

Environmental pollution: Sources, causes, effect and control

Dr. Renu Bhargava
Professor, Env Engg Section,
Deptt of Civil Engg.,
IIT, Roorkee



Pollution

Pollution may be defined as 'an undesirable change in the physical, chemical or biological characteristics of our air, water and land that may or will harmfully, affect human life, the lives of the desirable species, our industrial processes, living conditions and cultural assets, or that may or will waste or deteriorate our raw materials.

Pollution is mostly man made, but it can also be natural. Natural pollution is caused by volcanic eruptions, emission of natural gases, soil erosion, ultraviolet rays, cosmic rays etc.



Types of Pollution

- Atmospheric (air) pollution
- Water pollution
- Soil/land pollution
- Radioactive pollution
- Noise pollution



Air Pollution



Definition

Presence of foreign material in the air which are harmful to man and environment.



Sources of Air Pollution

A. Natural

B. Anthropogenic

Domestic

Commercial

Agricultural

Industrial

Transportation related sources



Natural sources

Natural pollutant emissions vary from one location to another, with seasonal, geological and meteorological conditions and with the type of vegetation

eg. Volcanic eruptions, forest fires, dust storms etc.



Domestic Sources

In residential areas, domestic activities are the major causes of pollutant emissions.

| Activity | Pollutants released |
|---------------|---|
| Space heating | CO, CO ₂ , NO _x , So _x , soot, smoke (if fossil fuels are burned at the residence) |
| Cooking | Fats (as solids, liquids, and vapors), particles, odors |
| Cleaning | Solvent vapors, dust, lint, spray can propellants |
| Gardening | Pesticides, fertilizers (some of which may be highly toxic) |
| Painting | Principally solvent vapors |
| Washing | Detergent particles, soap particles, lint |



Commercial Sources

- commercial sources of air pollution include the public services industries eg., dry cleaning of clothes.
- Other include restaurants, hotels, schools, printing and painting.



Agricultural Sources

- animal feed operations
- Cotton particles during harvesting and processing in sufficient quantities
- Pesticides and insecticides



Industrial sources

A few of the polluting industries are

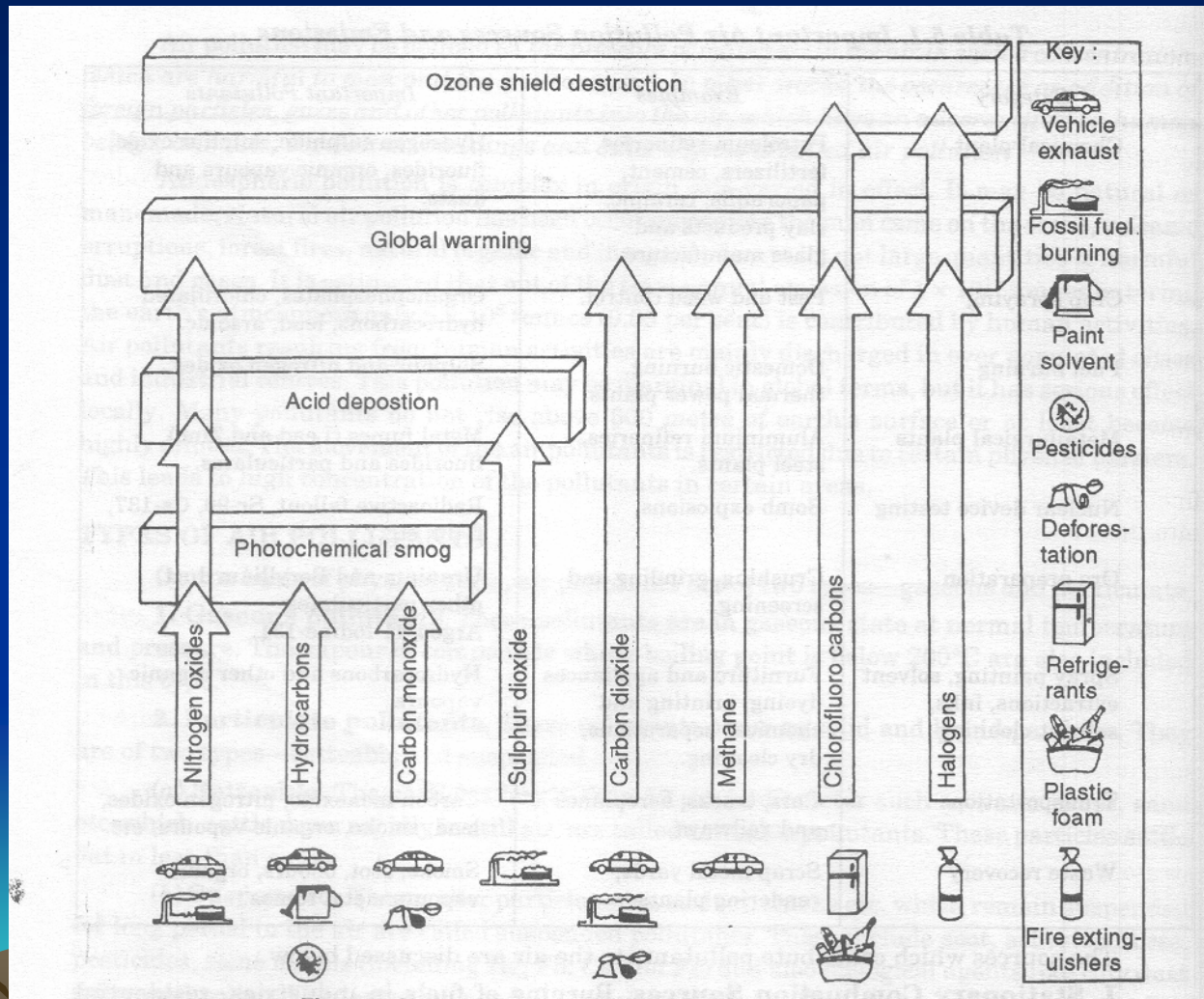
- Fertilizer and explosive manufactures (produces NO_x)
- Paper plants, natural gas cleaning and processing plants, oil refineries, synthetic fibers plant (Hydrogen sulfide)
- Cast iron and other metallurgical processes (CO)
- Industries related to petroleum and natural gas industries (VOCs)

