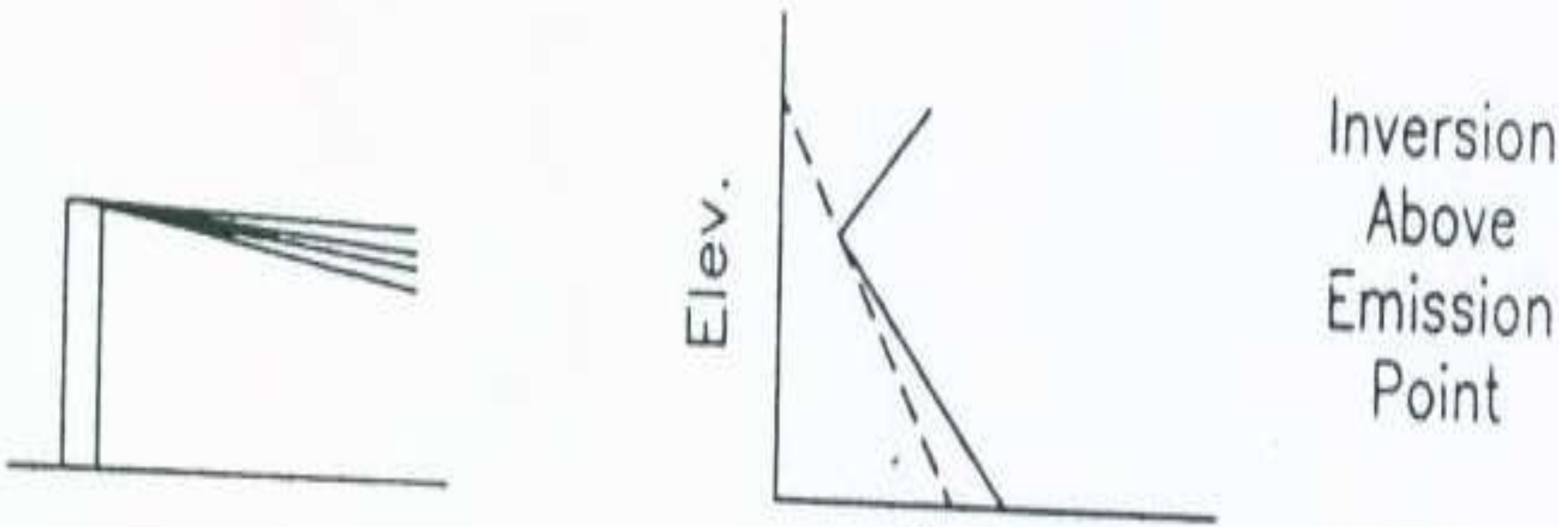


(e) Fumigation

Unstable

L-17/1 Atmospheric Stability &…

- **Under these conditions the concentration is relatively high and the probability of ground contact is also very high.**

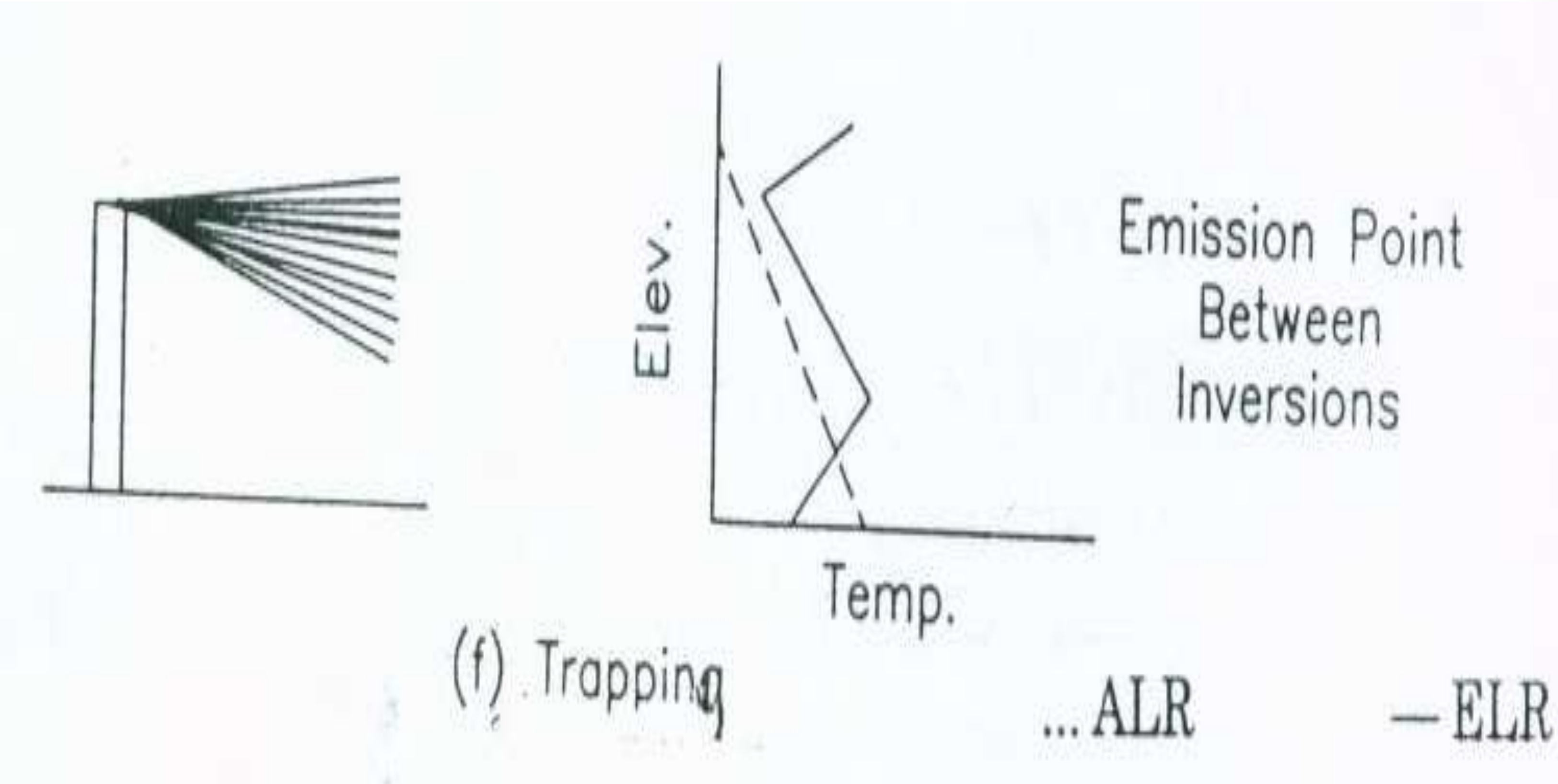


(e) Fumigation

Unstable

L-17/1 Atmospheric Stability &…

- **Trapping :- This refers to condition when the plume is a sandwich between inversions and thus can only diffuse within a limited vertical height.**



L-17/1 Atmospheric Stability &…

- **The lofting plume is the most favourable with regard to minimising air pollution.**
- **While, the fumigation and trapping plumes are very critical**
- **from ground level pollutant concentration point of view.**

L-18 Ambient Air Quality Standards

Air Quality Standards:-

- **Since 1960 it has become quite obvious that pollutants produced by human beings are overloading natural cleansing process in the atmosphere.**

- **The Clean Air Act (CAA) 1981 is a significant development in this direction.**

L-18 Ambient Air Quality Standards

Control :-

The only practical solution to this problem is complete elimination of production of CFC's, halons, carbon tetrachloride.

