



Pollution

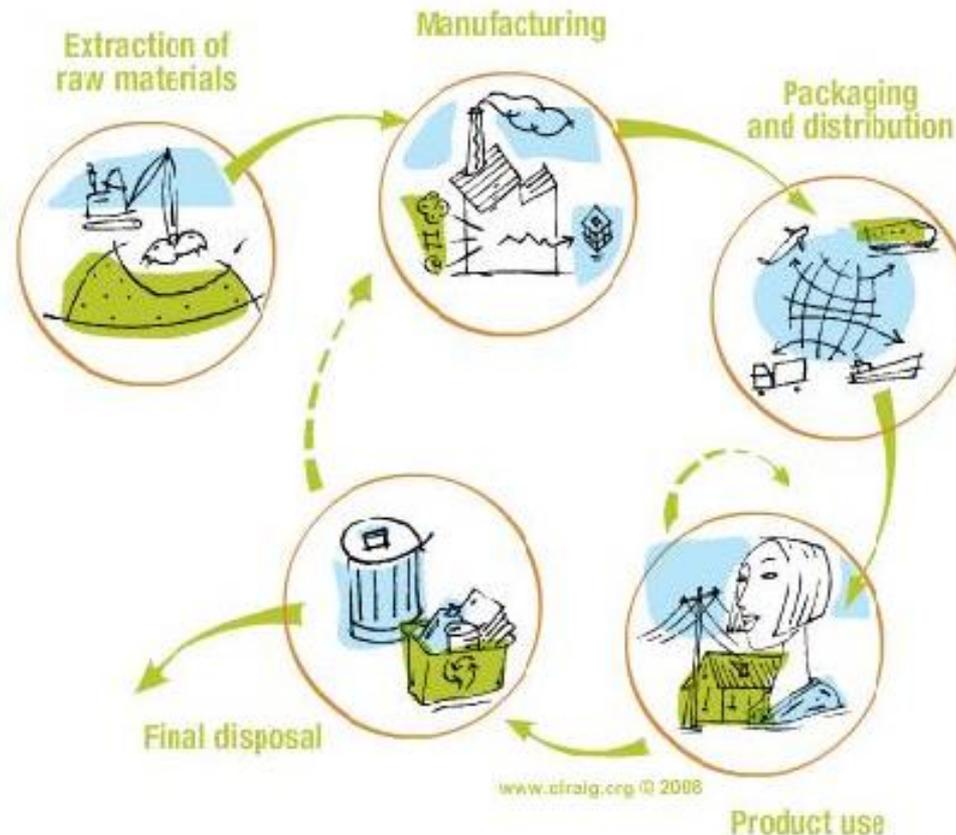
Unit - III



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- ❖ WHAT IS POLLUTION
 - ❖ WHEN DOES IT(POLLUTION) OCCURS?
 - ❖ TYPES OF POLLUTANTS
 - ❖ EFFECTS OF POLLUTION
 - ❖ NATURES MECHANISM OF TREATING POLLUTANTS
 - ❖ CLASSIFICATION OF POLLUTANTS(BASED ON ECOLOGICAL PERSPECTIVE)

- ❖ **Pollution** - the undesirable and unintended contamination of the environment by the manufacture or use of commodities. **Resource depletion** refers to the consumption of finite or scarce resources.
- ❖ **Carrying capacity** - Air and water as free goods

The life cycle of a product



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- ❖ Pollution - the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings.
 - ❖ Short-term economic gains at the cost of the long-term ecological benefits.
 - ❖ Pollutants include solid, liquid or gaseous substances
 - present in greater than natural abundance produced due to human activity.

EFFECTS OF POLLUTION

- ❖ 1. LOSS IN QUALITY OF ENVIRONMENT
- ❖ 2. LOSS IN HEIGENITY OF ENVIRONMENT
- ❖ 3. EFFECTS THE HEALTH OF LIVING ORGANISM
- ❖ 4. REDUCTION IN BIODIVERSITY

NATURES MECHANISM OF TREATING POLLUTANTS

❖ **Nature has self purification process for:**

- Air: dispersion and dilution into large body
- Water: micro-organisms/bacteria decomposes waste
- Soil: same as in case of water

BUT IN ALL CASES : NATURE HAS LIMITED CAPACITY TO TREAT POLLUTANTS;

IT CANNOT TREAT HUGE QUANTITIES OF WASTES GENERATED BY MODERN/CIVILIZED/AFFLUENT HUMAN SOCIETY.

Classification of Pollutants based on Ecological Perspective

❖ Degradable or non-persistent pollutants

- Rapidly broken down by natural processes.
- E.g. domestic sewage, discarded vegetables, etc.

❖ Slowly degradable or persistent pollutants

- Pollutants that remain in the environment for many years in an unchanged condition and take decades or longer to degrade.
- E.g. DDT and most plastics.

❖ Non-degradable pollutants:

- Cannot be degraded by natural processes. Once they are released into the environment they are difficult to eradicate and continue to accumulate.
- E.g. toxic elements like lead or mercury.

CAUSES, EFFECTS AND CONTROL MEASURES OF POLLUTION

- ❖ Air Pollution
- ❖ Water Pollution
- ❖ Soil Pollution
- ❖ Marine Pollution
- ❖ Noise Pollution



Air Pollution

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- ❖ 1.IMPORTANCE OF AIR POLLUTION
 - ❖ 2. **History of air pollution**

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- ❖ Average air required by human beings = 12 kg/day, which is nearly 12 to 15 times greater than the amount of food we eat.
 - ❖ So, even a small concentration of pollutants in the air becomes more significant in comparison to the similar levels present in food.
 - ❖ The nature and concentration of a pollutant determines the degree of harmful effects on human health.
 - ❖ **Pollutants that enter water have the ability to spread to distant places especially in the marine ecosystem.**

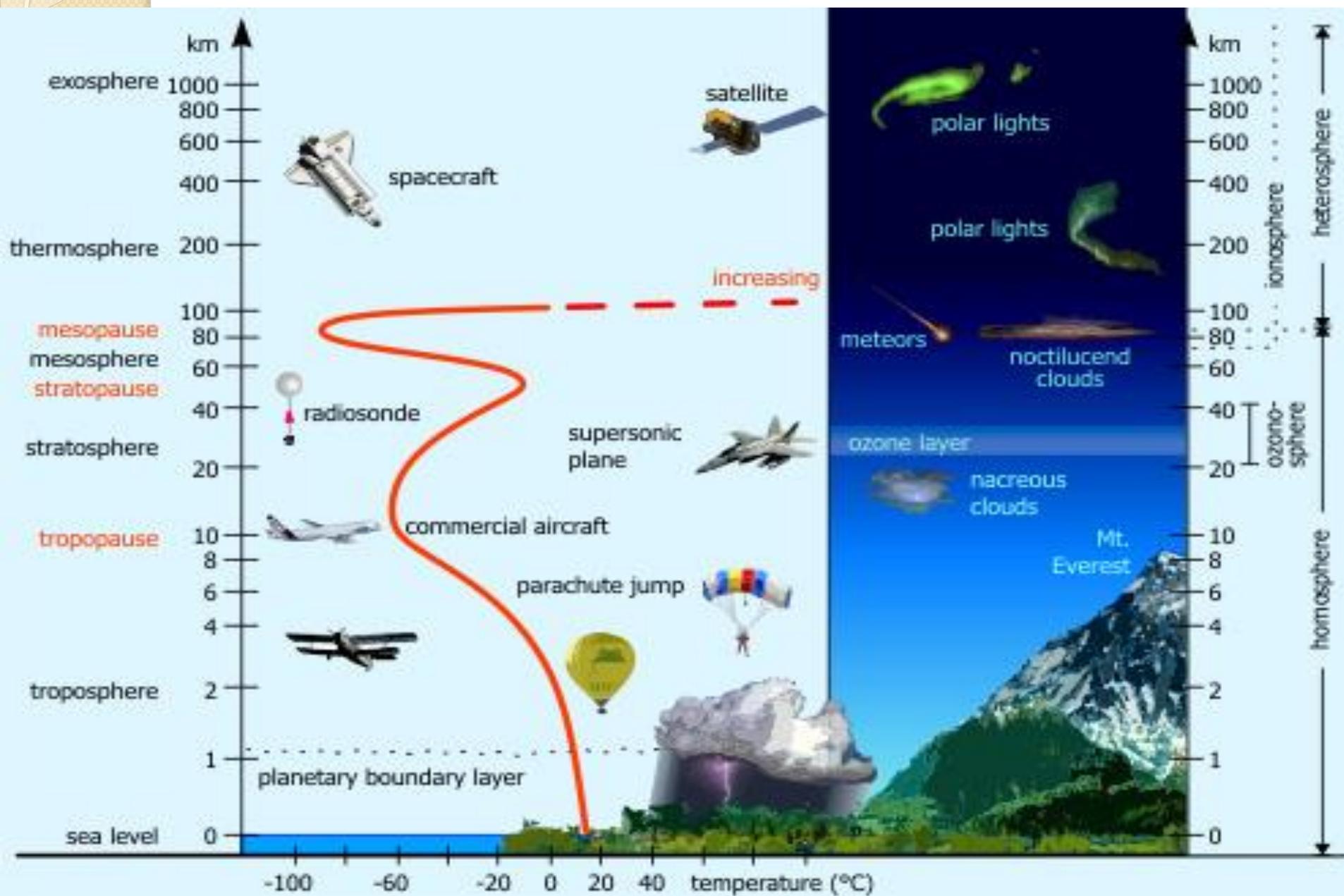
Air Pollution

History of air pollution

- ❖ Use of firewood as a means of cooking and heating - origin of air pollution on the earth.
- ❖ Air pollution - Hippocrates (400 BC).
- ❖ Increasing use of coal; air pollution became more pronounced especially in urban areas.
- ❖ Pollution due to smoke prompted King Edward I to make the first antipollution law in London to restrict people from using coal for domestic heating in the year 1273.
- ❖ In the year 1300 another Act banning the use of coal was passed.

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- ❖ 'London Smog', 1952 - resulted in more than 4000 deaths due to the accumulation of air pollutants over the city for five days.
 - ❖ Increase in air pollution in the 20th century - due to the development of the transportation systems and large-scale use of petrol and diesel.
 - ❖ Air Pollution Control Act in India, 1981 and Motor Vehicle Act for controlling air pollution - intended to prevent air pollution.
 - ❖ Bhopal gas tragedy - The greatest industrial disaster leading to serious air pollution (Methyl Isocyanine Gas accidentally released from the Union Carbide's pesticide manufacturing plant on the night of 3rd December 1984).

Structure of the atmosphere



Types and Sources of Air Pollution

- ❖ Air pollution - occurs due to the presence of undesirable solid or gaseous particles in the air in quantities that are harmful to human health and the environment.
- ❖ **Natural causes** - volcanoes, which release ash, dust, sulphur and other gases, or by forest fires that are occasionally naturally caused by lightning.
- ❖ Naturally occurring pollutants tend to remain in the atmosphere for a short time **and do not lead to permanent atmospheric change.**

Types of Pollutants

❖ Two types

- Primary pollutants
- Secondary pollutants

❖ Primary Pollutants

- Pollutants that are emitted directly from identifiable sources are produced by both natural events (e.g. dust storms and volcanic eruptions) and human activities (emission from vehicles, industries, etc.).
- **Five primary pollutants** together contribute about 90% of the global air pollution.
- These are carbon oxides (CO and CO₂), nitrogen oxides, sulfur oxides, volatile organic compounds (mostly hydrocarbons) and suspended particulate matter.

AIR POLLUTION: SOURCES

- ❖ 1. AUTOMOBILES
- ❖ 2. POWER PLANTS(COAL, HYDROCARBONS)
- ❖ 3. INDUSTRY(STEAM GENERATION SOURCES)
- ❖ 4. WASTE GASES, DUST, HEAT FROM INDUSTRY
- ❖ 5. VOLCANIC ERUPTIONS
- ❖ 6. FOREST FIRES
- ❖ 7. MINING ACTIVITIES
- ❖ 8. NUCLEAR ENERGY SOURCES