Transportation related sources

- Except agriculture the transportation sector releases one third of the total emissions of VOCs, nitrogen oxides, and lead and more two thirds of the carbon monoxide.



Sources of air pollution



Important Air Pollution Sources and emissions

| Category | Examples | Important Pollutants |
|---|---|---|
| Chemical plant | Petroleum refineries, fertilizers, cement, paper mill, ceramic, clay products and glass manufacture | Hydrogen sulphide, sulphur oxides, flourides, organic vapors and dusts. |
| Crop spraying | Pest and weed control | Organophosphates, chlorinated hydrocarbons, lead, arsenic. |
| Fuel burning | Domestic burning, thermal power plants | Suphur and nitrogen oxides. |
| Metallurgical plants | Aluminium refineries, steel plants | Metal fumes (Lead and Zinc) flourides and particulates. |
| Nuclear device testing | Bomb explosions | Radioactive fallouts, Sr-90, Ca-137, C-14, etc. |
| Ore preparation | Crushing, grinding screening | Uranium and Beryllium dust, other particulates, argon-41, Iodine-131 |
| Spray painting, solvent extractions, inks, solvent cleaning | Furniture and appliances dyeing, printings and chemical separations, dry cleaning | Hydrocarbons and other organic vapors |
| Transportation | Cars, trucks, aeroplanes and railways | Carbon monoxide, nitrogen oxides, lead, smoke, organic vapors etc. |
| Waste recovery | Scrap metal yards, rendering plants | Smoke, soot. Odors. Organic vapors metal fumes. |

Pollutants

Classification

Primary pollutant

Gaseous ---oxides of carbon, oxides of sulphur, oxides of nitrogen, hydrocarbons

Particulate---lead, SPM, RSPM, Pollen, dust, fly ash etc.

Secondary pollutant

Photochemical smog, acid rain



Photochemical smog

The product of photochemical reactions are formaldehyde, peroxybenzoyl Nitrate (PBzN), peroxyacetyl nitrate (PAN), and acrolein.

Hydrocarbons + NO_x + Sunlight \longrightarrow Photochemical smog

The NO-NO₂-O₃ photochemical reaction sequence



In presence of sunlight



Where $h\nu$ means photon ($\lambda < 0.38\mu\text{m}$)