- **Such steps will stop the increase of CFC's in the atmosphere but -**

L-18 Ambient Air Quality Standards

Control :-

- **Such steps will stop the increase of CFC's in the atmosphere but -**

- **because of their long life-times the already emitted CFC's will remain in the atmosphere for centuries.**

L-19 Ambient Air Quality Standards

- **The main objective to enact any pollution law is to control pollutant sources so that ambient pollutant concentrations are reduced to levels considered safe.**

The preferred sequence of development of air quality standards are given below-

L-19 Ambient Air Quality Standards

The preferred sequence are given below-

1. **Prepare air quality criteria which are**

- **the analysis of the relationship between pollutant concentrations in the air and**

- **the adverse effect associated there with.**

L-18 Ambient Air Quality Standards

2. **By quality criteria we mean a good air quality i.e. the concentration of pollutant which we believe that we can live without adverse effect on health and welfare.**

3. **Air quality standards are legal limits placed on levels of air pollutants in the ambient air during a given period of time.**

L-18 Ambient Air Quality Standards

Types of Air Quality Standards:-

1. **Ambient Air Quality Standards- are the legal limits placed on the conc. of air pollutants in a community where people and things are exposed.**

- **Air quality standards are the permissible exposure of all living and non living things for 24 hours, per day, 7 days, per week.**

L-18 Ambient Air Quality Standards

2. Emission Standards:- These establish permitted levels for specific groups of emitters and-

- **require that all members of those groups exit no more than these permitted emission levels.**
- **These are based on two type of sources.**

L-18 Ambient Air Quality Standards

- **Emission standards for mobile sources related to aircraft, ships, motor vehicles.**

- **Emission standards for stationary sources related to stationary site, processes, stack chimney, coal cleaning, cotton guns etc.**

L-18 Ambient Air Quality Standards

- **Air pollutants are classified under five categories-**

i) **First are set in the table.**

ii) **Those pollutants which are hazardous to human health, e.g. asbestos, Ne and Hg.**

iii) **Those which are regulated in stationary sources like coal cleaning plants, cotton guns etc. e.g. H_2SO_4 mist, NO_x & SO_x**

Air Quality Standards by Environmental Protection Agency, USA

S.No.	parameter	Standard µg/M^3	Conc.ppm	Remarks
01.	Suspended Particulates	75 260	---- ---	Annual Mean 24h
02.	SO_2	80 365	0.83 0.14	Annual Mean 24h
03.	CO	1000	9.0	8h once/year Max.
04.	NO_x	100	0.05	Annual
05.	Ozone	235	0.12	1h daily Max.once/year
06.	Non Methane HC.	160	0.24	6h not more than once/year

L-18 Ambient Air Quality Standards

4. **Emissions of mobile sources e.g. NO_x and Hydrocarbons.**

5. **The elements and compounds to be controlled for public health e.g. As, Cd, Ni, Cr, Cu, Zn, F, Cl H_2S polychlorinated biphenyls, fine particulates and radionuclide etc.**

Indian Air Quality Standard

- Conc. of substances in

$$\mu g/m^3 = \frac{ppm \times Mol.Wt.of\ the\ gas \times 10^6}{22,400}$$

Category	Area	Concentration in µg/m3			
		SPM	SO_2	NO_X	CO
A.	Industrial & mixed	500	120	120	5000
B.	Residential & Rural	200	80	80	2000
C.	Sensitive. (Hills and Health resorts etc.)	100	30	30	1000

L-19 Techniques used to control gaseous pollutants

Control Measures:-

The most effective means of controlling the air pollution is to-

- **prevent the formation of the pollutants or minimize their emission at the source itself.**

- **There are three major means of controlling air pollution.**

L-19 Techniques used to control gaseous pollutants

There are three major means of controlling air pollution.

- **By Fuel Selection and Utilization:-**
- **By Process Modification:-**
- **By Site Selection and Zoning:-**

L-19 Techniques used to control gaseous pollutants

By Fuel Selection and Utilization:-

- **Combustion of fossil fuels, oils, coals gives large amount of smoke.**
- **Smoke formation can easily be reduced by using oil instead of coal.**
- **Coal tar also gives better result when oil is used as fuel.**

L-19 Techniques used to control gaseous pollutants

By Site Selection and Zoning:-

- **The process of locating a single industrial plant is called 'Site Selection'**

- **which results in the production of a <u>single source of pollution</u> as compared with variety of emission sources.**

L-19 Techniques used to control gaseous pollutants

By Process Modification:-

There are four methods

1. Absorption **2. Adsorption**

3. Combustion

4. Condensation or trapping.

T L-19 echniques used to control gaseous pollutants

1. Absorption

- **This method is applicable for highly soluble gases.**

- **Here basically absorption or mixing occurs.**

- **This is being done between pollutant & absorber.**

L-19 Techniques used to control gaseous pollutants

An absorbent must be –

- **Non-toxic, non-inflammable chemical**
- **Stable, non-volatile, non-corrosive,**
- **Easily available & less expensive.**

L-19 Techniques used to control gaseous pollutants

Absorption techniques are used for:

$SO_{2,}$ NO_2, H_2S, $NH_{3,}$ HC etc.

Common absorbents are:

- **Ammonia for SO_2 in fertilizer industry,**
- **MgO, lime (CaO), $CaCO_3$, $P_2O_{5.}$**

L-19 Techniques used to control gaseous pollutants

The efficiency depends on-

- **Amount of surface contact between gas &liquid**
- **Contact period**
- **Concentration of the absorbing medium**
- **Speed of the reaction**

Techniques used to control gaseous pollutants

pollutant	absorber
SO_2	ETHYL ALCOHOL
H_2S	PHENOL

L-19 Techniques used to control gaseous pollutants

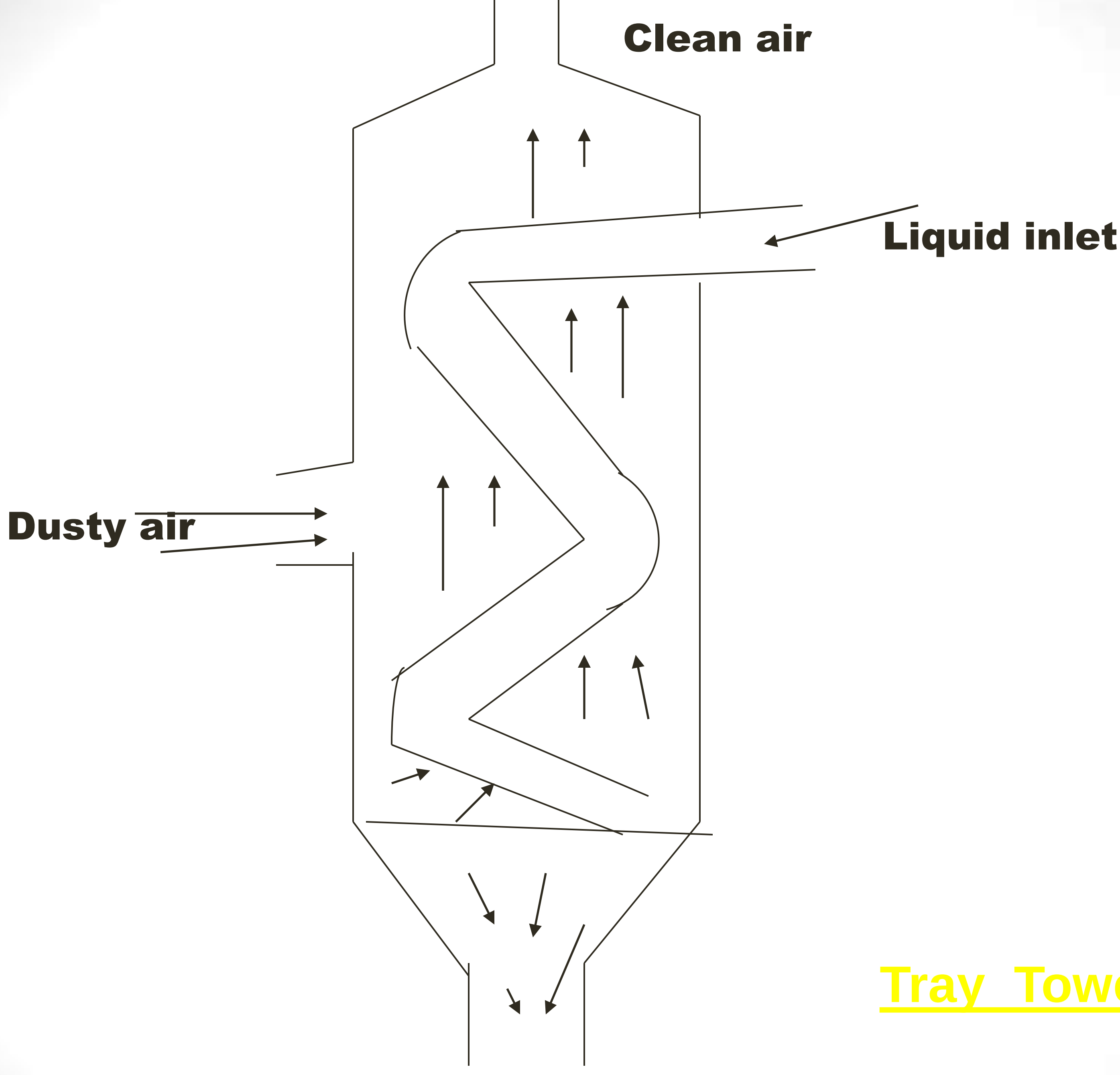
Absorption is done by:

1. Tray tower 2. Spray tower

3. Packed bed scrubber

1.Tray towers are horizontal trays or plates are designed in such a way

- **which provide large liquid absorption area.**



Tray Tower

L-19 Techniques used to control gaseous pollutants

Spray tower

- **Here water is sprayed through nozzles**
- **Can remove pollutants upto.2µm size.**

- **It avoids hazards.**
- **It occupies less space**
- **It can cause corrosion**

(fig. next)

L-19 Techniques used to control gaseous pollutants

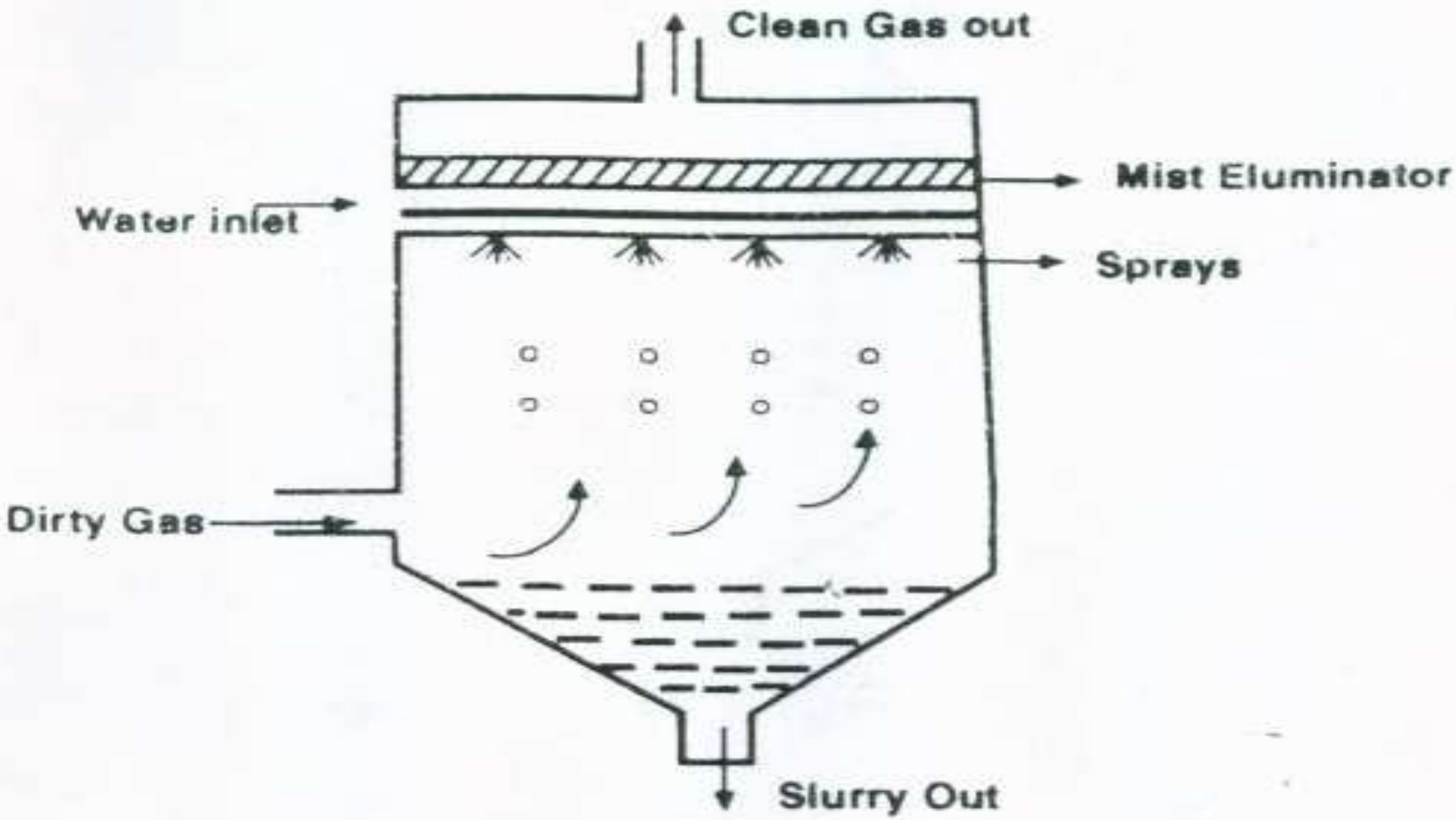


Fig. Spray tower

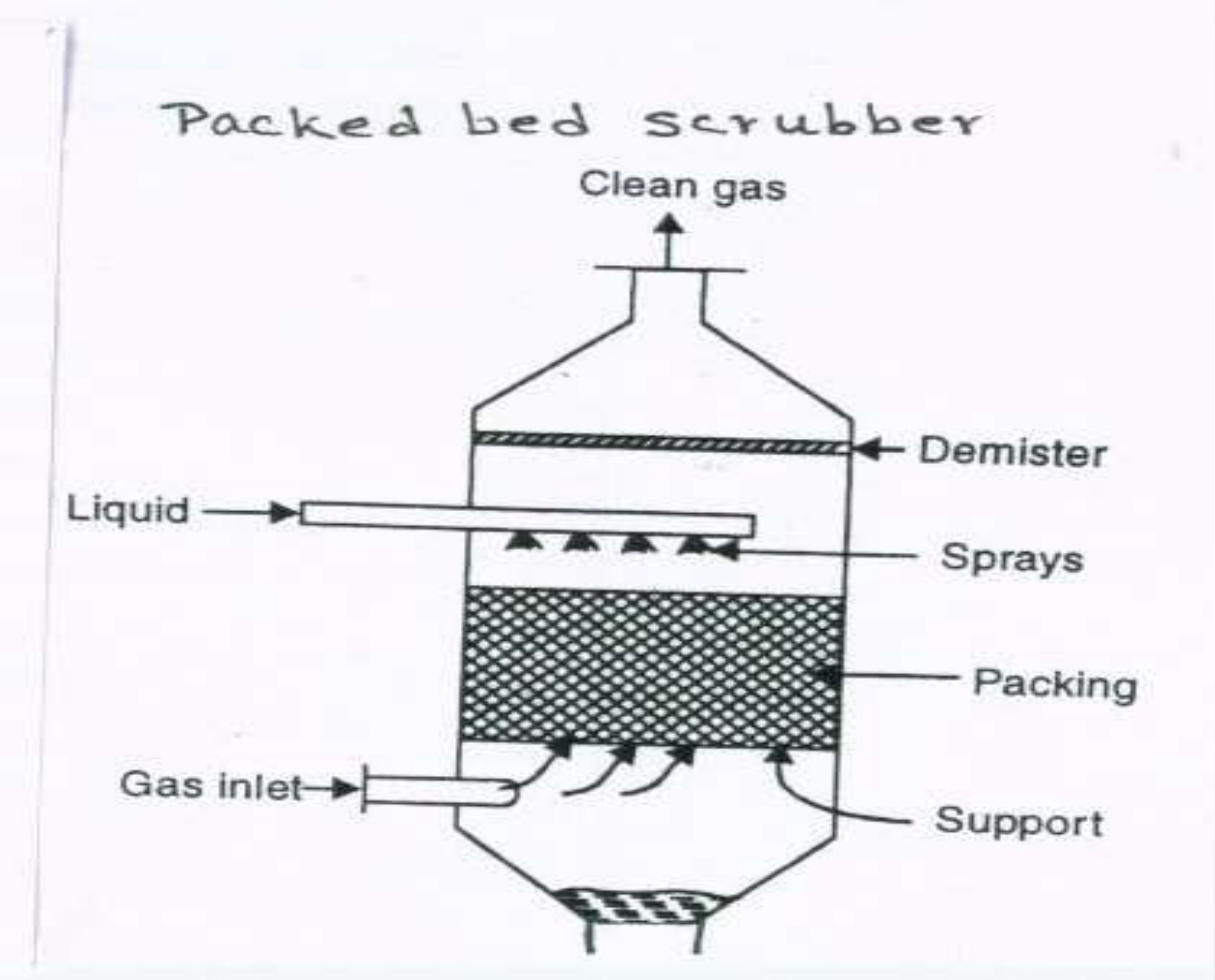
L-19 Techniques used to control gaseous pollutants