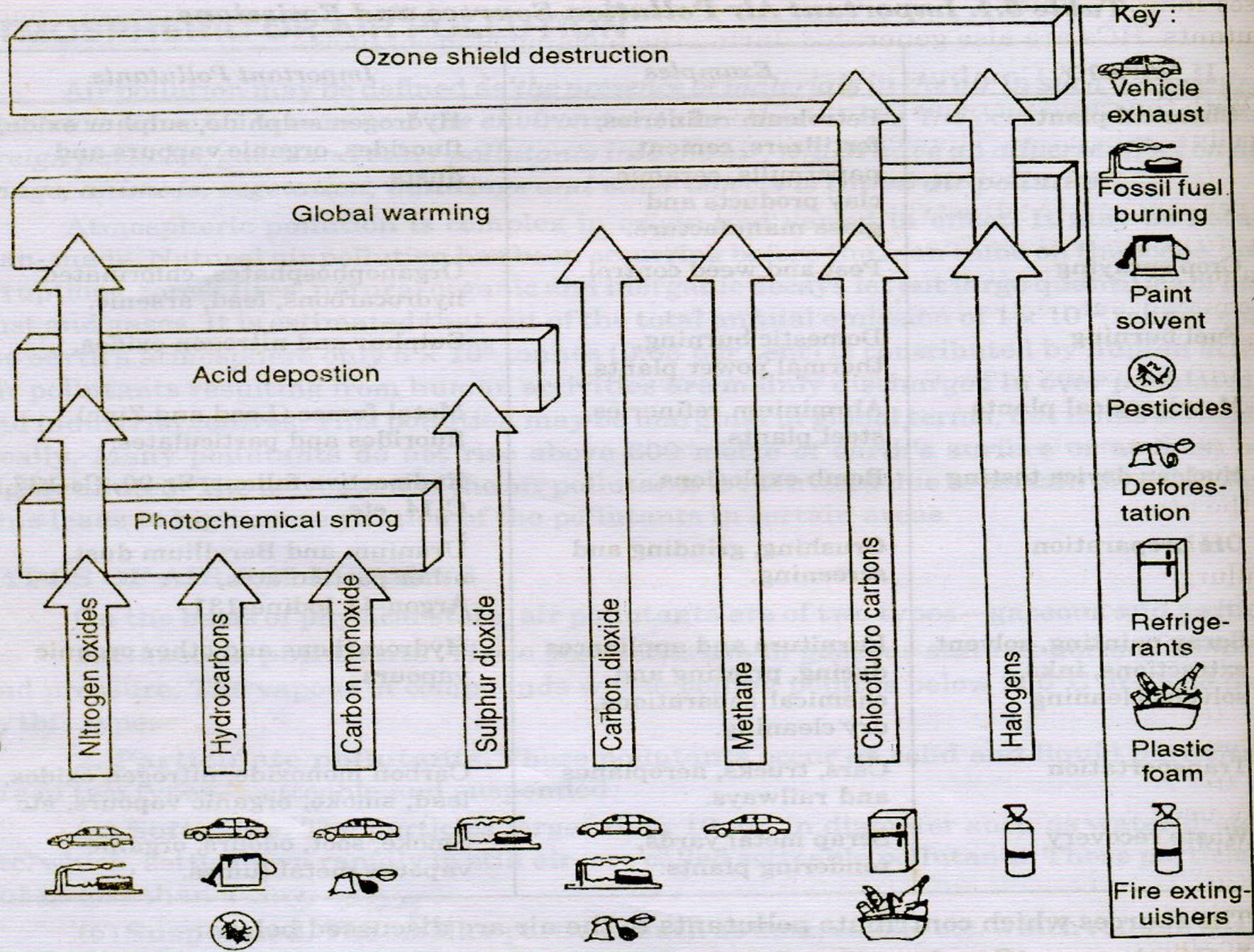


Fig. 1.1. Sources of air pollution and their environmental effects

Effects of air pollution on living organisms

- ❖ 1. EYES IRRITATION
- ❖ 2. SKIN ALLERGIES
- ❖ 3. INFLAMATION/INFECTION TO RESPIRATORY SYSTEM
- ❖ 4. REDUCTION OF IMMUNITY
- ❖ 5. Cox: **headache(low levels)**
- ❖ **Mental impairment(high levels)**
- ❖ 6. Sox: **Acid rains buildings/monuments corrosion**
- ❖ 7. Particulate matter: photochemical reaction reduces visibility
- ❖ 8. Nox: Asthma, common colds, Bronchitis
- ❖ 9. VOC: Mutations, Cancer, Reproductive problems

❖ Carbon monoxide

- produced when organic materials such as natural gas, coal or wood are incompletely burnt.
- Vehicular exhausts are the single largest source of carbon monoxide.

❖ Sulfur oxides are produced when sulfur containing fossil fuels are burnt.

❖ Nitrogen oxides are found in vehicular exhausts.

- Nitrogen oxides are significant, as they are involved in the production of secondary air pollutants such as ozone.
- Causes **smog** and Contributes to **Green House Effect**

❖ VOCs either evaporate from fuel supplies or are remnants of fuel that did not burn completely.

- ❖ **SPMs** – Suspended Particulate Matter: small pieces of solid material (e.g. smoke particles from fires, bits of asbestos, dust particles and ash from industries) dispersed into the atmosphere.
 - The effects of particulates range from soot to the carcinogenic (cancer causing) effects of asbestos, dust particles and ash from industrial plants that are dispersed into the atmosphere.
- ❖ **Lead** - a major air pollutant that is emitted by vehicles, usually reported in the ambient air of metropolitan cities.

❖ **Secondary pollutants:**

- Produced in the atmosphere when certain chemical reactions take place among the primary pollutants.
- E.g. Sulfuric acid, nitric acid, carbonic acid, etc.

Effects of air pollution on living organisms

- ❖ Prolonged smoking or exposure to air pollutants can cause diseases such as lung cancer, asthma, and chronic bronchitis etc.
- ❖ Cigarette smoking is responsible for the greatest exposure to CO.
- ❖ Exposure to air containing even 0.001% of CO for several hours can cause collapse, coma and even death.
- ❖ SO₂ irritates respiratory tissues. Chronic exposure causes a condition similar to bronchitis.
- ❖ NO_x especially NO₂ can irritate the lungs, aggravate asthma or chronic bronchitis and also increase susceptibility to respiratory infections such as influenza or common colds.
- ❖ Inhaling ozone, a component of photochemical smog causes coughing, chest pain, breathlessness and irritation of the eye, nose and the throat.

❖ **Effects on plants**

- When some gaseous pollutants enter leaf pores, they damage the leaves of crop plants.
- Chronic exposure of the leaves to air pollutants can break down the waxy coating that helps prevent excessive water loss and leads to damage from diseases, pests, drought and frost.

❖ **Effects on materials**

- Air pollutants break down exterior paint on cars and houses.
- Air pollutants have discolored irreplaceable monuments, historic buildings, marble statues, etc.

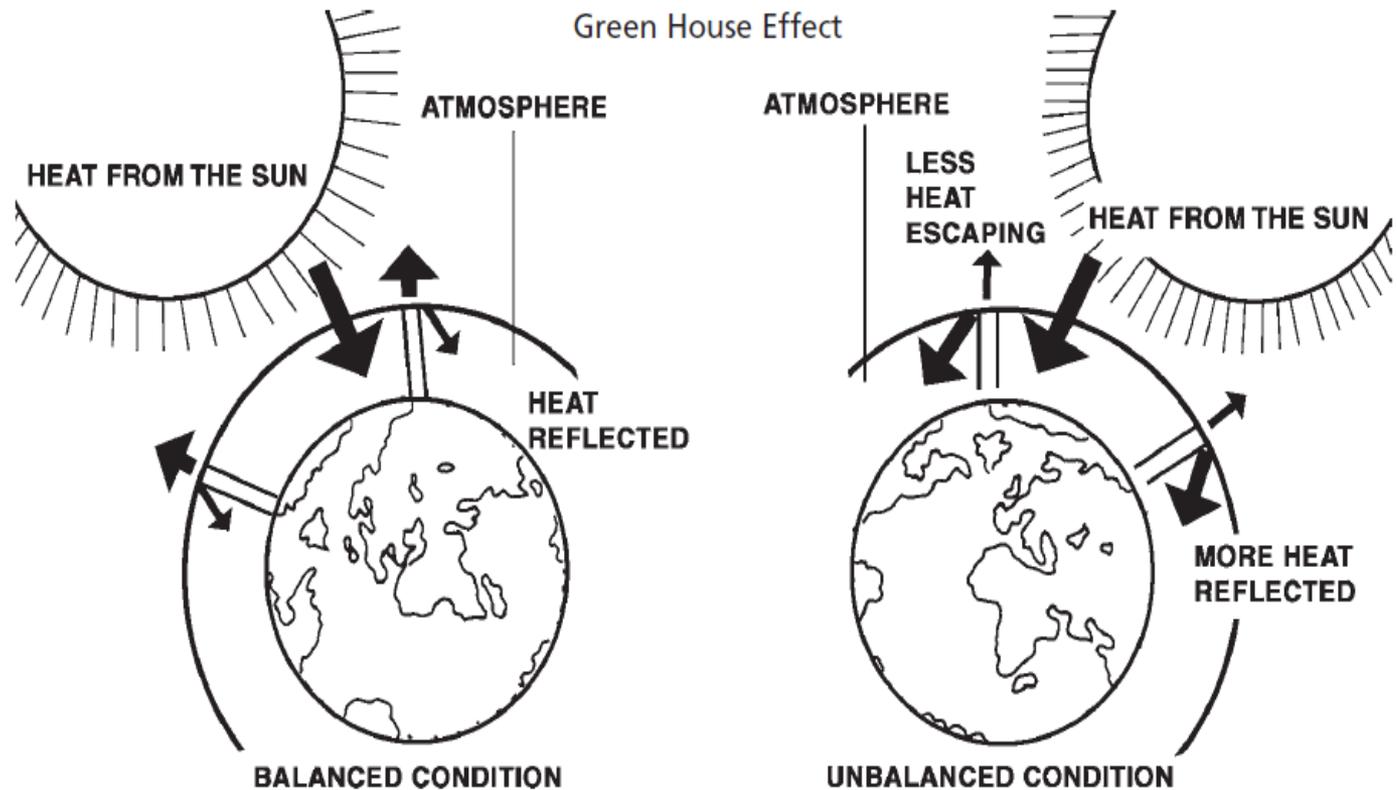
Effects of air pollution on the stratosphere

- ❖ The upper stratosphere consists of considerable amount of ozone, which works as an effective screen for ultraviolet light.
- ❖ Though the ozone is present up to 60 km, its greatest density remains in the region between 20 to 25 km.
- ❖ The ozone layer not only contains O_3 but a mixture of other common atmospheric gases.
- ❖ In the most dense O_3 layer, there will be only one O_3 molecule in 100,000 gas molecules.
- ❖ Even small changes in the O_3 concentration can produce dramatic effects on life on earth.
- ❖ In the absence of pollutants, the creation and breakdown of O_3 are purely governed by natural forces, but the presence of certain pollutants can accelerate the breakdown of O_3 .

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- ❖ **Effects on human health:** Sunburn, cataract, aging of the skin and skin cancer are caused by increased UV radiation.
 - ❖ **Food production:** UV radiation affects the ability of plants to capture light energy during the process of photosynthesis. This reduces the nutrient content and the growth of plants.
 - ❖ **Effect on materials:** Increased UV radiation damages paints and fabrics, causing them to fade faster.

Effect on climate:

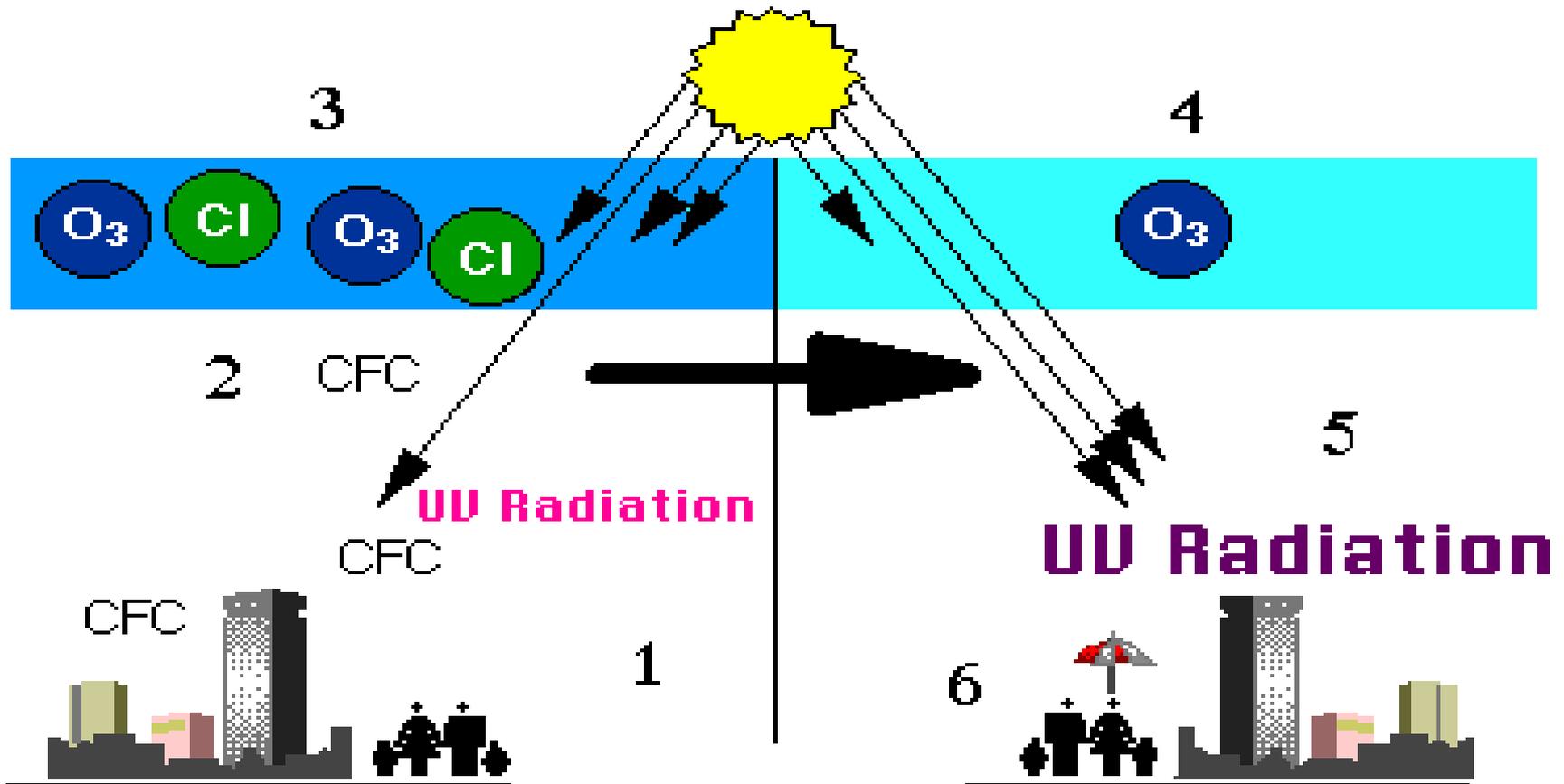
Atmospheric changes induced by pollution contribute to global warming, a phenomenon which is caused due to the increase in concentration of certain gases like CO₂, NO_x, CH₄, H₂O and CFCs.



The relative contribution by Green House gases

❖ CO ₂	:50%
❖ CH ₄	19%
❖ NO _x	4%
❖ CFC's	17%
❖ O ₃	8%
❖ H ₂ O	2%

Ozone depletion - What does it do?