Ozone then convert NO back to NO₂



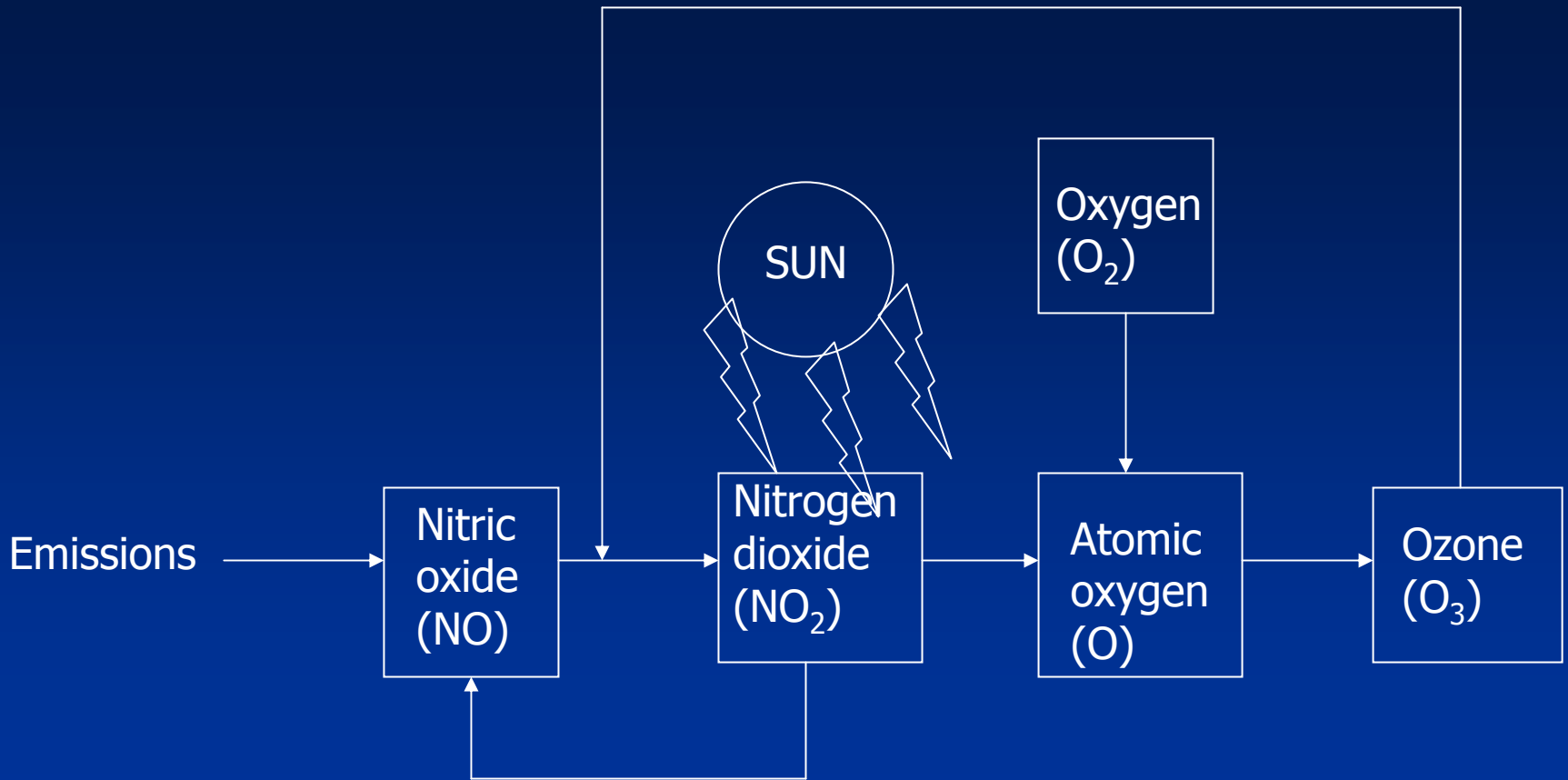
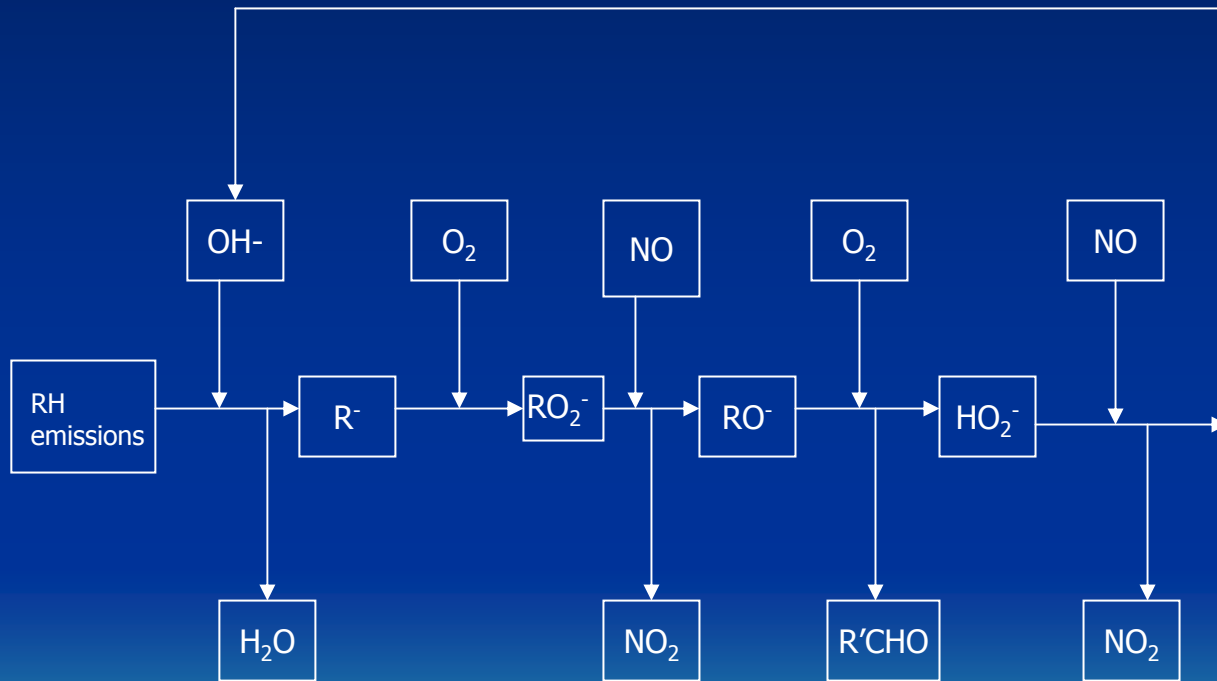