Packed bed scrubbers

- **The soluble gases are removed**
- **The gas passes through packed bed.**
- **The packed bed is made up of coke & broken stone**

(fig. next)

L-19 Techniques used to control gaseous pollutants



L-19 Techniques used to control gaseous pollutants

2. ADSORPTION

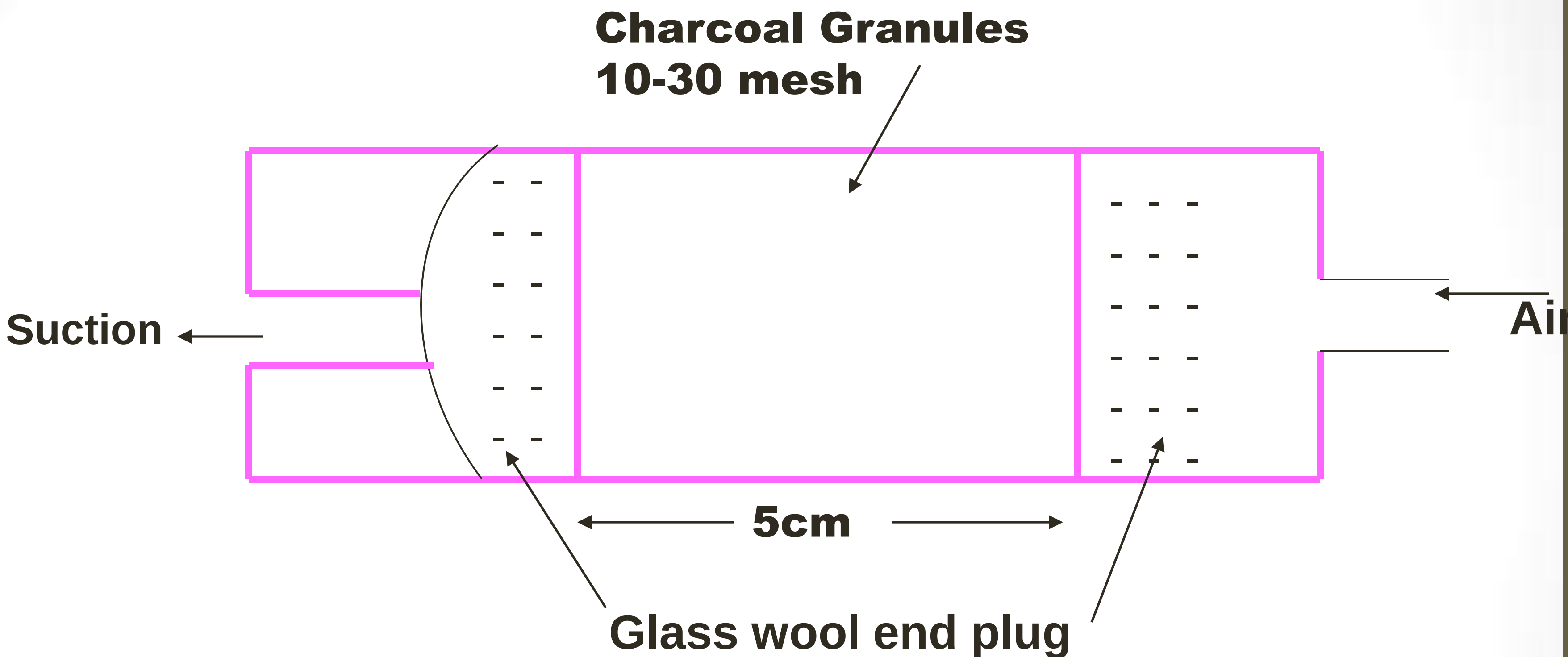
- **This is surface phenomenon.**
- **Here gases or liquids are adsorbed on adsorbent.**

Adsorption on solids

- **Granular porous solids like activated charcoal is used**
- **This has a large surface area.**

(fig. next)

L-19 Techniques used to control gaseous pollutants



CHARCOAL ADSORPTION TUBE

L-19 Techniques used to control gaseous pollutants

Adsorption can be of major two types:

a) **Physical adsorption or Physiosorption or Vander waal's adsorption.**

b) **Chemical adsorption or Chemisorption or Langmuir adsorption**

L-19 Techniques used to control gaseous pollutants

a) Physical adsorption or Physiosorption

or

vander waal's adsorption.

- **Weak Vander waal's forces exist between the adsorbate and the adsorbent.**
- **By evolution of heat the gaseous material get condensed upon the surface of solid.**

L-19 Techniques used to control gaseous pollutants

a) Physical adsorption or Physiosorption or vander waal's adsorption …

- **…..This can be easily reversed by changing the temperature or pressure.**

b) Chemical adsorption or Chemisorption or Langmuir adsorption

- **Very strong chemical bonds exist between the adsorbate and adsorbent.**

L-19 Techniques used to control gaseous pollutants

b) Chemical adsorption or Chemisorption or Langmuir adsorption

…….

- **This can't be easily reversed.**
- **Liberate greater energy and more heat.**
- **Irreversible-chemical composition of the adsorbate changes during the process.**

L-19 Techniques used to control gaseous pollutants

ADSORPTION

- **Equipments like Multiple fixed bed adsorbers can be used.**
- **Activated charcoal arranged in trays is used.**
- **Adsorbent can be reused also.**

- **Adsorption of a gas on solid occurs in three stages.**

L-19 Techniques used to control gaseous pollutants

- **Adsorption of a gas on solid occurs in three stages.**

1. **The diffusion of pollutants from the bulk gas phase to the solid surface.**

2. **Diffusion of gas molecules into the pores of the solids.**

3. **The actual adsorption on the active site in the pore and it is very fast.**

L-19 Techniques used to control gaseous pollutants

Physical Adsorption	Chemical Adsorption
Non reactive	Reactive
Gases are adsorbed as such	Gases are chemically converted
Very fast	Comparatively slow
Heat is released	More heat and energy is released.

L-19 Techniques used to control gaseous pollutants

Physical Adsorption	Chemical Adsorption
reversible Weak bonds Vander wall forces	irreversibl e strong bonds chemical bonds

L-19 Techniques used to control gaseous pollutants

3. COMBUSTION

This is specially used for CO&HC

Combustion depends on

1. **sufficient time to burn**
2. **sufficient O_2 supply**
3. **sufficient ignition temperature**
4. **turbulence**

L-19 Techniques used to control gaseous pollutants

there are three methods of Combustion:

a) Direct combustion or flaring

b) Thermal incineration or flame combustion

c) Catalytic Oxidation

L-19 Techniques used to control gaseous pollutants

a) Direct combustion or flaring

- This method is generally used in petrochemical plants and refineries.
- This is done in combustors.
- This is not successful with excess pollutants like Sulphur, Chlorine, and Fluorine.
- Here another fuel is taken to preheat the dusty air.