- 1 - CFCs released
- 2 - CFCs rise into ozone layer
- 3 - UV releases Cl from CFCs

- 4 - Cl destroys ozone
- 5 - Depleted ozone -> more UV
- 6 - More UV -> more skin cancer

UPPER ATMOSPHERE

EXOSPHERE

The farthest layer

640 to 64,000 km (400 to 40,000 mi) above Earth's surface
The air dwindles to nothing as molecules drift into space.

THERMOSPHERE

Where the temperature rises

80 to 640 km (50 to 400 mi) above Earth's surface

Even though the air there is thin, it absorbs so much solar radiation that the temperature can reach up to 230° C (440° F). Within the thermosphere are the ionosphere and magnetosphere. The ionosphere contains electrically charged particles that can interfere with radio broadcasts. Charged particles in the magnetosphere are affected by Earth's magnetic field and under the right conditions, create the beautiful, shimmering Northern and Southern Lights.

MIDDLE ATMOSPHERE

MESOSPHERE

Where shooting stars blaze

50 to 80 km (31 to 50 mi) above Earth's surface

Space debris begins to burn up as it enters the mesosphere. The temperature drops as you leave Earth dipping to as low as -90° C (-130° F) at the top of the layer.

STRATOSPHERE

Where the protective ozone layer floats

16 to 50 km (10 to 31 mi) above Earth's surface

The concentration of protective ozone peaks at about 22 km (14 mi) up. The stratosphere contains 20 percent of the molecules in the atmosphere and gets warmer as you go away from Earth.

LOWER ATMOSPHERE

TROPOSPHERE

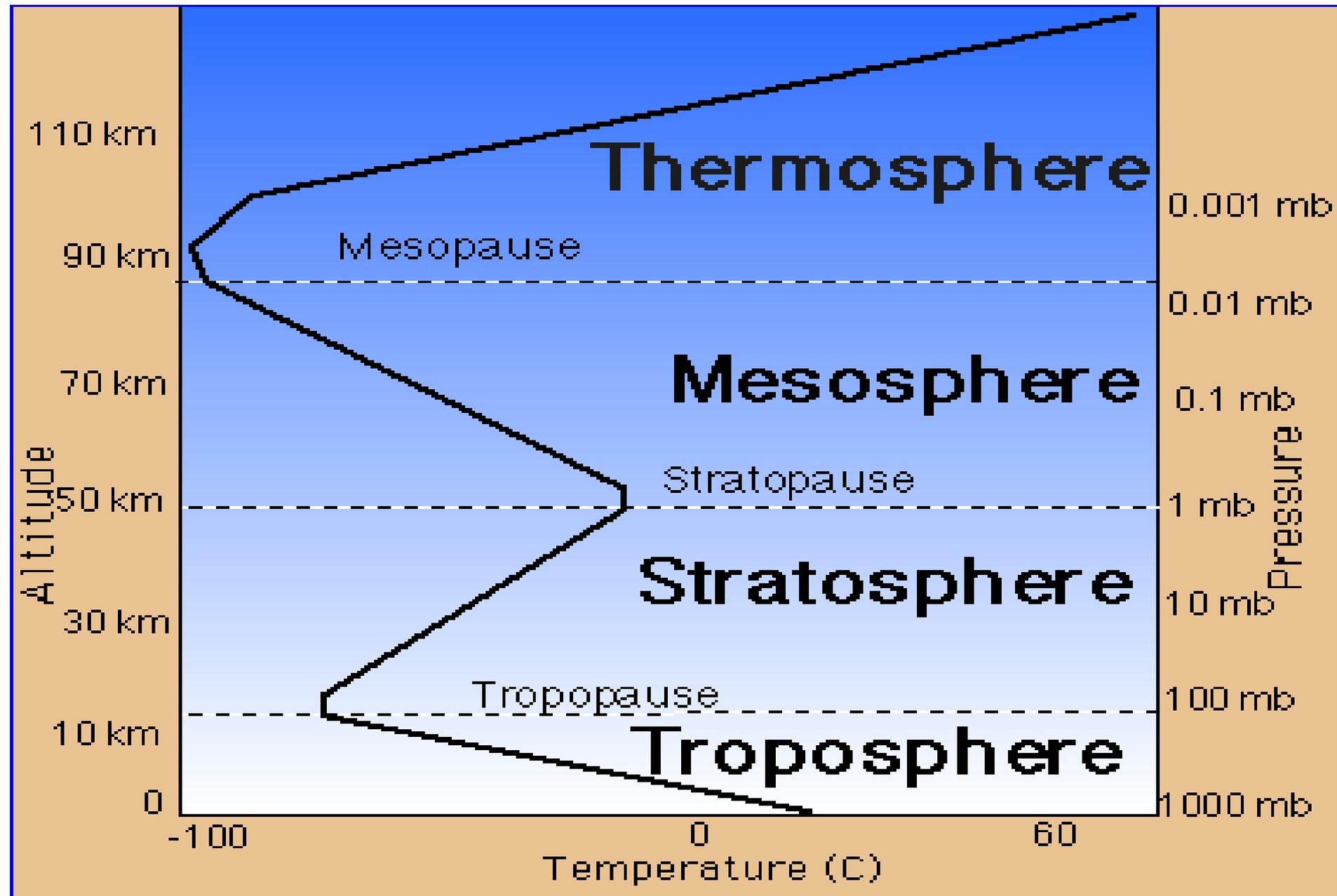
Where weather forms

Up to 16 km (10 mi) above Earth's surface

Storms take place in the troposphere, which contains about 75 percent of the atmosphere. The troposphere extends eight km (five mi) up from Earth's surface at the North and South Poles and 16 km (10 mi up) at the Equator. It gets cold near the top, as low as -75° C (-103° F).

EARTH

Structure of the atmosphere



CONTROL MEASURES

❖ PREVENTIVE TECHNIQUES/CONTROL MEASURES :

➤ 1. Using Suitable Equipment:

- coarse particles removal by Gravity settling chambers, cyclone separators
- Fine particles removal by Bag filters, ESP's

➤ 2. Building Higher Smoke-Stacks

➤ 3. locate Industries away from residential areas and by consideration of wind flow.

➤ 4. substitution of raw materials

➤ 5. Encourage renewable energy utilization

➤ 6. Treat gaseous pollutants by Absorption/Adsorption etc.,

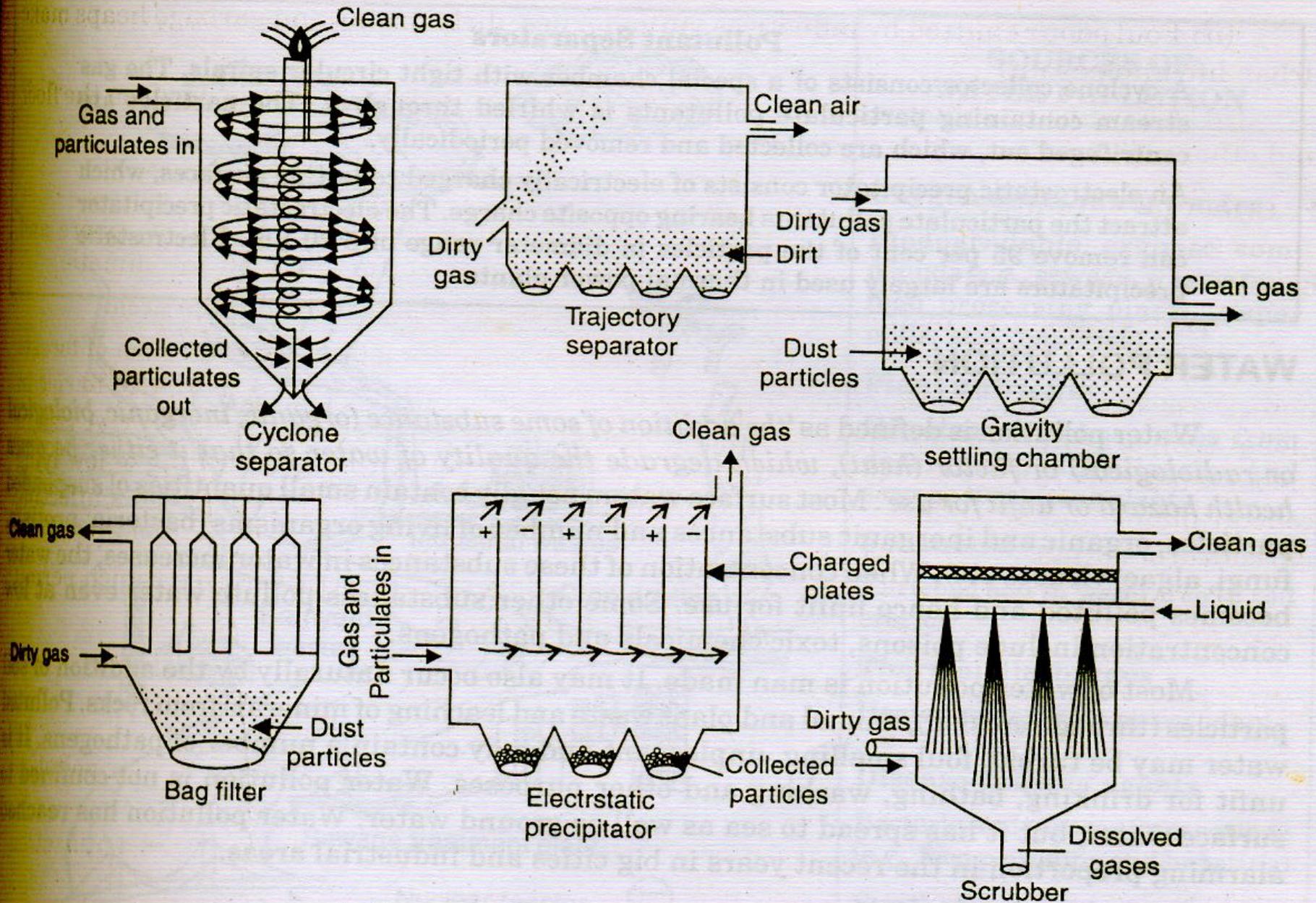


Fig. 5.8. Devices to control air pollution.

(b) Control of Gaseous Pollutants

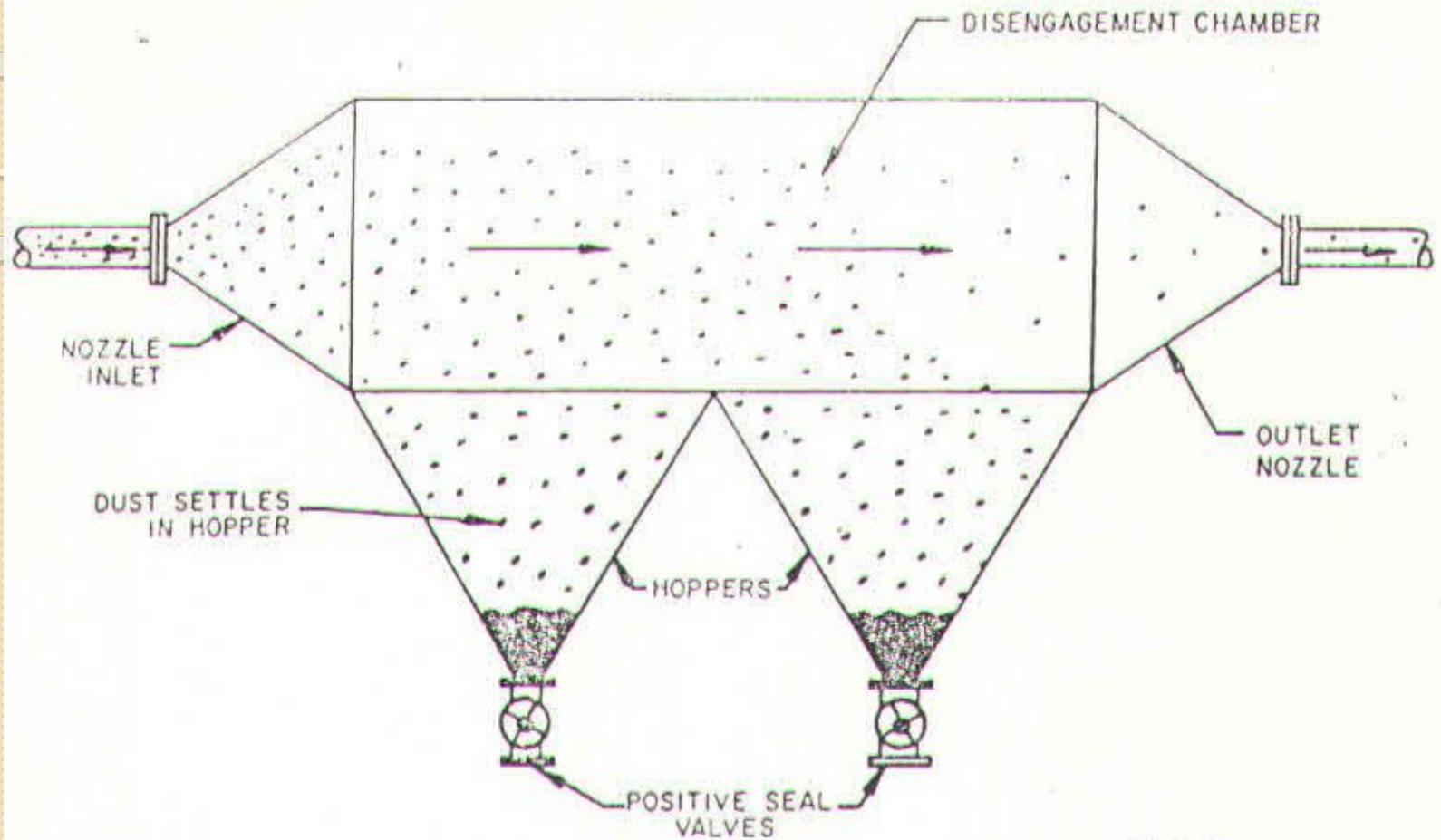
Types of particulates

Term	Meaning	Examples
Aerosol	General term for particles suspended in air	Sprays from pressurized cans
Mist	Aerosol consisting of liquid droplets	Sulfuric acid mist
Dust	Aerosol consisting of solid particles that are blown into the air or are produced from larger particles by grinding them down	Dust storm
Smoke	Aerosol consisting of solid particles or a mixture of solid and liquid particles produced by chemical reaction such as fires	Cigarette smoke, smoke from burning garbage
Fume	Generally means the same as smoke but often applies specifically to aerosols produced by condensation of hot vapors of metals.	Zinc/lead fumes
Plume	Geometrical shape or form of the smoke coming out of a chimney	
Fog	Aerosol consisting of water droplets	
Smog	Term used to describe a mixture of smoke and fog.	