Fig. 3: Atmospheric nitrogen photolytic cycle

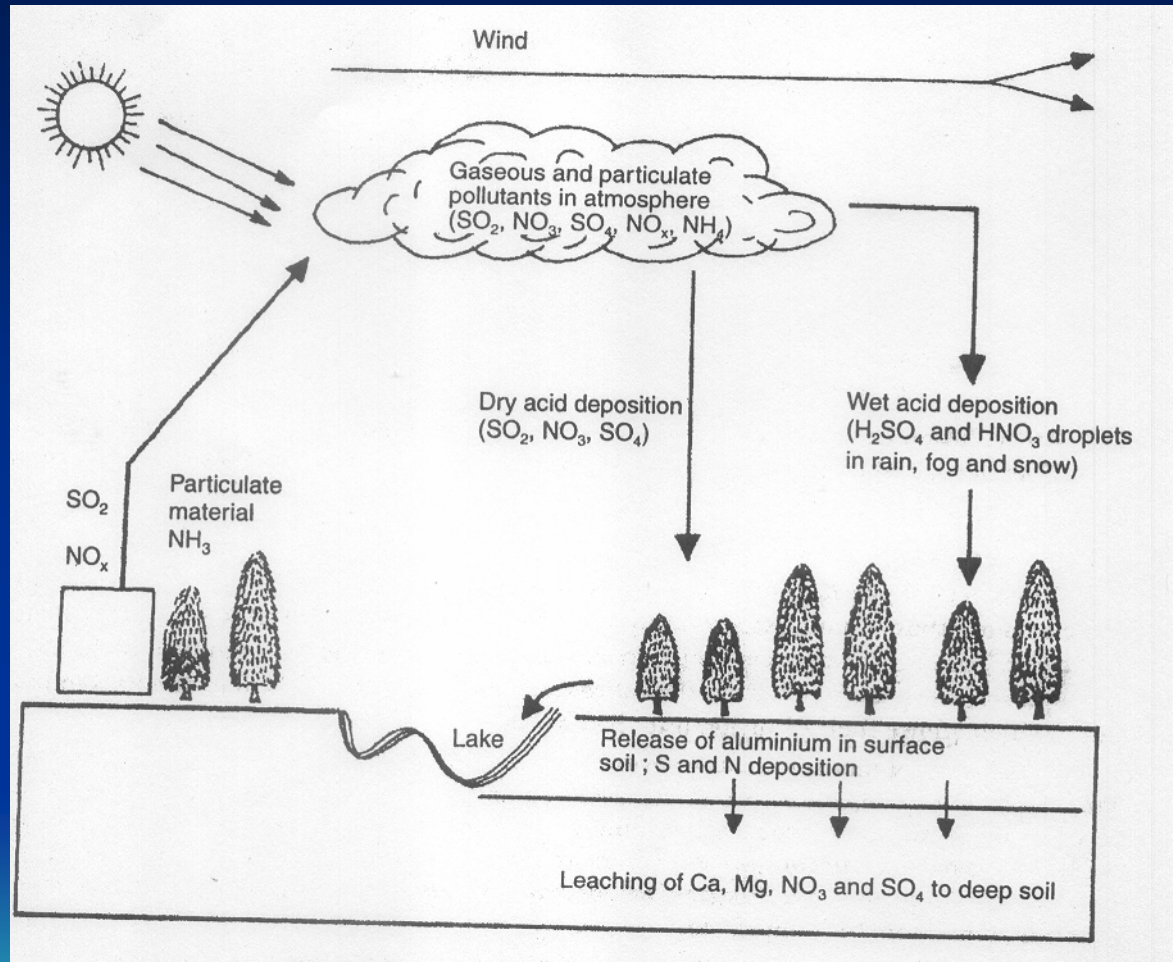
Reaction of hydrocarbons with NO_x
HC can cause NO to convert to NO_2
Reducing NO removes O_3 slowly
Increase in NO_2 gives rise to increase in ozone production as shown below