L-19 Techniques used to control gaseous pollutants

b) Thermal incineration

or flame combustion

- **It is the most efficient and most flexible technique.**
- **It is used for aerosol emissions**
- **And for low conc. Of combustible gaseous pollutants.**

L-19 Techniques used to control gaseous pollutants

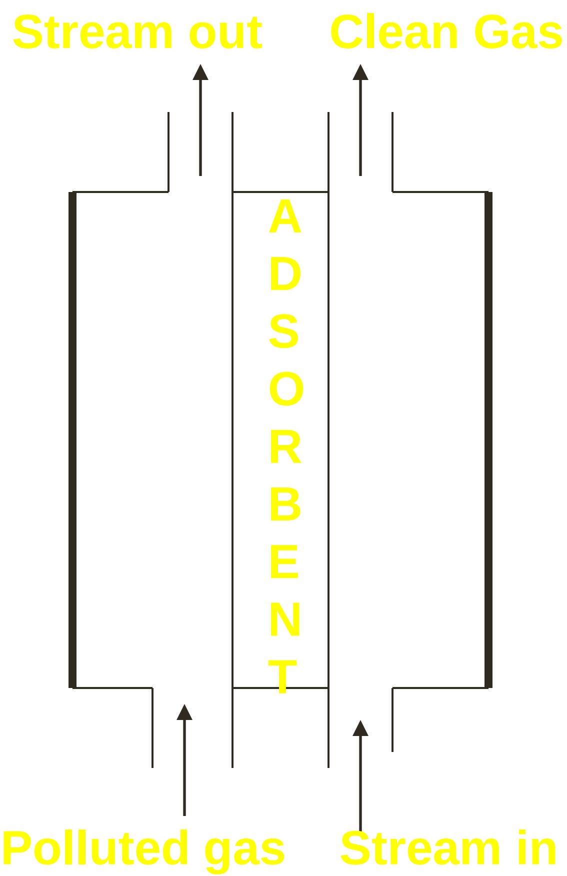
b) Thermal incineration or flame combustion

- **The waste gas is preheated and then introduced into the chamber.**

- **The velocity promote turbulence and thorough mixing it with fuel.**

- **Thermal incineration needs minimum maintenance.**

L-19 Techniques used to control gaseous pollutants



THERMAL INCINERATOR

L-19 Techniques used to control gaseous pollutants

c) Catalytic oxidation

- **When thermal incineration is not possible due to high fuel cost catalytic oxidation is used.**
- **Catalysts used are Pt, Pd, Cu, activated alumina, animal charcoal etc.**
- **The incinerator consists of-**

i) a preheating chamber and

ii) a catalytic bed.

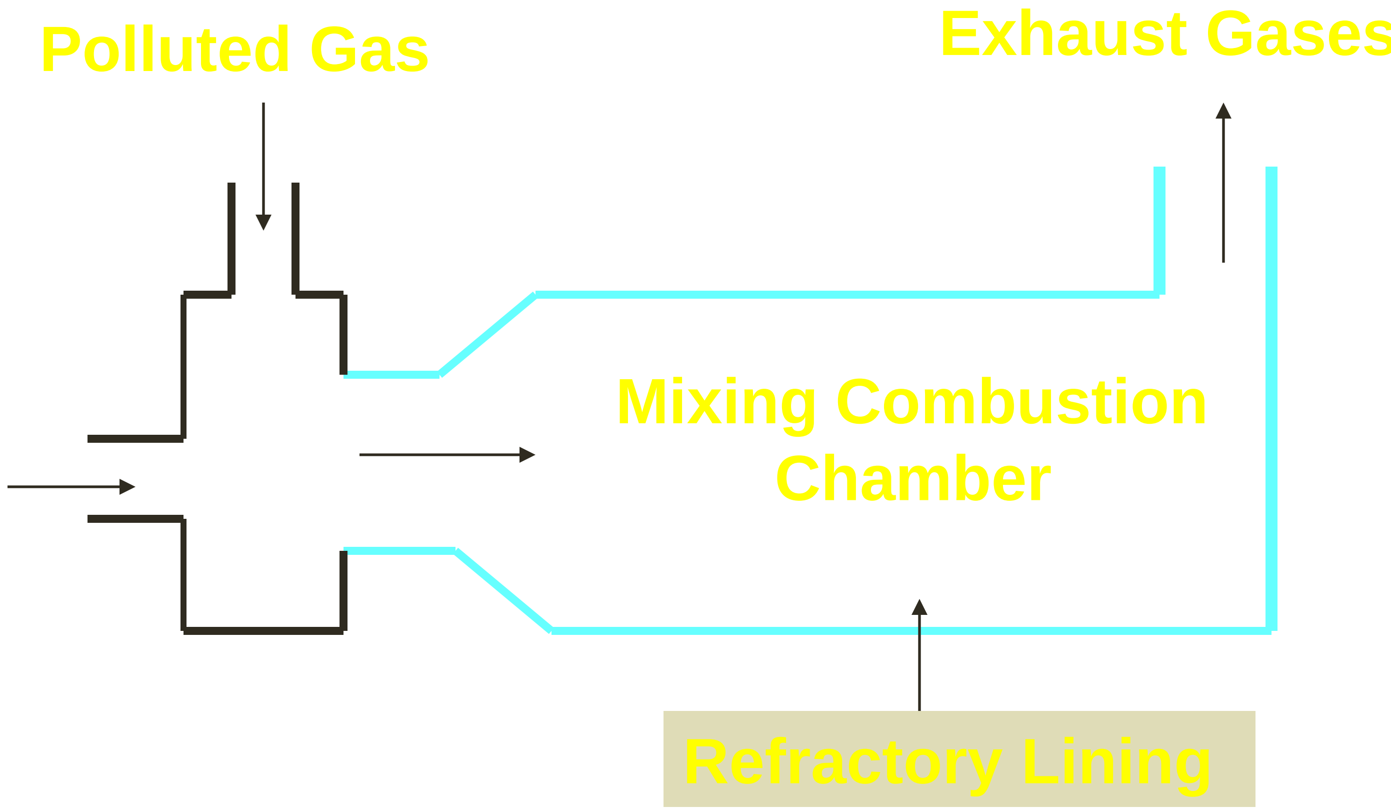
L-19 Techniques used to control gaseous pollutants

c) Catalytic oxidation

- It is used for the control of SO_x, NO_x, CO and HC.
- Catalyst bed may be single or multiple fixed.

- For complete combustion ≈ 1% excess O_2 is required.
- The catalyst bed is cleaned periodically.

L-19 Techniques used to control gaseous pollutants



Catalyst Oxidation Technique

Catalyst Oxidation Techniques

S.No.	Process	Contaminants in waste Gas	Catalytic Oxidation temp.(^{0}C)
01.	Coke Ovens	Wax, Oil vapours	315-371
02.	HNO_3 manufacturing	NO, NO_2	260-650
03.	Printing Process	Solvents	315
04.	Catalytic cracking	CO, HC	343-427
05.	Varnish cooking	Hydrocarbons	315-371

TECHNIQUES TO CONTROL PARTICULATE POLLUTION

L-20 Techniques used to control particulate pollutants

Methods Used for Air Pollution Control

Control devices for particulate matter

- **Internal Separators**
  - **Gravity settling chamber**
  - **Cyclone Collector**
  - **Fabric Filters**
- **Wet Collection Devices**
  - **Spray Towers**
  - **Cyclonic Scrubber**
  - **Venturi Scrubber**
  - **Packed Bed Scrubbers**
- **Electrostatic Precipitators**

L-20 Techniques used to control particulate pollutants

(1) Internal Separators:- These separate dust particles from the gas. These are of following types:

a) Gravity Settling Chamber

b) Cyclonic Collectors

c) Fabric Filters

L-20 Techniques used to control particulate pollutants

a) Gravity Settling Chamber:-

- **It consists of a chamber in which dust is separated from gas by reducing the velocity of passing gas.**
- **Due to this dust particles settle down in the chamber and coarse particles are removed.**

L-20 Techniques used to control particulate pollutants

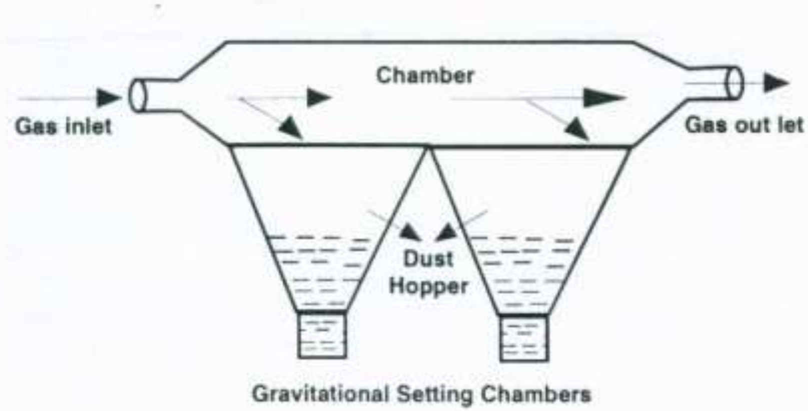


Fig. Gravitational Settling chambers

L-20 Techniques used to control particulate pollutants

(Gravity Settling Chamber)

Advantages:-

- **It is cheap and has low initial cost.**
- **It needs low maintenance.**

Disadvantages:-

- **It needs large space.**
- **It can not achieve high efficiency for removing small size particles. (< 10 µm)**