Gravity Settling Chambers

- ❖ Relies on the terminal velocity of a particle to settle out of a gas stream.

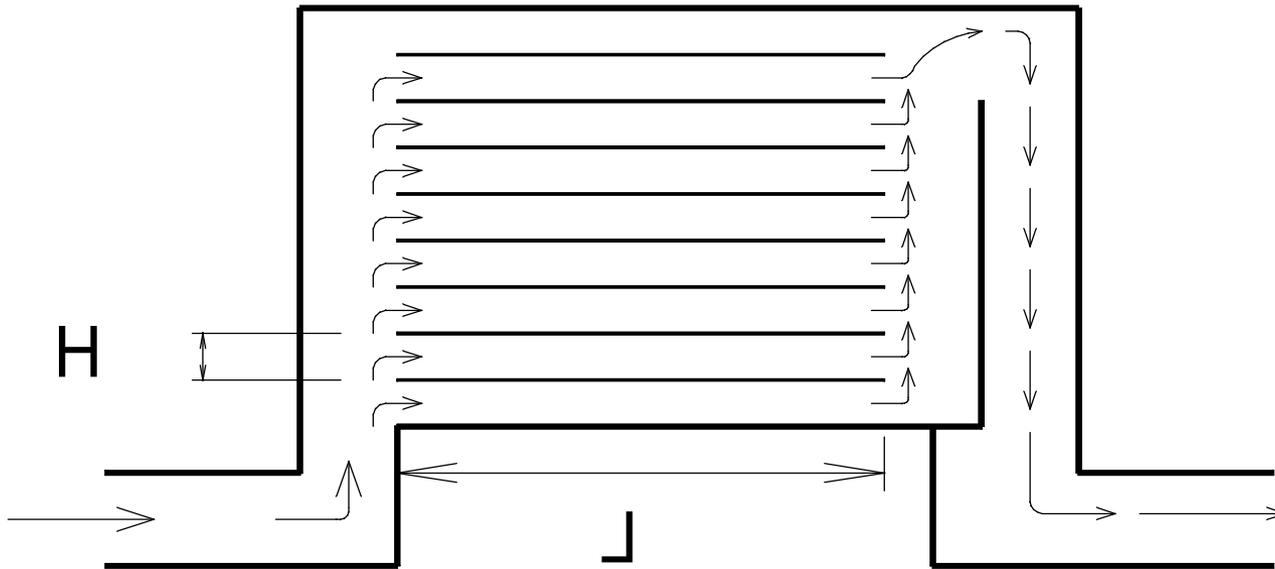
**Drag force (F_D) + Buoyancy force (F_B) = Total weight of the particle
(Gravity force)**



A conventional design

Gravity Settling Chambers

- ❖ Novel designs based on multiple chambers in parallel



HOWARD SETTLING CHAMBER

Cyclones

- The general principle of inertia separation is that the particulate-laden gas is forced to change direction. As gas changes direction, the inertia of the particles causes them to continue in the original direction and be separated from the gas stream.
- The walls of the cyclone narrow toward the bottom of the unit, allowing the particles to be collected in a hopper.
- The cleaner air leaves the cyclone through the top of the chamber, flowing upward in a spiral vortex, formed within a downward moving spiral.
- Cyclones are efficient in removing large particles but are not as efficient with smaller particles. For this reason, they are used with other particulate control devices.

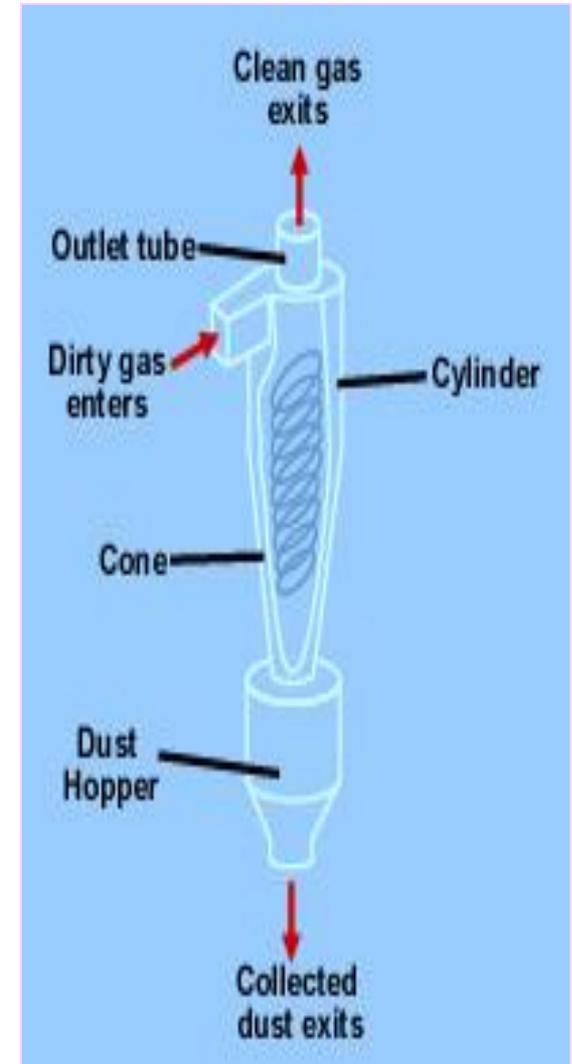
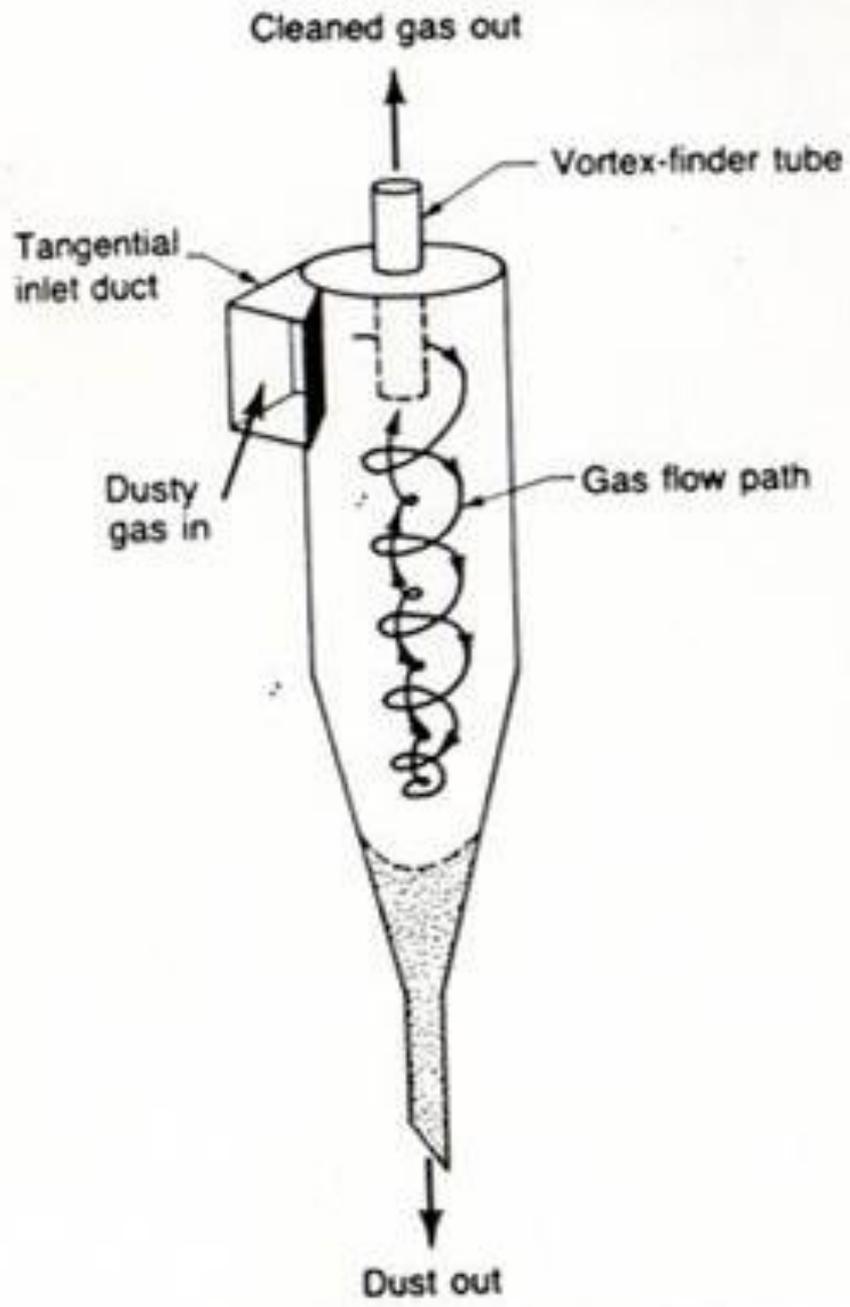
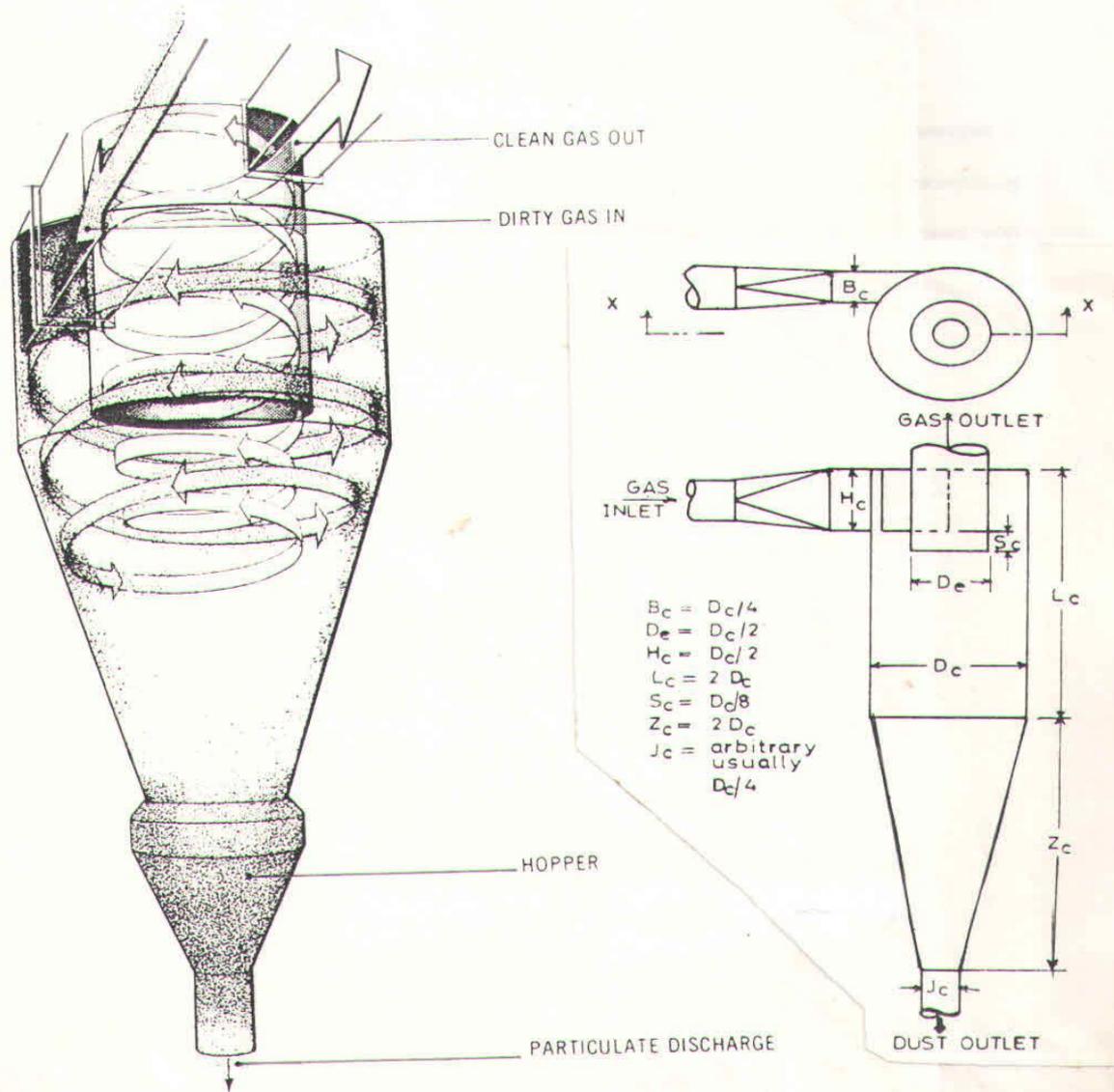