Effects

| Pollutants | Effects on Man, Vegetation and other materials |
|-------------------------------|---|
| Carcinogenic hydrocarbon | On man --- Cancer |
| Carbon monoxide | On man – Poisoning, increased accident liability |
| Dust | On man--- Respiratory diseases, fiseases like silicosis (cough, cold, sneezing, allergic deseases, etc), asbestosis, byssinosis, poisoning from metallic dust |
| Hydrogen sulphide | On man– irritation of respiratory passages, danger of respiratory paralysis and asphyxiation On materials– Darkening of painted surfaces, corrosion |
| Hydrogen flouride | On man – irritation, diseases of bone (flourosis), mottling of teeth, respiratory diseases On vegetation – destruction of crops |
| Heavy metals | On man – specific poisoning, retardation of activities of brain, interference in enzyme activities in liver and kidney |
| Nitrogen dioxide | On man –irritation , brochitis, oedema of lungs |
| Photochemical smog (oxidants) | On man – lung irritation, asthma, bronchitis,etc On vegetation –destruction of vegetation On materials– deterioration of rubber products such as tyres and insulating wires |
| Sulphur dioxide | On man– suffocation, irritation of throat and eyes, respiratory diseases. On vegetation– destruction of sensitive crops and reduced yield On materials – corrosion. |

Acid Rain and dry acid deposition



Control of Air pollution

I. Control of particulate matter

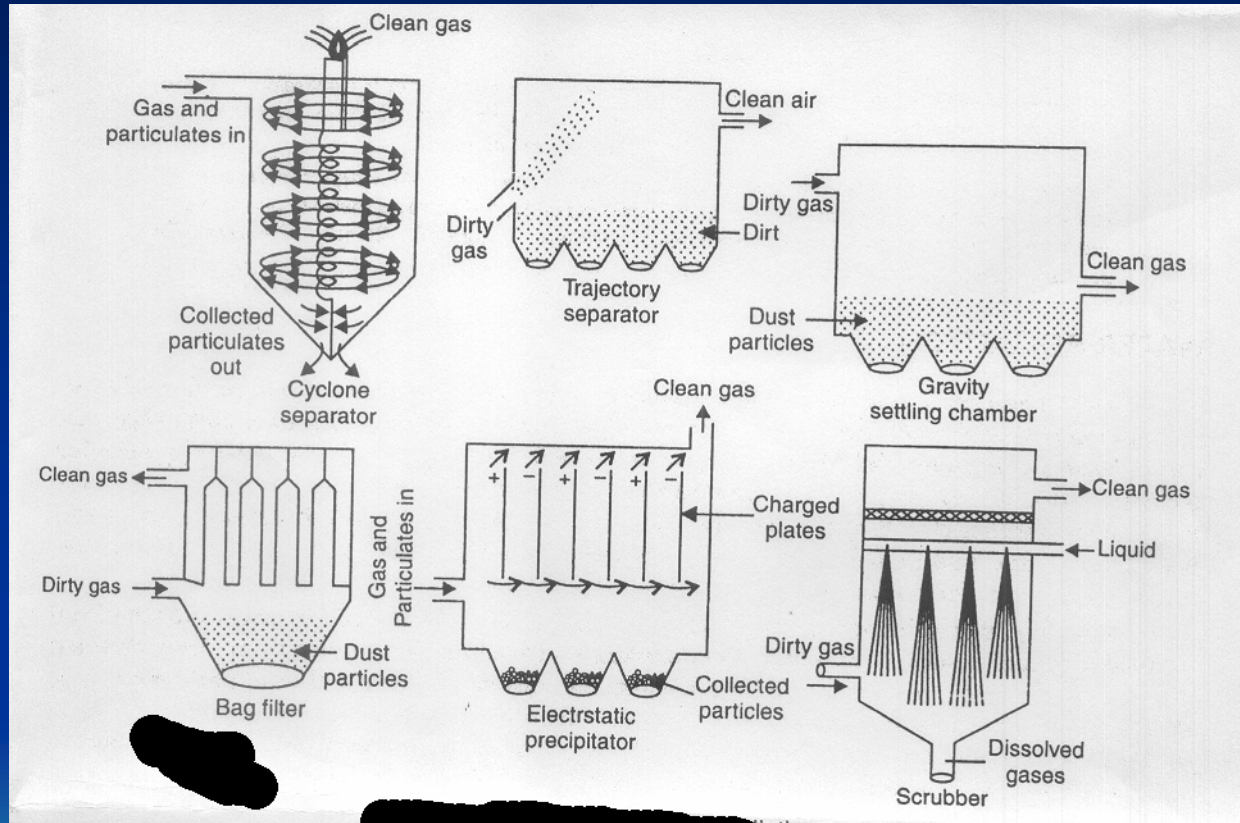
- Arresters
- Scrubbers

II. Control of gaseous pollutants

III. Control of automobile exhaust



Some air pollution control devices



Air pollution Meteorology

- The rate of decrease of temperature with increase in height is called the temperature lapse rate. If the rate of decrease refers to the air environment, it is called the environmental lapse rate.