L-20 Techniques used to control particulate pollutants

b) Cyclonic Collectors:-

- **When a centrifugally forced rotation is provided to incoming gas,**
- **it throws the heavy particles of the gas to the outer periphery of the cyclone, and**
- **then these heavy particles slide down into the collector.**

L-20 Techniques used to control particulate pollutants

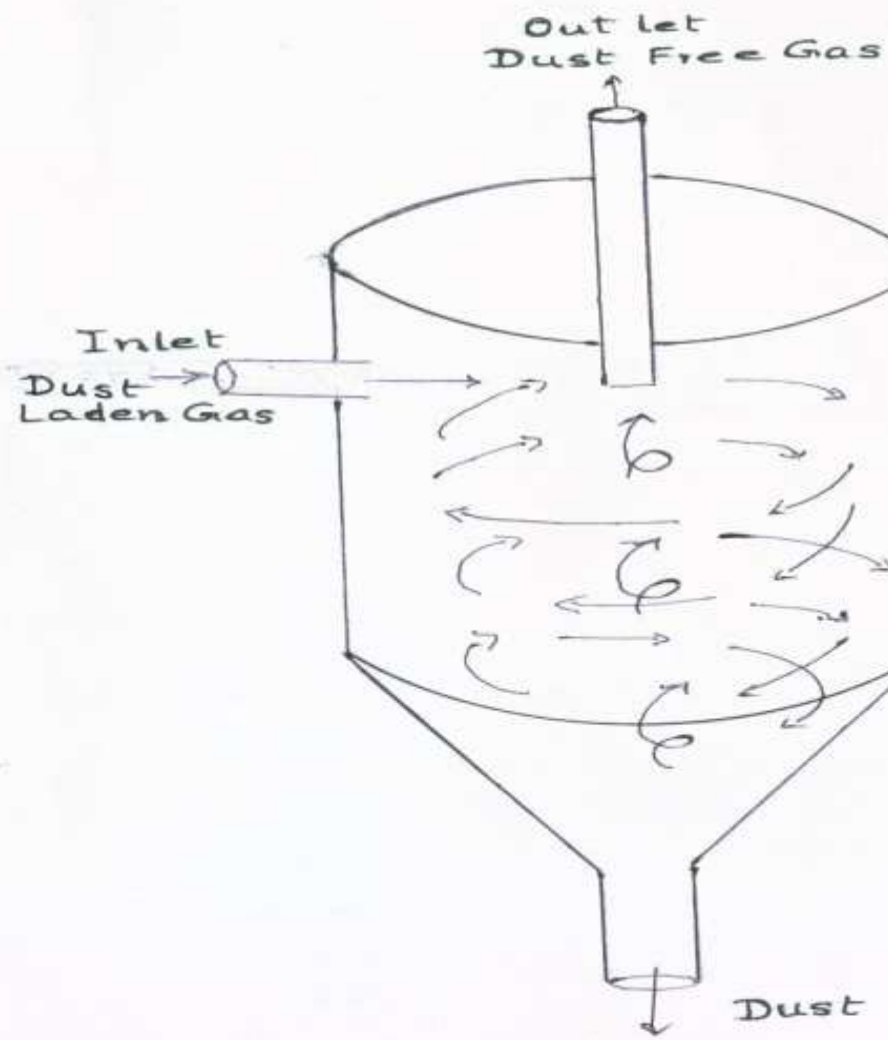


Fig. Cyclone Collector

L-20 Techniques used to control particulate pollutants

- **In the cyclone the gas is first allowed to flow through a circular path,**

- **which produces centrifugal force on the suspended particles,**

- **which in turn are forced to move upwards at the central portion of the cyclone.**

L-20 Techniques used to control particulate pollutants

Advantages:-

- **Initial Cost is low.**
- **Low maintenance.**
- **Easy in operation.**

Disadvantage:-

It has low efficiency for the particles below 10 µm.

L-20 Techniques used to control particulate pollutants

Fabric Filters:-

- **Fabric filters systems typically consist of a tubular bag,**
- **suspended at such a manner that the collected particles fall into the fabric bags.**

L-20 Techniques used to control particulate pollutants

- **The structure in which the bags hang is known as a 'bag house'.**

- **In the fabric filters a dusty gas is allowed to pass through a fabric on which dust is attached.**

L-20 Techniques used to control particulate pollutants

- **If the gas is flowing at low velocity the particulates settle down as a result of sedimentation.**

- **Fine particles are also attached to the fabric.**

- **Bags are 1m to 7 m in size and its collection efficiency is about 99%.**

L-20 Techniques used to control particulate pollutants

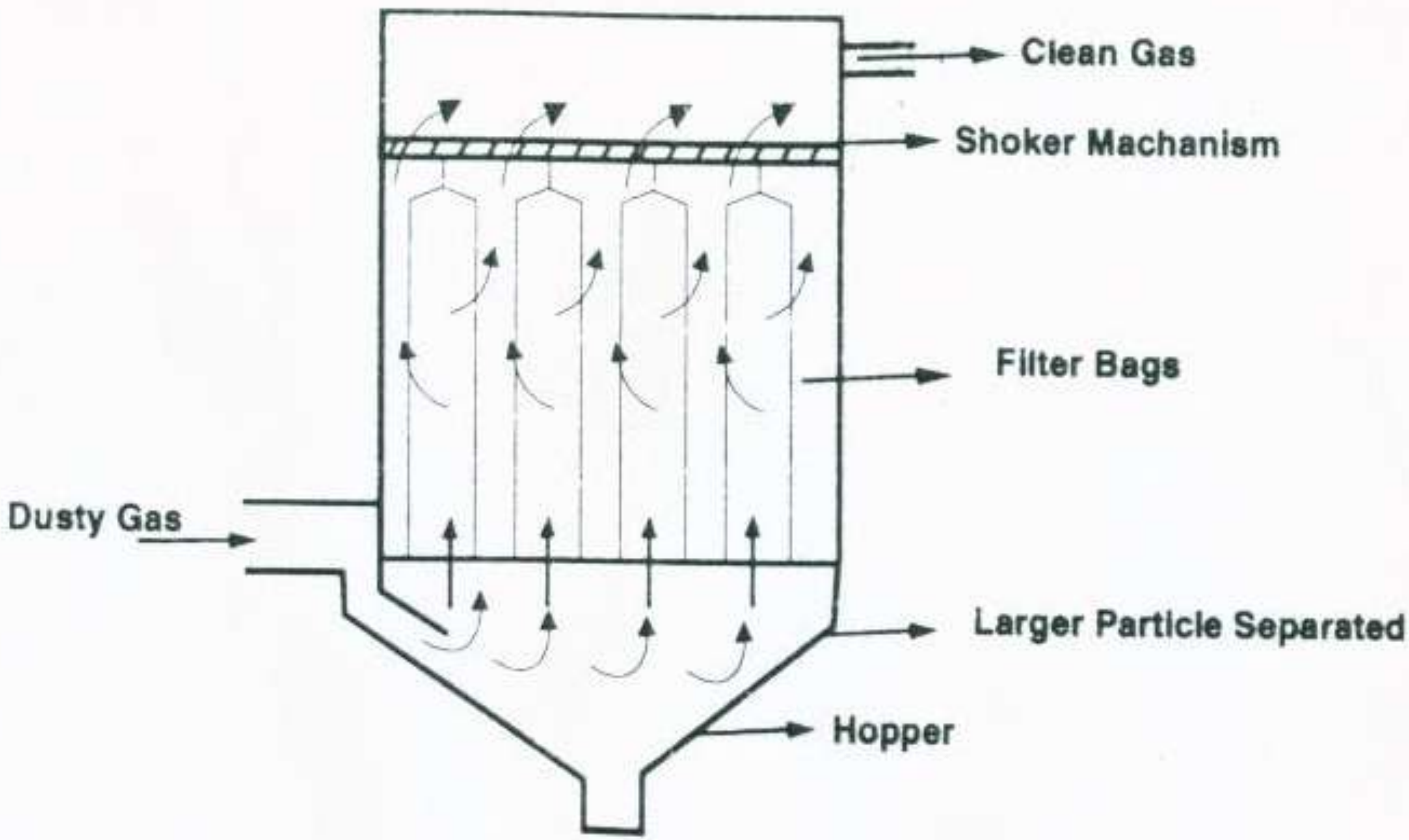


Fig. Bag filter

L-20 Techniques used to control particulate pollutants

Advantages:-

- **It has high collection efficiency for particles < 10 μm in diameter.**
- **It has simple operation and construction.**