Figure: Cyclone Collector





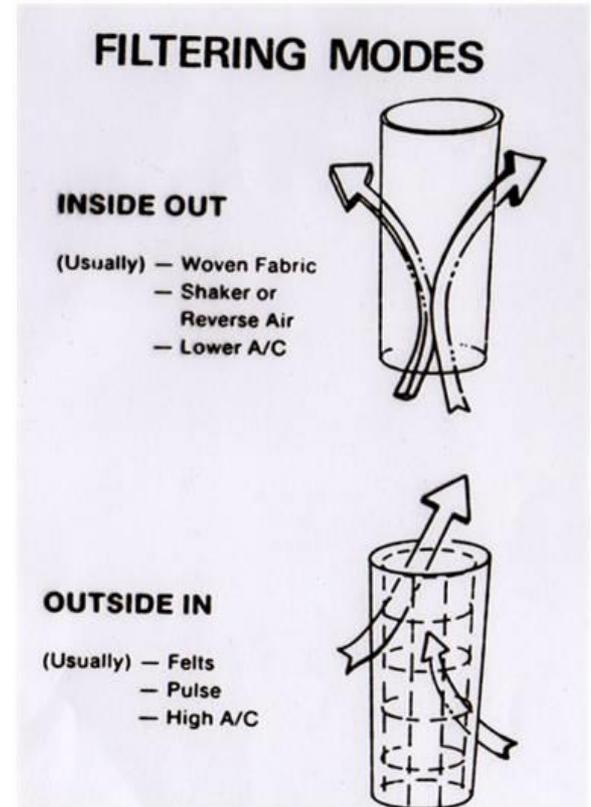
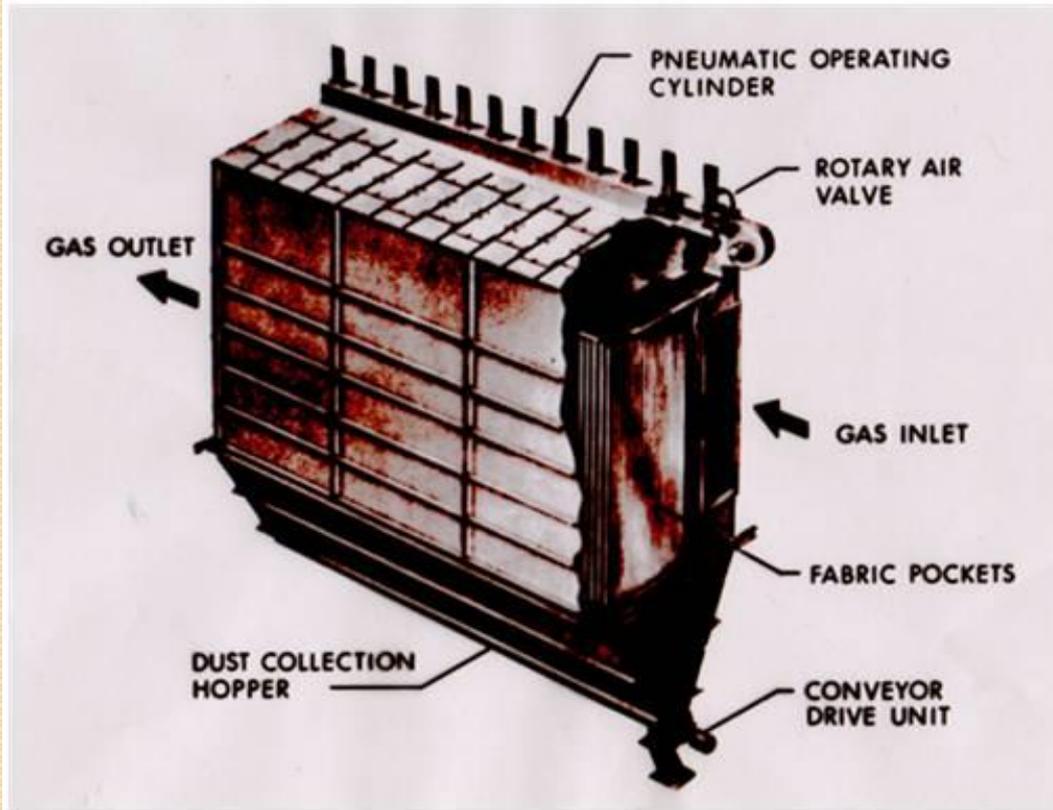
Cyclone [Courtesy the American Lung Association.]



Cyclone Installation at Wood Working Plant

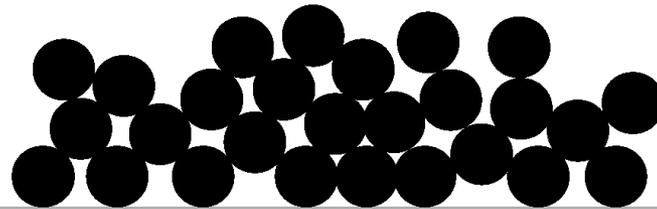
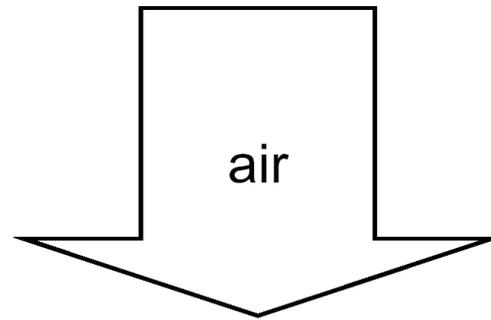
<http://www.fkinc.com/cyclones.htm>

Fabric Filters



Fabric Filter

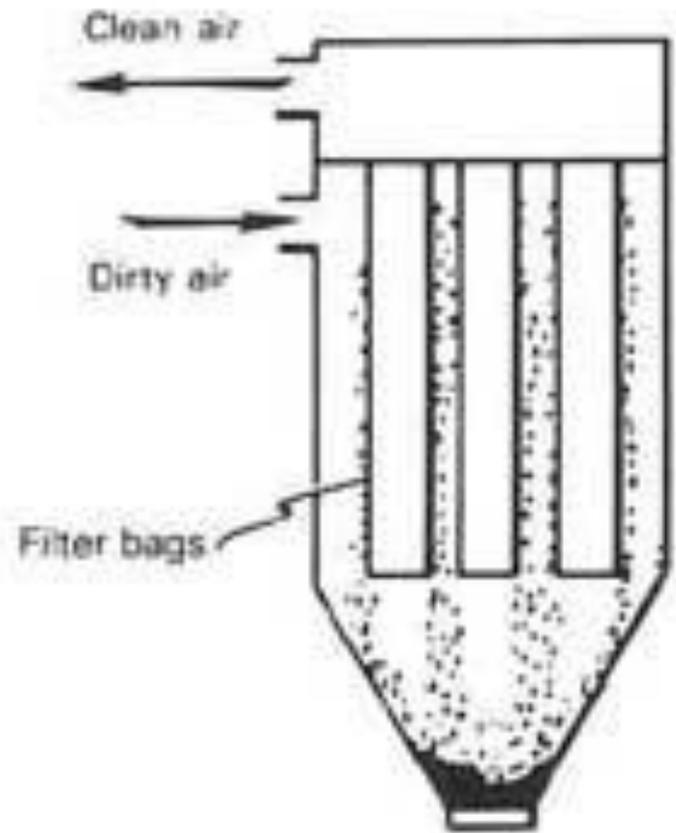
Air Filtration



filter medium

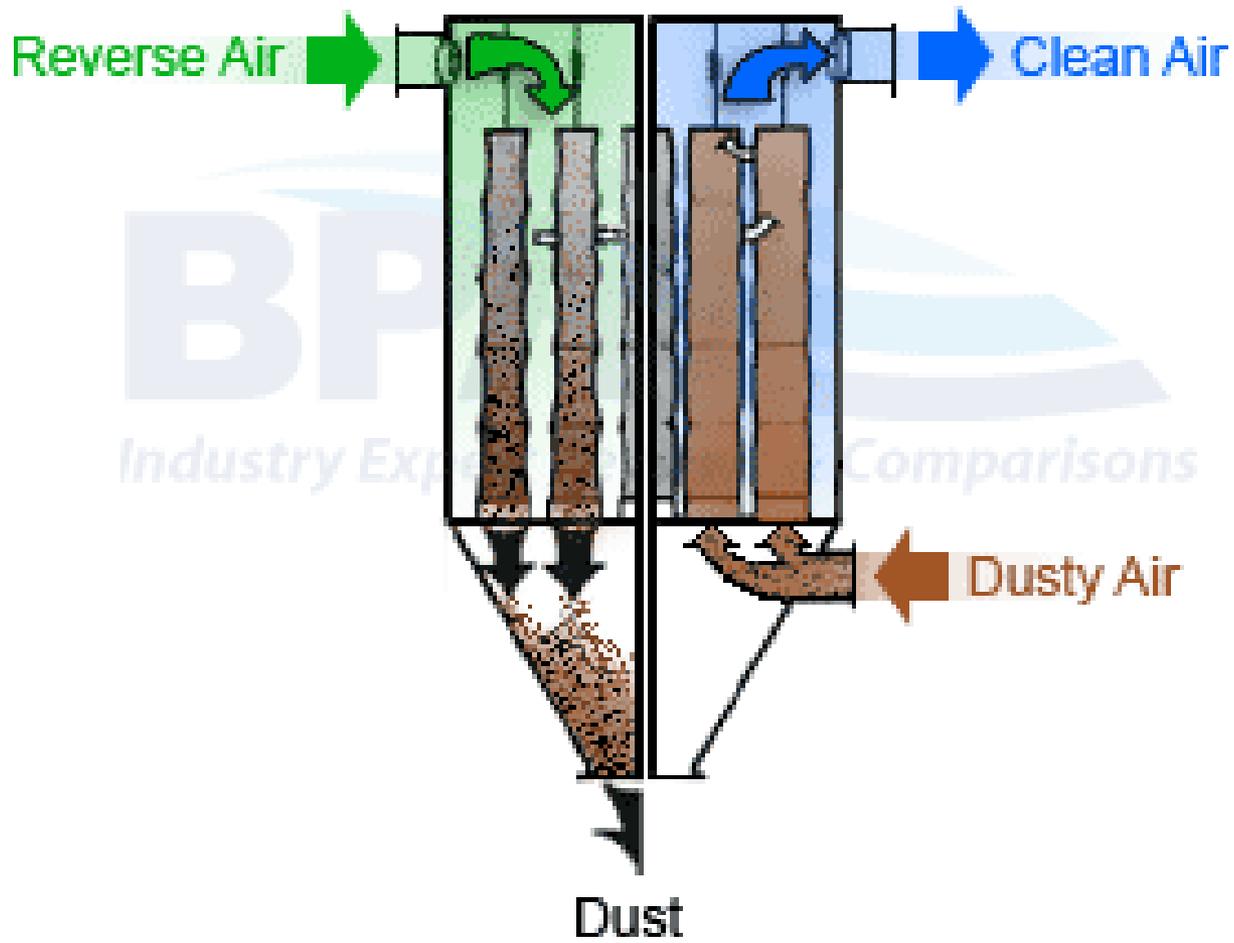
❖ Fabric filters

- ❖ Commonly known as baghouses, fabric collectors use filtration to separate dust particulates from dusty gases. They are one of the most efficient and cost effective types of dust collectors available and can achieve a collection efficiency of more than 99% for **very fine particulates**.
- ❖ Dust-laden gases enter the baghouses and pass through fabric bags that act as **filters**. The bags can be of woven or felted cotton, synthetic, or glass-fiber material in either a tube or envelope shape.
- ❖ The high efficiency of these collectors is due to the dust cake formed on the surfaces of the **bags**. The fabric primarily provides a surface on which dust particulates collect through the following four mechanisms:

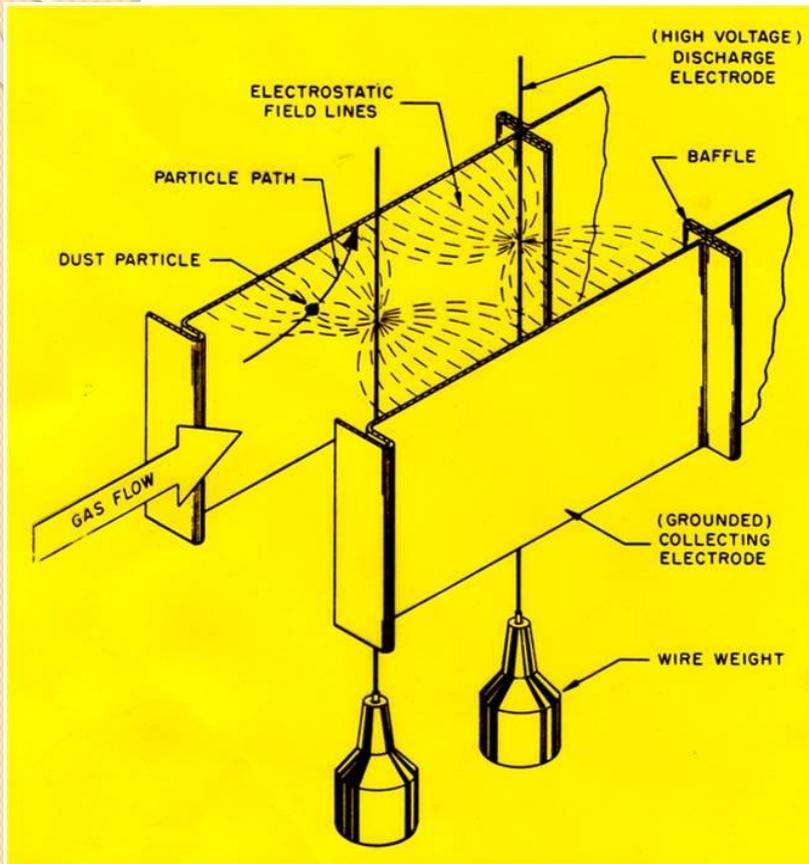


Baghouse

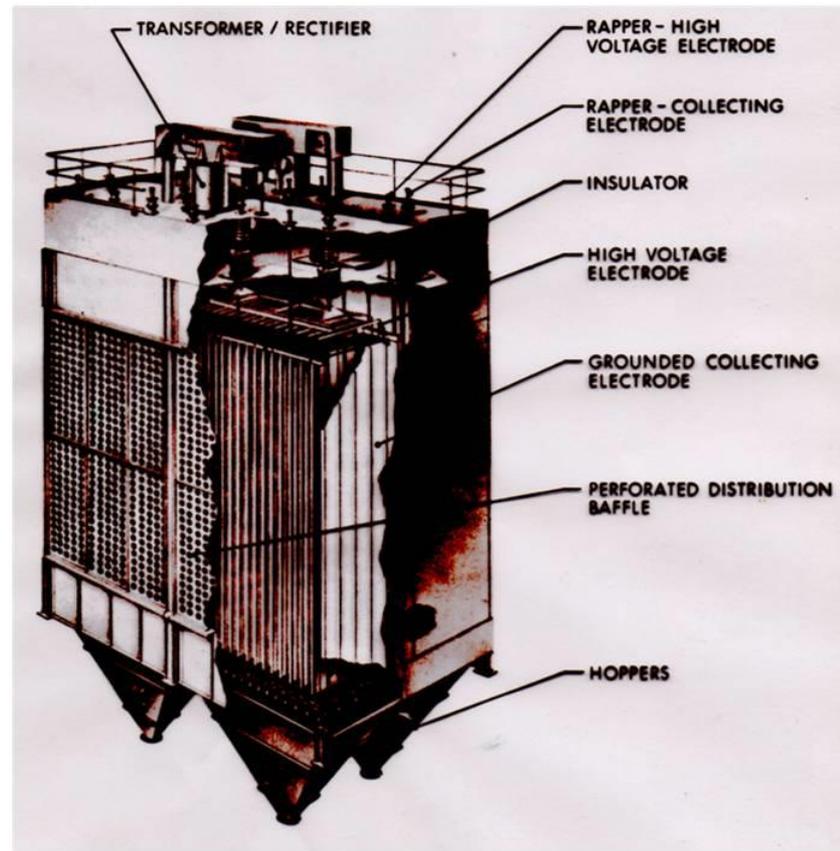




Electrostatic Precipitator



Electrostatic Charging of Dust Particles



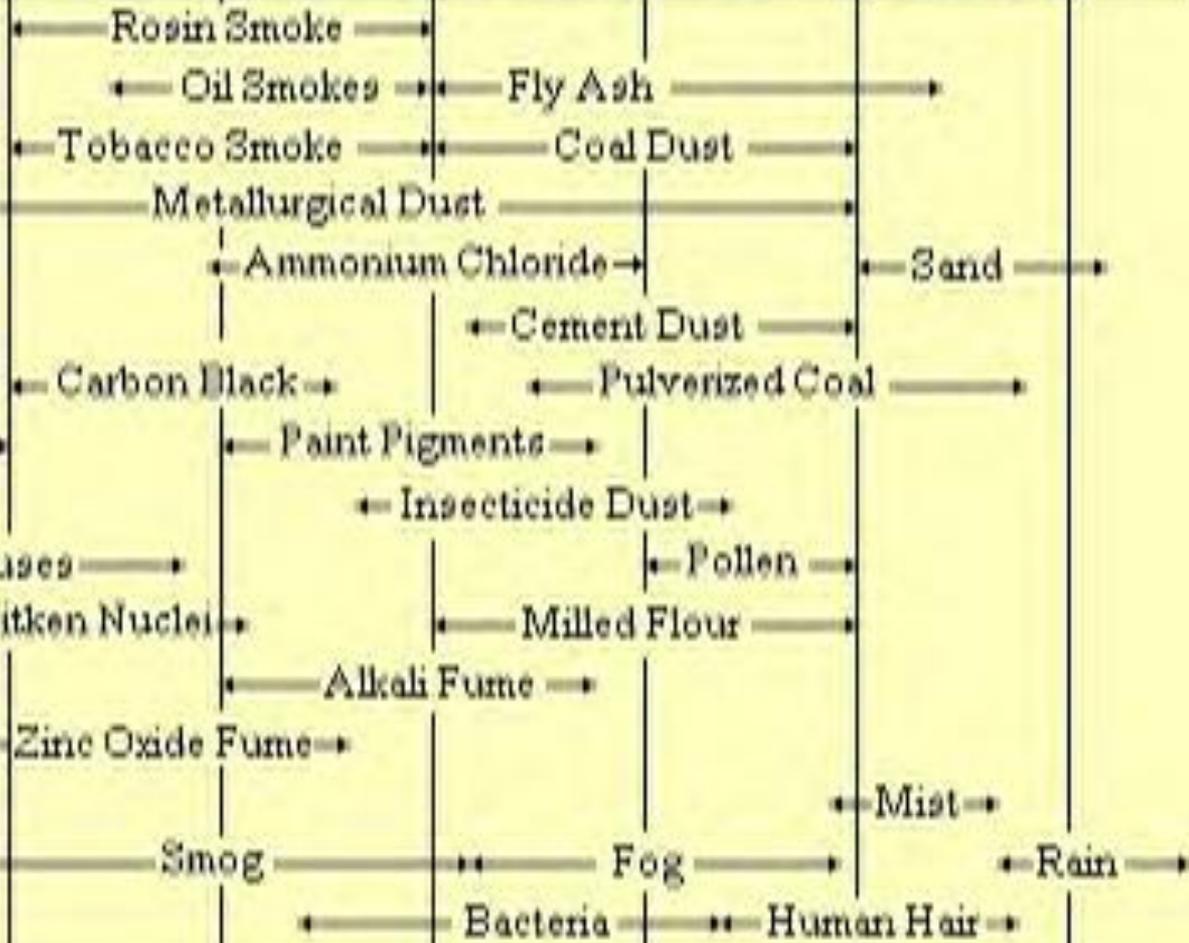
Cutaway of Electrostatic Precipitator

Particle Diameter in Microns

0.0001 0.001 0.01 0.1 1 10 100 1000

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Electrostatic Precipitator Collection Range

What happens to pollutants in the atmosphere?

❖ Once pollutants enter the troposphere

- They are transported downwind
 - Diluted by the large volume of air
 - Transformed through either physical or chemical changes or are removed from the atmosphere by rain.
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- ❖ The atmosphere normally disperses pollutants by mixing them in very large volume of air - dilute the pollutants to acceptable levels.

❖ The rate of dispersion varies in relation to the following aspects:

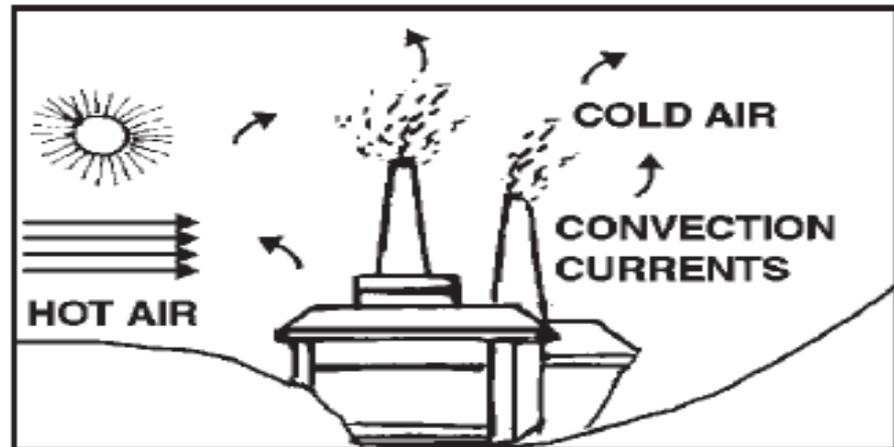
➤ Topography

➤ Meteorological conditions

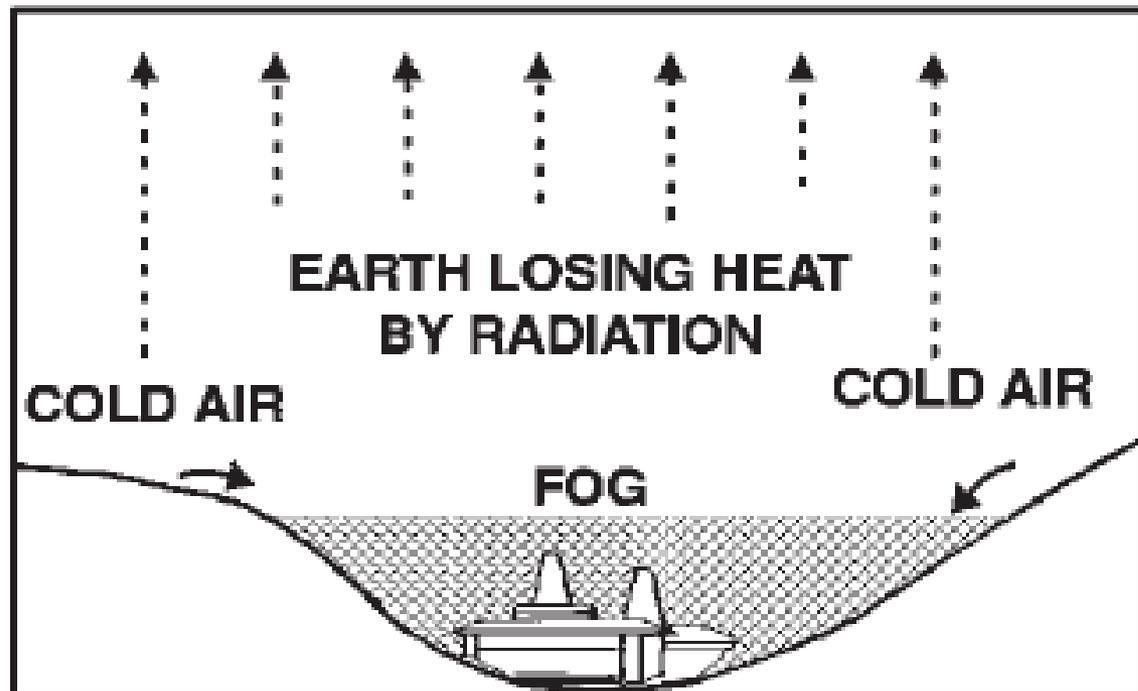
❖ Topography

➤ As the earth's surface becomes warmed by sunlight, the layer of air in contact with the ground is also heated by convection.

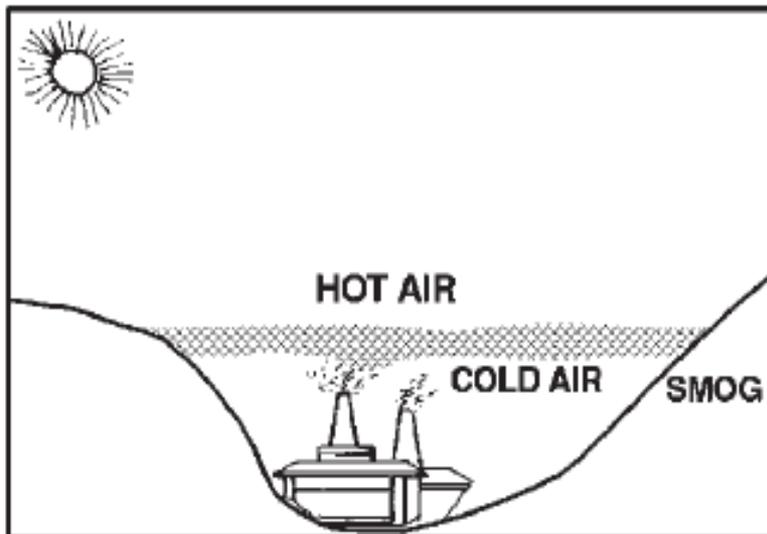
➤ Rise of warmer air, effective dispersion of pollutants produced in the surface layer.



- ❖ In the evening, the ground starts to lose heat and the air near the ground begins to cool rapidly.
- ❖ Due to the absence of wind, a static layer of cold air is produced as the ground cools, which induces condensation of fog.
- ❖ The morning sun cannot initially penetrate this fog layer.
- ❖ The cold air being dense cannot rise and is trapped by the warm air above.
- ❖ It cannot move out of the area due to the **surrounding hills**. The topographic features resemble a closed chemical reactor in which the pollutants are trapped.

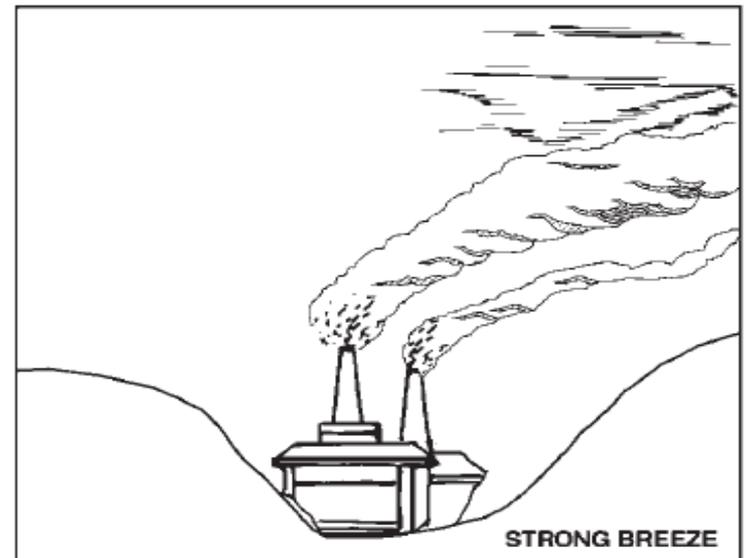
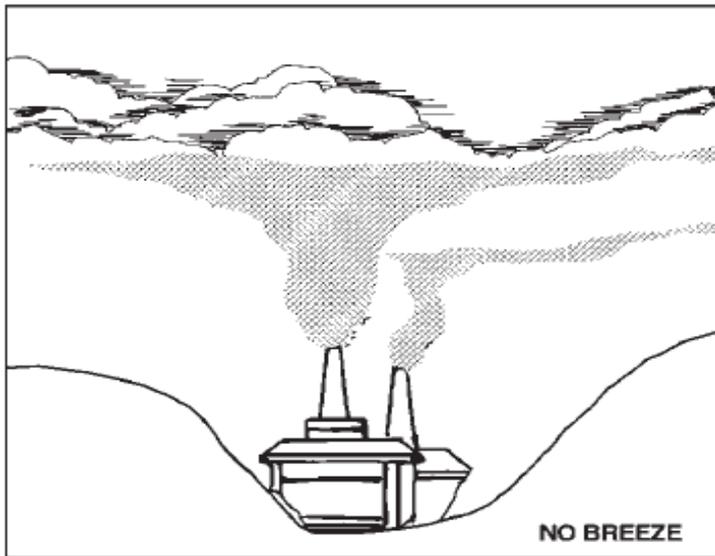


- ❖ This condition often continues through the cool night and reaches its maximum intensity before sunrise.
- ❖ When the morning sun warms the ground, the air near the ground also warms up and rises within an hour or two.
- ❖ This may be broken up by strong winds. In cold regions this situation can persist for several days. Such a situation is known as smog (smoke + fog).
- ❖ Example: 'London Smog', 1952.