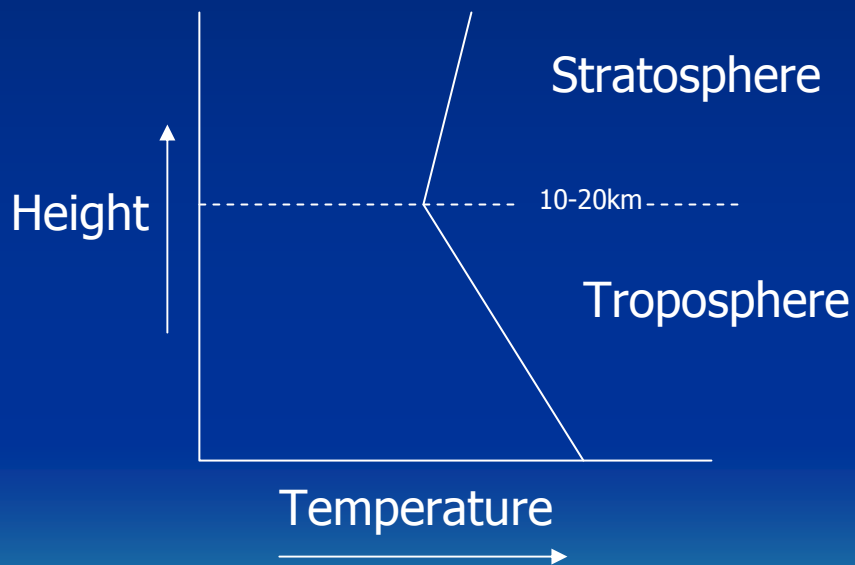
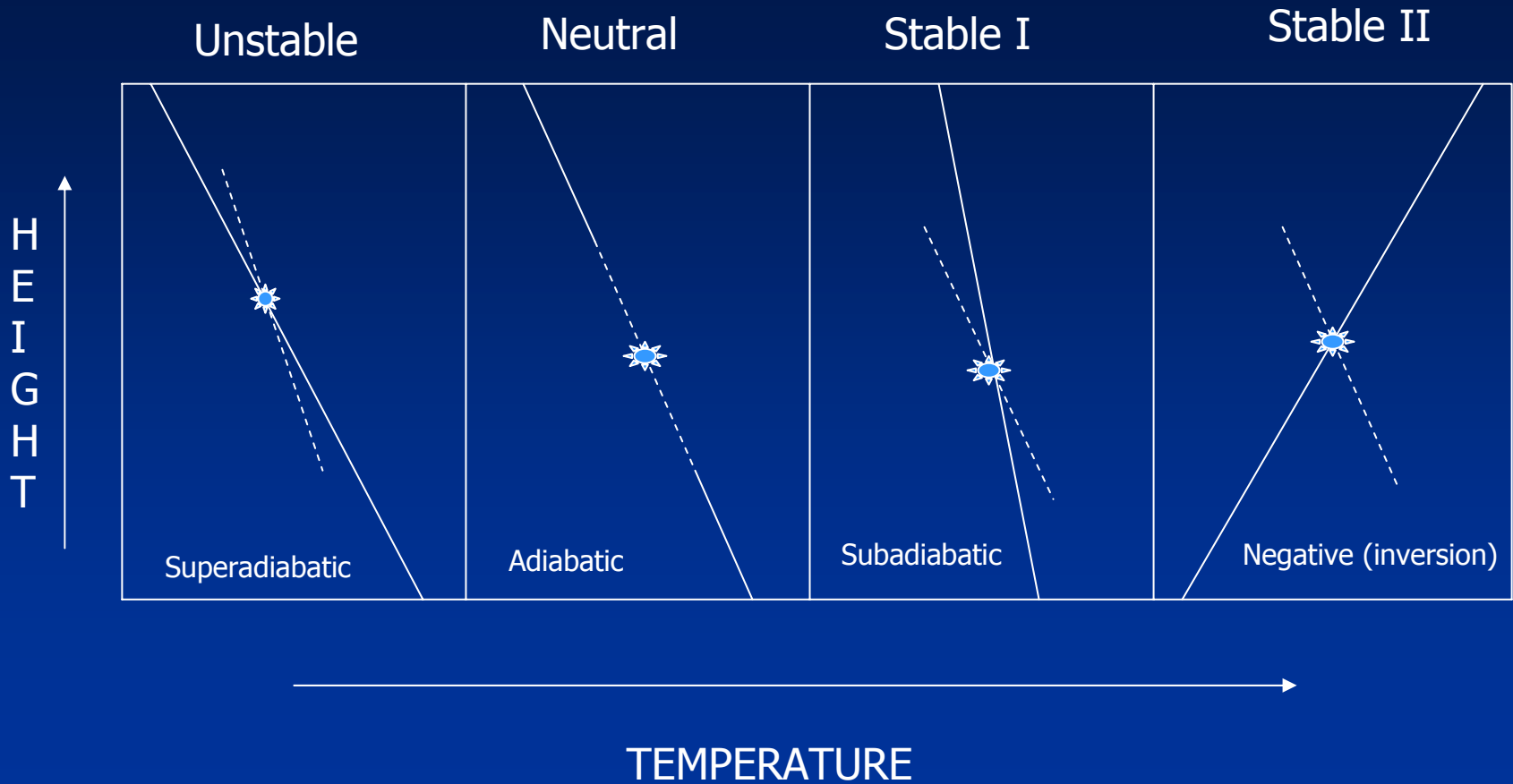


Fig.1: Temperature change with height illustrating positive lapse in the troposphere.