Disadvantages:-

- **It needs high maintenance, and fabric replacement.**
- **Size is bigger.**

L-20 Techniques used to control particulate pollutants

2) Wet Collection Devices:-

- **In wet collection devices mixed phases of gases and liquids are used.**
- **Particles are washed out of the gas flow by a water spray.**

L-20 Techniques used to control particulate pollutants

2) Wet Collection Devices:-

- **These are of four types-**

i) Spray Towers

ii) Cyclonic Scrubber

iii) Venturi Scrubber

iv) Packed Bed Scrubber

L-20 Techniques used to control particulate pollutants

i) Spray Towers:-

- **This is the simplest type of wet scrubber is in which water is introduced by spray nozzles.**

- **The polluted gas flows upwards and particle collection results because of inertial impacts.**

L-20 Techniques used to control particulate pollutants

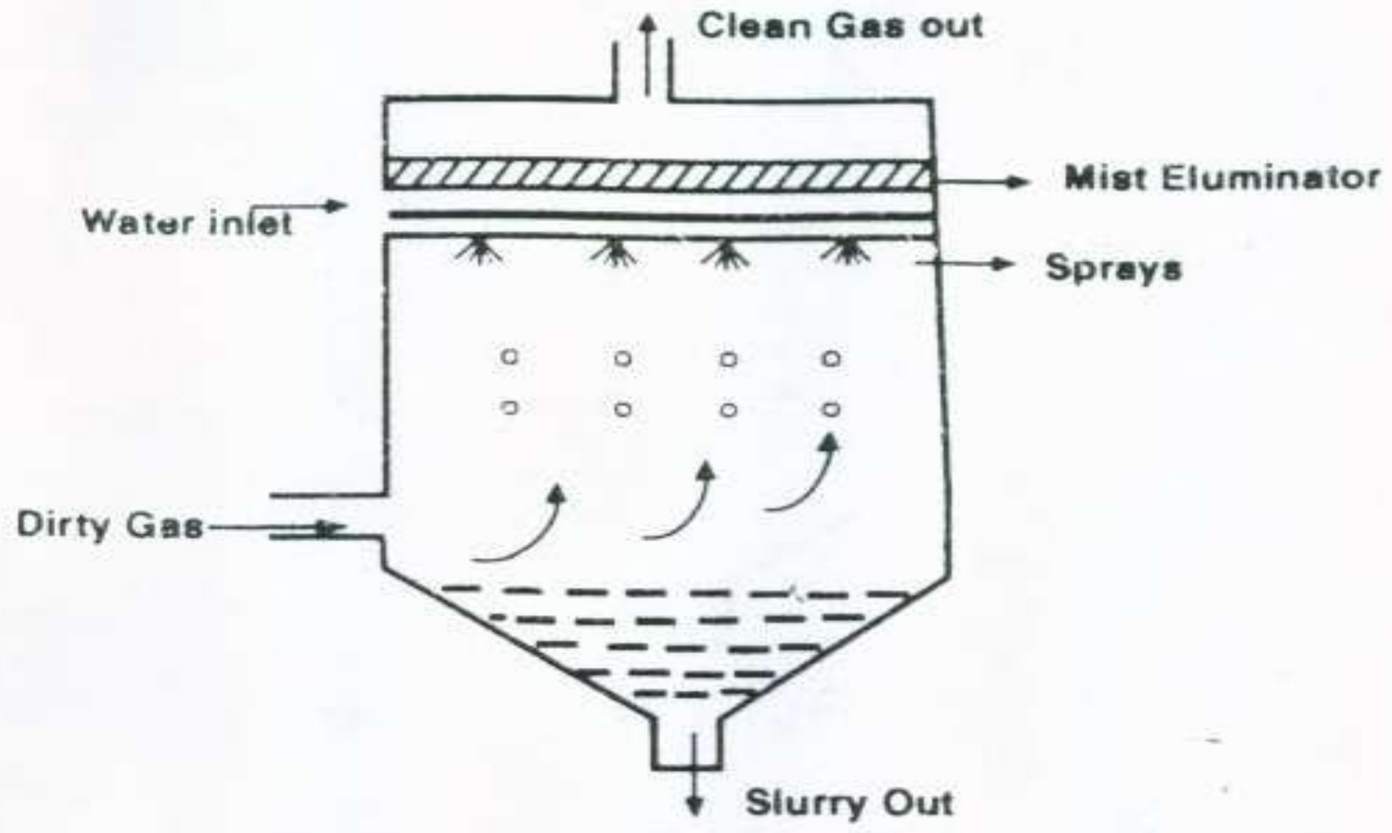


Fig. - Spray tower

L-20 Techniques used to control particulate pollutants

ii) Cyclonic Scrubber:-

- **The gas is introduced in a centrifugal manner in the cyclonic scrubber.**
- **At the entrance of gas water is sprayed and**
- **plates are provided to remove the moisture from the gas after the removal of the dust.**
- **It can remove dust particle of 5 μm size.**

L-20 Techniques used to control particulate pollutants

iii) Venturi Scrubber:-

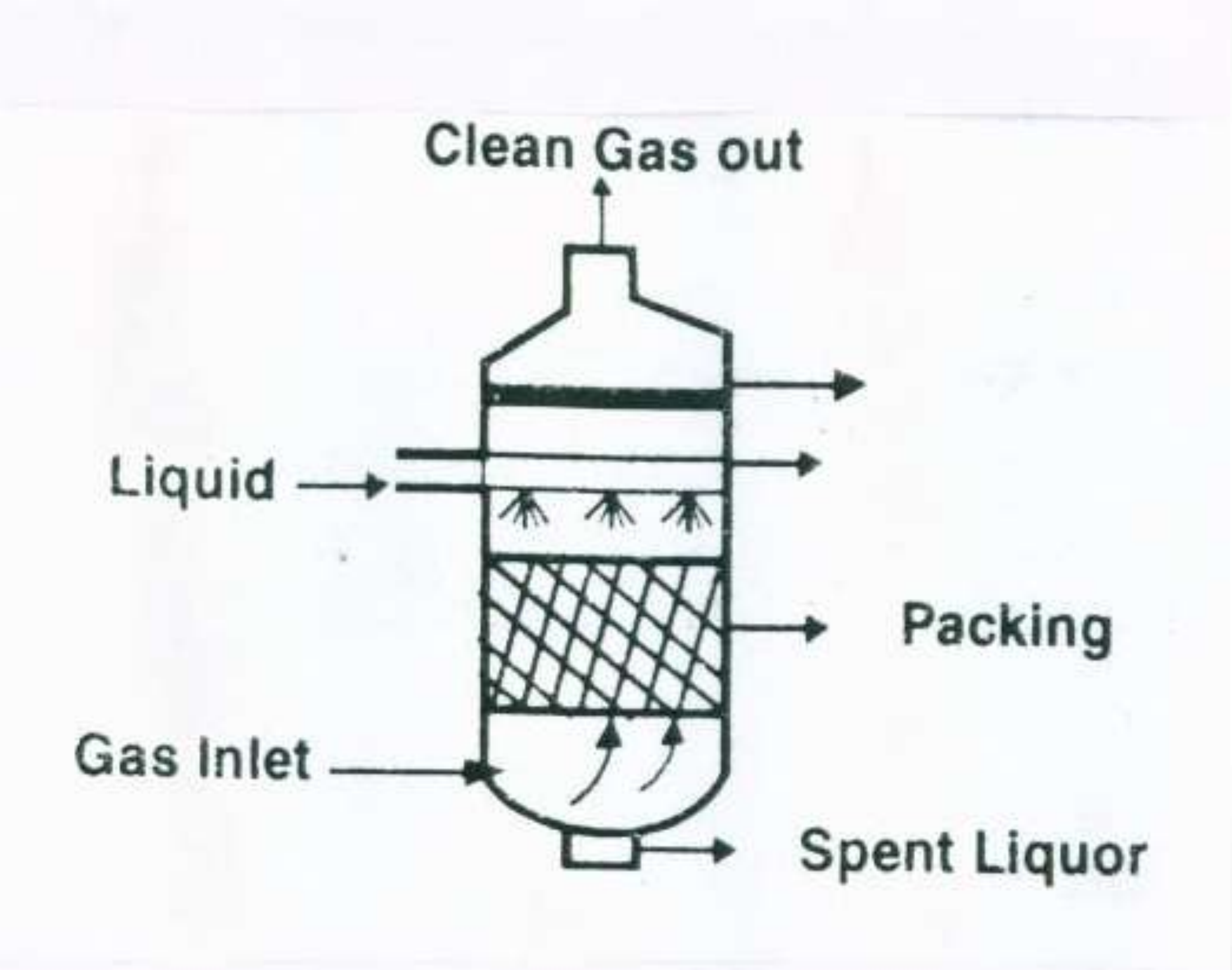
- It consists of a venture throat through which dirty gas is passed.
- In venturi scrubber gas liquid mixture is separated by the centrifugal force of the liquid droplets.
- It is capable of cleaning even very fine particles.