Meteorological Conditions

- ❖ The **velocity** of the wind affects the dispersal of pollutants.
- ❖ Strong winds mix polluted air more rapidly with the surrounding air diluting the pollutants rapidly.
- ❖ When SO_x and NO_x are transported by prevailing winds, they form secondary pollutants such as nitric acid vapor, droplets of sulfuric acid and particles of sulphate and nitrate salts.
- ❖ These chemicals descend on the earth's surface in two forms: wet (as acidic rain, snow, fog and cloud vapor) and dry (as acidic particles).
- ❖ The resulting mixture is called acid deposition, commonly called **acid rain**.



Control measures for air pollution

- ❖ Air pollution can be controlled by two fundamental approaches:
 - Preventive techniques
 - Effluent control
- ❖ One of the effective means of controlling air pollution is to have proper equipment in place. This includes:
 - devices for removal of pollutants from the flue gases though **scrubbers**,
 - use of dry and wet collectors,
 - **filters, electrostatic precipitators**, etc.
- ❖ Providing a greater height to the stacks can help in facilitating the discharge of pollutants as far away from the ground as possible.
- ❖ Industries should be located in place so as to minimize the effects of pollution after considering the topography and the wind directions.

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- Putting a greater emphasis on **pollution prevention** rather than control
 - Reducing the use of fossil fuels
 - Improving the quality of vehicular fuel/Maintenance
 - Increasing the use of renewable energy

Air pollution in India

- ❖ World health Organization (WHO) – rates Delhi as the fourth most polluted city in the world.
- ❖ Central Pollution Control Board (CPCB), January 2003 - Ahmedabad's air is most noxious followed by Kanpur, Solapur and Lucknow with small particulate levels (PM10) 3-4 times the standard of $60 \mu\text{g}/\text{m}^3$.
- ❖ Indian cities show high particulate pollution with 14 cities hitting critical levels.

Air quality monitoring

- ❖ India - has no well established system of monitoring air pollution.
- ❖ Late 1960s - planners focused only on a few pollutants SO_x , NO_x and SPM.
- ❖ Other pollutants such as CO and lead(Pb) were monitored only on a limited scale.
- ❖ Strengthened air quality management with continuous monitoring of air is needed to have a better quality of air.
- ❖ Strict air pollution control laws are required. Some of the suggestions include:
 - Putting a greater emphasis on pollution prevention rather than control
 - Reducing the use of fossil fuels
 - Improving the quality of vehicular fuel
 - Increasing the use of renewable energy

Water Pollution

A photograph showing a polluted riverbank. In the foreground, a large pile of trash, including plastic bottles, paper, and other debris, is scattered along the shore. A large, brown, woven basket or container is also visible among the trash. In the background, a concrete dam with several pillars spans across the river. The water is dark and reflects the surrounding environment. The sky is bright, and there are green trees and bushes in the distance.

Water Pollution - Introduction

- 71% of the earth's surface is covered by water but only a small fraction is available as fresh water.
- About 97% of the total water is found in oceans.
- 3% is fresh water, 2.997% is locked in ice caps or glaciers.
- Only 0.003% of the earth' total volume of water is easily available to us as soil moisture, groundwater, water vapor and water in lakes, streams, rivers and wetlands.

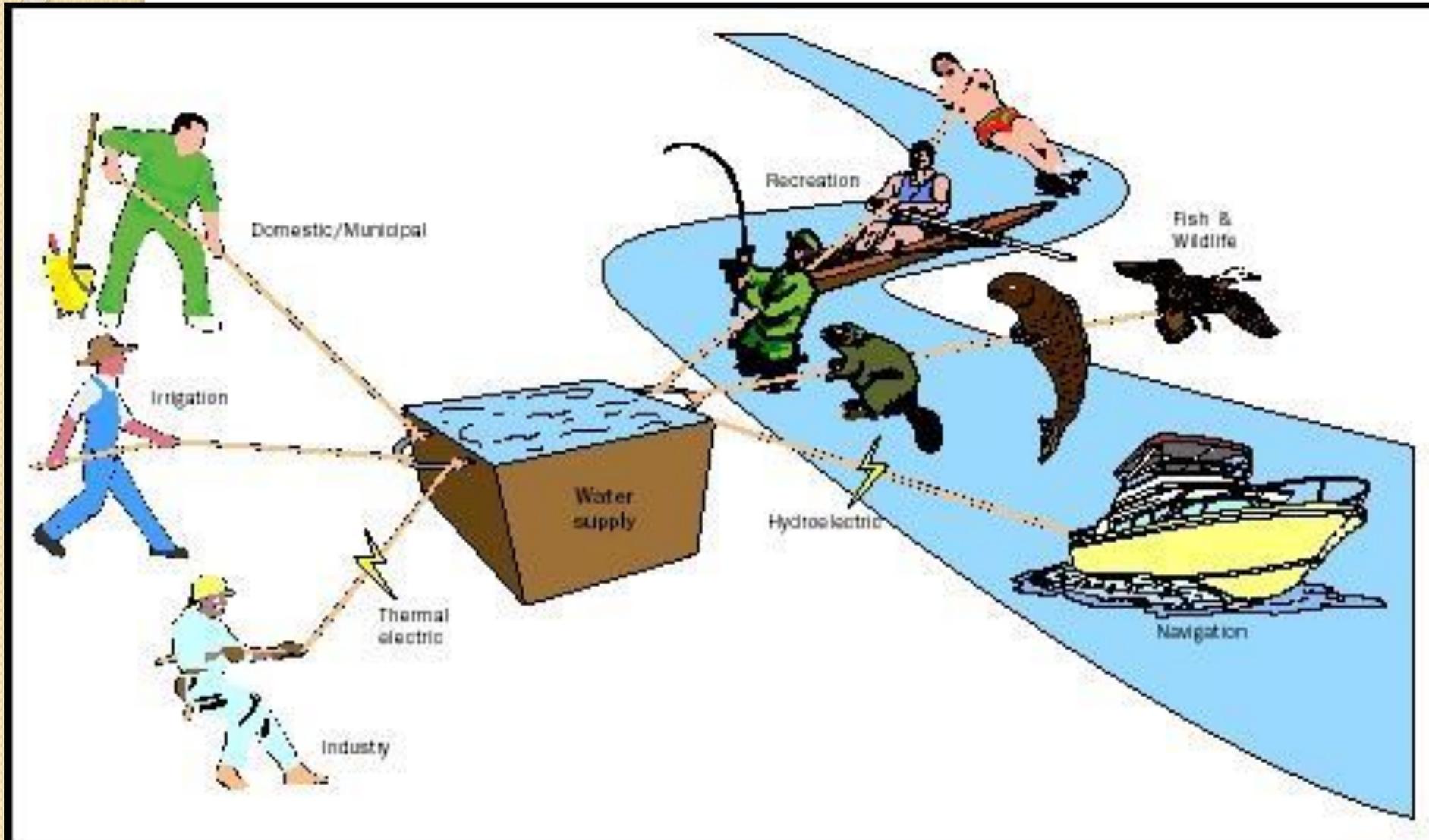
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- ❖ Water is indispensable Renewable Natural resource
 - ❖ Water is the Elixir (supposedly able to prolong life indefinitely)of Life
 - ❖ Our body contains 60%water(approx.)
 - ❖ If water content of our body falls by:
 - 1% we feel thirsty
 - 10% may cause life threat

 - ❖ Water helps in human:
 - ❖ Nutrient uptake
 - ❖ Recovery wastes from different organs
 - ❖ Maintaining body temperature

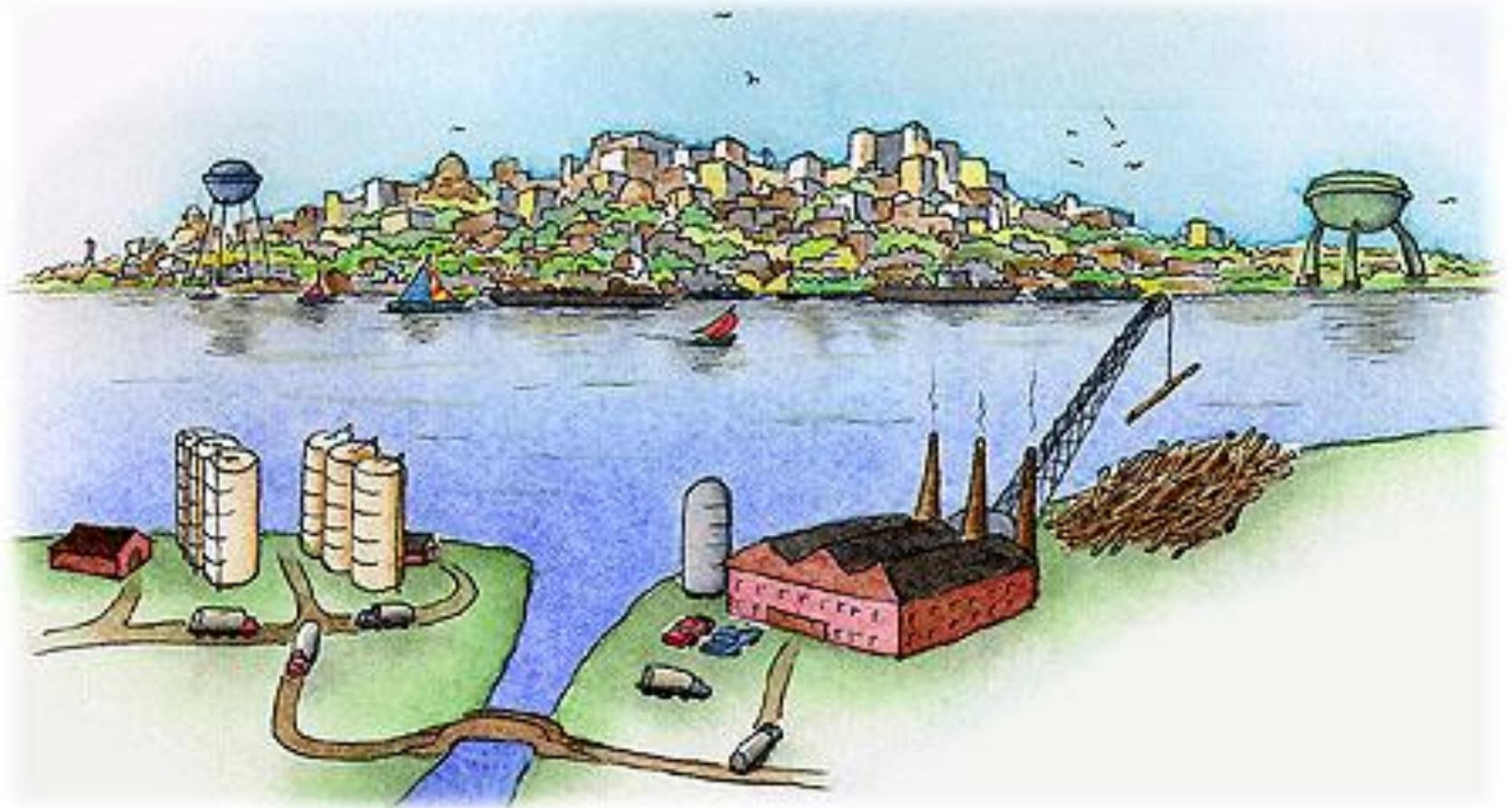
Uses of Water

- Drinking and other domestic uses
- Industrial cooling
- Power generation
- Irrigation
- transportation
- Waste disposal
- Reaction medium, a solvent and many more

Uses



Uses



Water Pollution

- ❖ **Water is said to be polluted when the quality or composition of water changes directly or indirectly as a result of anthropogenic activities such that it becomes unfit for any purpose.**