Environmental Lapse Rate

Process Lapse Rate (Adiabatic)

Fig 2: Stability of an air parcel determined by environmental lapse rate.

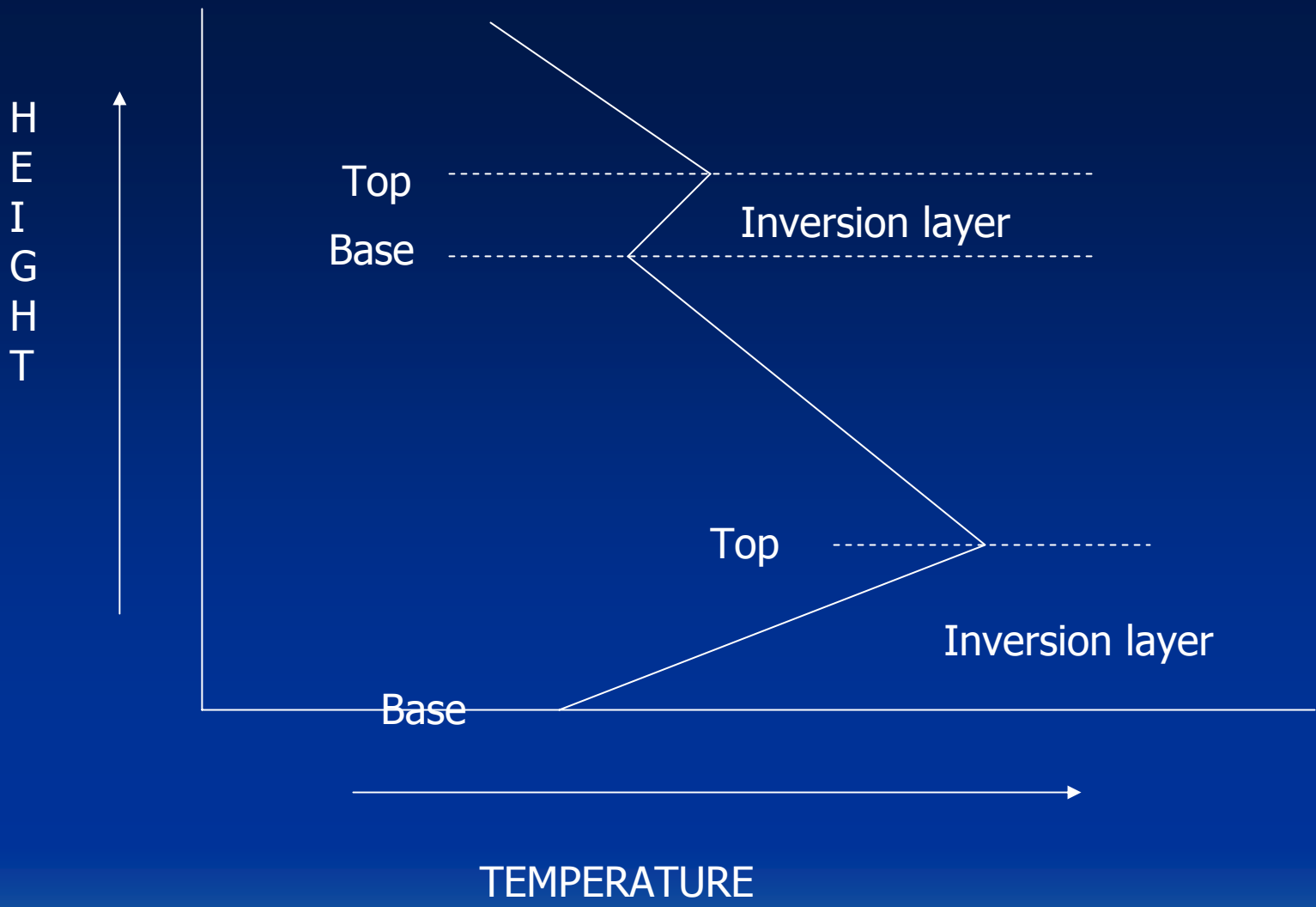


Fig.3: Surface inversion and inversion aloft.

Assesment

The pollution can be assesed by the use of

- a. High volume sampler
- b. Gas bubbler
- c. Respirable dust monitoring equipments
- d. Stack monitoring



Water pollution

It is defined as the addition of some substance (organic, inorganic, biological or radiological) or factor (heat), which degrade the quality of water so that it either becomes health hazards or unfit for use.