L-20 Techniques used to control particulate pollutants

iv) Packed Bed Scrubber:-

- **In the packed bed scrubber dirty gas moves upward and**
- **comes in contact with the scrubbing liquid stream**
- **which is moving downwards over the packing in a flow.**

L-20 Techniques used to control particulate pollutants



Packed Bed Scrubber

L-20 Techniques used to control particulate pollutants

(Packed Bed Scrubber)

Advantages:-

- **It needs moderate space.**
- **In this simultaneous removal of gases occur.**
- **It reduces hazards of explosive dust air mixture.**
- **By this gases can be neutralised using proper scrubbing liquid.**

L-20 Techniques used to control particulate pollutants

(Packed Bed Scrubber)

Disadvantages:-

- **In this devices corrosion is a big problems.**
- **Disposal of wet slide is also a problem.**
- **These consume high energy.**

L-20 Techniques used to control particulate pollutants

(3) Electrostatic Precipitator:-

- **Large particles can be removed by different methods but-**
- **the removal of small size (0.0001cm) particles is difficult.**
- **for these particles an electrostatic precipitator (ESP) is used.**

L-20 Techniques used to control particulate pollutants

(Electrostatic Precipitator)

The principle of ESPs is that

- **when the particulates move through a region of high electric potential,**
- **they become charged and get attracted to the oppositely charged plate.**

L-20 Techniques used to control particulate pollutants

(Electrostatic Precipitator)

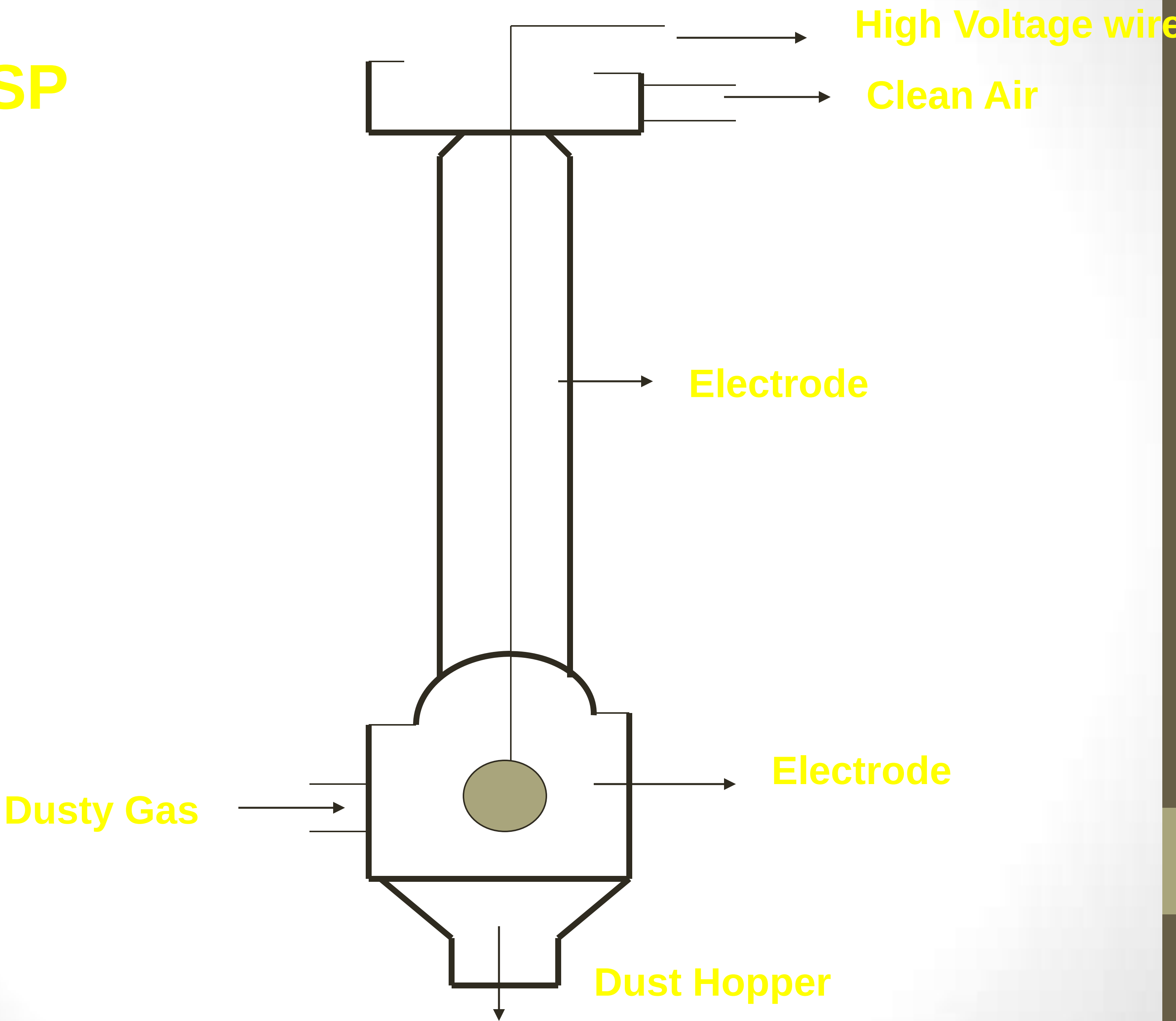
- **ESPs consists of a series of high voltaic plates having charge +vie or –ve,**
- **a thick cylinder with an inlet and outlet.**
- **When the dusty air enters the ESP,**

L-20 Techniques used to control particulate pollutants

(Electrostatic Precipitator)

- **the large size particles settle down due to gravity and**
- **the smaller charged particles settle on the oppositely charged plate surface.**
- **The efficiency of ESP is 99.9%.**

ESP


High Voltage wire
Clean Air
Electrode
Electrode
Dusty Gas
Dust Hopper

L-20 Techniques used to control particulate pollutants

(Electrostatic Precipitator)

Advantages:-

- **Power requirements is less.**
- **Its efficiency is 99.9%.**
- **It can handle both gases and mists for high volume flow.**

L-20 Techniques used to control particulate pollutants

(Electrostatic Precipitator)

Disadvantages:-

- **High initial cost and large space requirement.**
- **Sensitive to variable particulate loadings.**
- **Safeguard of operating personal from high voltage is necessary.**

Assignment-2

Q.1. Discuss in brief :-

i) Primary pollutant. (CO and SOX)

ii) Secondary pollutant.

Q.2. What is "Photochemical smog"? Discuss with schematic diagram.

Q.3.Write short notes on :-

a) Green house effect.

b) Ozone depletion.

c) Atmospheric stability.

d) Plum flow.

Assignment-2

Q.4. What is "Acid Rain", Give bad effects and controlling method.

Q.5. Describe the different techniques for controlling the :-

a) Particulate pollutants.

b) Gaseous pollutants.

Q.6 Discuss the ambient air quality standards.

SOME CASE STUDIES

1. In 1930 Meuse Valley of Belgium

- Was trapped by inversion for 5 days.
- Resulting death of about 60 people.

2. The notorious LONDON episode

- In 1952 under heavy continuous smog conditions
- causing more than 4000 deaths.

3. The BHOPAL disaster

is an example of industrial pollution accidents.

SOME CASE STUDIES

Bhopal on 3rd December 1984

- **at midnight a pesticide manufacturing plant UNION CARBIDE factory released**
-
- **a potent toxicant METHYL ISO CYANATE (MIC) gas due to the functional failure of vent scrubber outlet- about 30 tonnes.**
- **About 100,000 people died, additional 100,000 suffered severe disability due to suffocation, cardiac failure and pulmonary disorders.**

SEARCH MORE YOURSELVES


THANKS