Sources of water pollution

Point source

1. Municipal waste water

Most important characteristics

BOD, COD, DO, metals

2. Industrial waste water

Inorganic

Different metals,
Fluorides, sulphates,
Cyanide, oxides of iron,
mercury, acid, alkali etc

Organic

Carbohydrate,
proteins, oils, fats,
phenols, organic acids etc.

3. Thermal pollution

Main sources are thermal and nuclear power plant

Non-point sources

Agricultural sources

Fertilizers, pesticides, fungicides

Substances like DDT gives rise to biomagnification



A few industrial sources of water pollution

| <i>Type of Industry</i> | <i>Inorganic pollutants</i> | <i>Organic pollutant</i> |
|-------------------------|--|--|
| Mining | Mine Wastes : Chlorides, various metals, ferrous sulphate, sulphuric acid, hydrogen sulphide, ferric hydroxide, surface wash offs, suspended solids, chlorides and heavy metals. | |
| Iron and Steel | Suspended solids, iron cyanide, thiocyanate, sulphides, oxides of copper, chromium, cadmium, and mercury. | Oil, phenol and neptha. |
| Chemical Plants | Various acids and alkalies, chlorides, sulphates, nitrates of metals, phosphorus, fluorine, silica and suspended particles. | Aromatic compounds solvents, organic acids, nitro compound dyes, etc. |
| Pharmaceutical | | Proteins, carbohydrates, organic solvent intermediate products, drugs and antibiotics. |
| Soap and Detergent | Tertiary ammonium compounds alkalies. | Fats and fatty acids, glycerol, polyphosphates, sulphonated hydrocarbons. |
| Food processing | — | Highly putrescible organic matter and pathogens. |
| Paper and Pulp | Sulphides, bleaching liquors. | Cellulose fibres, bark, wood sugars organic acids. |

Effect on the aquatic system

- The oxygen demand in waste consumes DO from water and it may bring it down to a value less than 4ppm which is threshold value for the survival of fish and other aquatic life. Reduced DO also eliminate the sensitive species like plankton, mollusc and fish while annelid worm and some insect larvae are tolerant to low DO content.
- The DO of the water depends upon the temperature of water
- Heavy metals and high temperature also affects the organisms
- Eutrophication → algal bloom



Effects on human health

- The waste water or sewage contains pathogens which when consumed causes jaundice, cholera, typhoid, amoebiosis etc.
- Heavy metals can cause serious health problems. Mercuric compounds are converted by bacterial actions into methyl mercury which causes numbness of limbs, lips and tongue, blurring of vision and mental derangement
- Minamata disease was caused in 1952 in Japan due to consumption of mercury
- Cadmium can cause itai itai disease which is a painful disease of bones and joints, cancer of lungs and liver.
- lead causes anaemia, headache, loss of muscle power and bluish line around gums



Excess nitrate (ground water) may be fatal for infants. It causes Methaemoglobinemia or blue baby disease

Haemoglobin + nitrate \longrightarrow methaemoglobin

Flouride \longrightarrow Causes teeth deformaty hardening of bones and Skeletal florosis



Control

1. Sewage should be suitably treated before discharging into the water body

Conventional waste treatment

Primary

Screen
Grit Chamber
Settling

Secondary

Biological treatment
ASP
Trickling filter
Oxydation pond
Oxydation ditch
Aerated Lagoon
UASB and
Sludge Thickening
and treatment

Tertiary

Polishing ponds
Nutrient removal
Disinfection



Soil /land Pollution

- The top soil gets polluted by the addition of the substances to the soil which adversely affect physical, chemical and biological properties of soil and reduces its productivity
- The process of soil production is very slow and hence the soil can be considered as non-renewable resource.
- Soil pollution may occur by dumping and disposing the waste directly on land, application of agrochemicals or indirectly through air pollution.
- Main soil pollutants are
 - Industrial waste
 - Pesticides
 - Fertilizers and manures
 - Discarded waste
 - Solid and semi solid
 - Radioactive sources
 - And other polluting materials entering indirectly



Effect

- Salination of the soil
- The soil may become infertile
- The pollutants may leach down with the rain water polluting the ground water



Control

- Manage the solid waste properly
- Pneumatic pipes should be laid for collecting and disposing waste
- Industrial waste should be dumped in special pits
- Chemical fertilizers and pesticides used may be reduced--- biofertilizer, biopesticides



Radioactive pollution

- Natural sources--- from earth's crust
- Man made sources
- Nuclear power plant
- Atomic explosions
- Nuclear fall out
- Radioactive isotopes used in laboratories, radiation therapy



Effects of radioactive pollution

- It depends upon half life, energy releasing capacity, rate of diffusion, rate of deposition of pollutant and the environmental factors like wind, temperature and rainfall
- The radiations can cause damage to skin, sun burns, impair metabolism etc.



control

- Proper precaution should be taken to prevent the nuclear fall out
- Leakage should be checked
- Safe Disposal of radioactive waste
- Regular monitoring
- Prevent occupational exposure



Noise pollution