Sources of water Pollution

❖ **Point sources of pollution:**

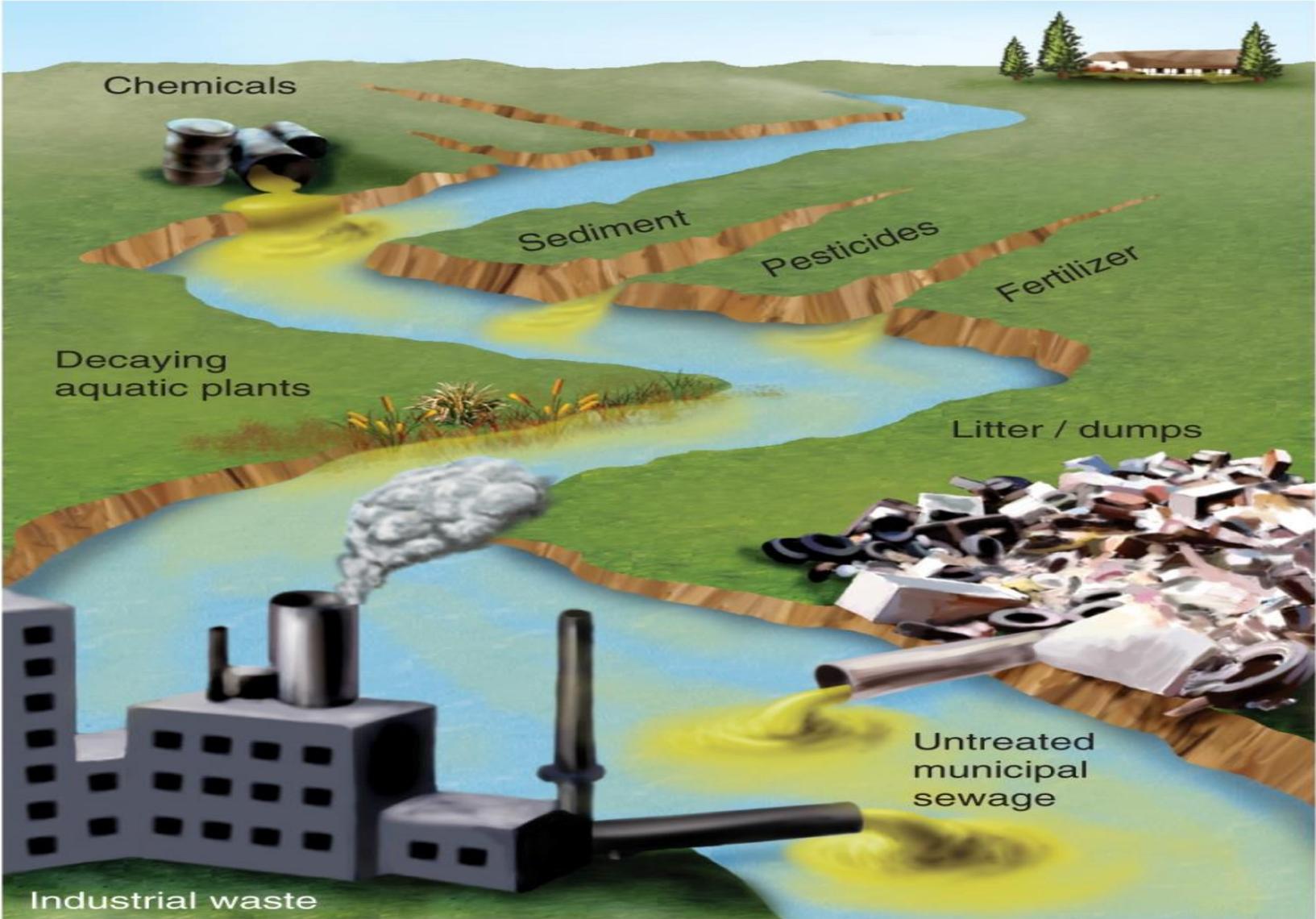
- When a source of pollution can be readily identified with a definite source and place where it enters the water.
- E.g. Municipal and Industrial Discharge Pipes.

❖ **Non-point sources of pollution**

- When a source of pollution cannot be readily identified.
- Agricultural runoff, acid rain, etc

Point sources of water pollution

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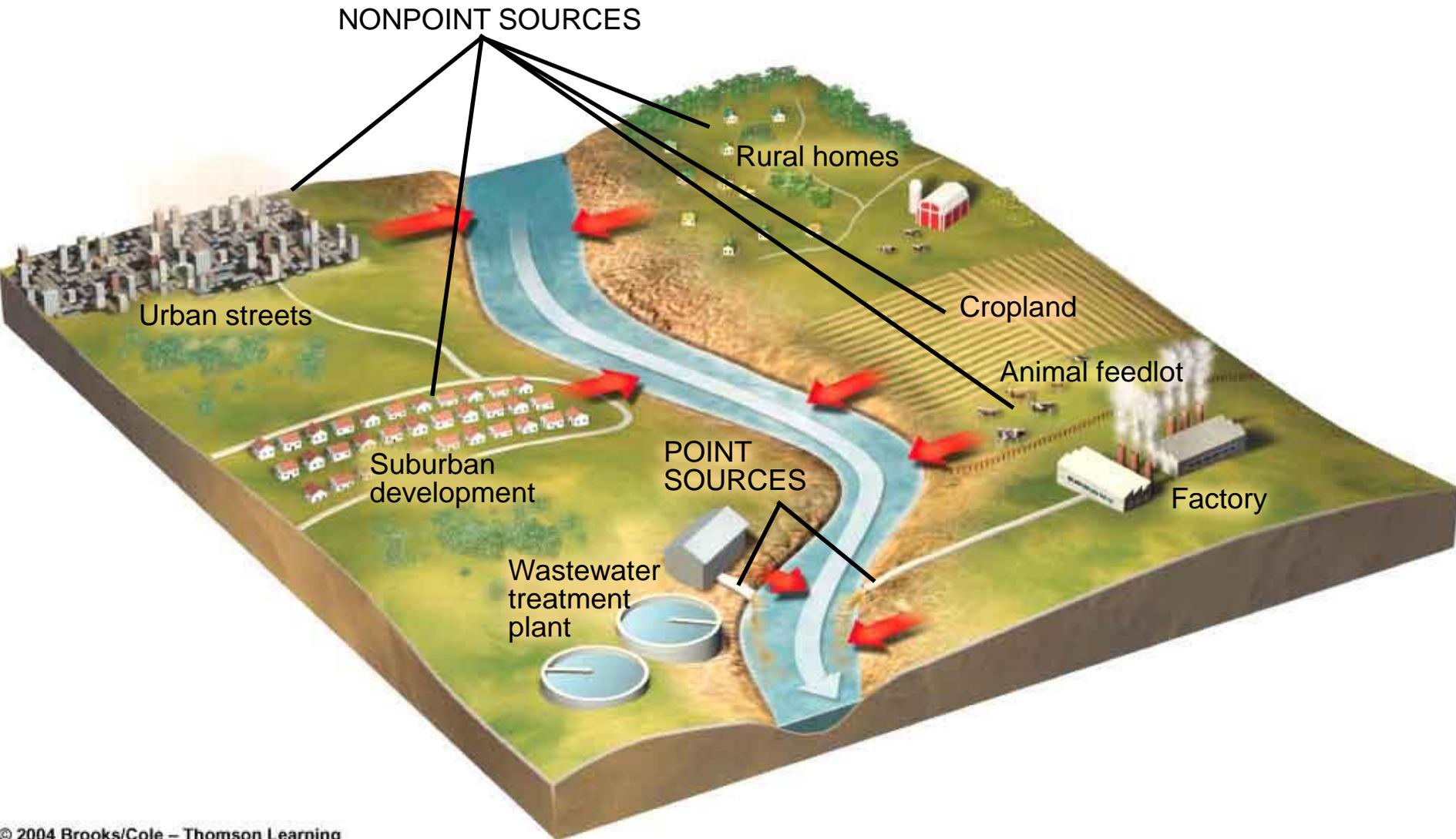
uncontrolled runoff from livestock yard

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Photograph by Tim McCabe, courtesy USDA Natural Resources Conservation Service

Point and Nonpoint Sources



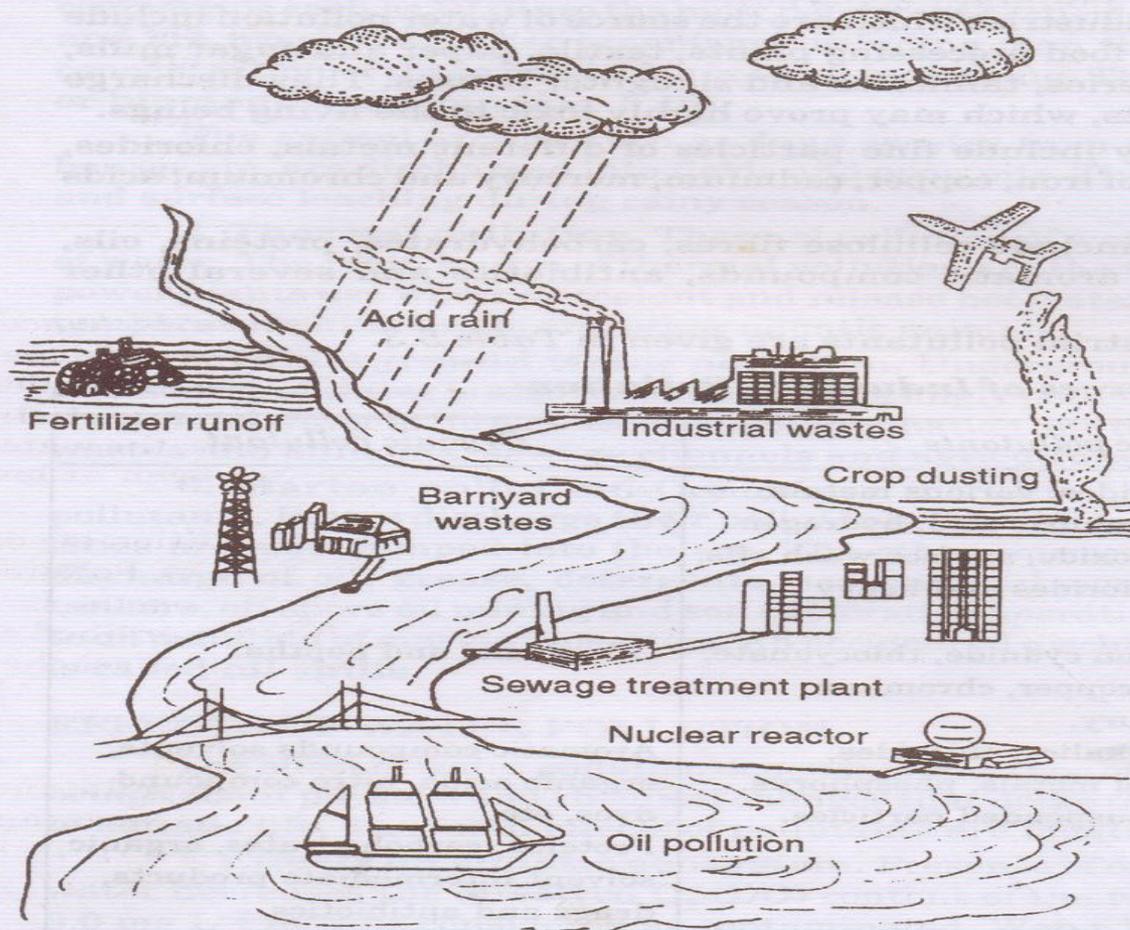


Fig. 5.9. Main sources of water pollution.

SOURCES OF WATER POLLUTION

Oxygen demanding wastes

Biodegradable organic compounds (e.g., sewage, wastes from food processing plants, paper mills, and tanneries)

Plant nutrients

Nitrates and phosphates from detergents, fertilizers, and sewage treatment plants

Sediments

Enriched soil in water due to soil erosion

Thermal discharges

Heated water from power plants

Disease-causing agents

Bacteria and viruses from sewage (e.g., food poisoning and hepatitis)

Synthetic organic compounds

Pesticides, industrial chemical (e.g., PCBs)

Radioactive substances

From nuclear power plants, medical and research facilities, and nuclear weapons testing

Measurement of BOD

BOD is measured by keeping a sample of water, containing known amount of oxygen for 5 days at 20°C in the dark. At the end of this period the oxygen content is again measured. The amount of oxygen utilized during the period indicates BOD of the water sample. A sample of water with weak organic waste has BOD below 1500 gm/litre. A high BOD indicates intense level of microbial pollution.

Since BOD is limited to organic wastes only, therefore, it is not a reliable method of measuring water pollution. Another slightly better mode is **Chemical Oxygen Demand (COD)**. It measures all oxygen consuming pollutant materials present in water.

Classification/Categorization of Water Pollutants

- ❖ **Disease-causing agents (pathogens)**
- ❖ **Oxygen depleting wastes**
- ❖ **inorganic plant nutrients**
- ❖ **water soluble inorganic chemicals**
- ❖ **organic chemicals**
- ❖ **Sediment of suspended matter**
- ❖ **Water soluble radioactive isotopes**
- ❖ **Hot water (Thermal discharge)**
- ❖ **Oil**

Disease-causing agents

- ❖ **Disease-causing agents (pathogens)** include bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and untreated human and animal wastes.

Sources

- ❖ tanning
- ❖ meat packaging
- ❖ food processing
- ❖ sewage

Effects

- ✓ Cholera
- ✓ Typhoid
- ✓ Amoebic dysentery
- ✓ Gastro enteritis
- ✓ Malaria
- ✓ Yellow fever

Oxygen depleting wastes

- ❖ **Oxygen depleting wastes** are organic wastes that can be decomposed by aerobic bacteria.
 - Large populations of bacteria **use up** the oxygen present in water to **degrade** these wastes., following which water quality deteriorates.
 - The amount of oxygen required to break down a certain amount of organic matter is called the biological oxygen demand (BOD).
 - The amount of BOD in the water is an indicator of the level of pollution.

Contin.....

Sources

- Sewage
- Food processing plant
- Pulp & Paper mills
- Tanning operations
- Chemical industries

Effects

- depletes DO level
- produce annoying odours
- affects taste
- colour

Oxygen in Water

- ❖ **Amt of O_2 in water good indicator of water quality**
- ❖ **6ppm supports game (/pastime) fish & other aquatic life.**
- ❖ **2ppm or less supports worms, bacteria, fungi, decomposers.**

How does O_2 get into water?

- ❖ **Dissolves from air**
- ❖ **Turbulence over rocks traps air in bubbles**
- ❖ **Photosynthesis from algae & plants**

How is O_2 removed from water?

- ❖ **Respiration by plants & animals**
- ❖ **Chemical processes**
- ❖ **A lot by bacteria & other decomposers**

Inorganic plant nutrients:

- These are water soluble nitrates and phosphates that cause excessive growth of algae and other aquatic plants.
- The excessive growth of algae and aquatic plants due to added nutrients is called **eutrophication**.
- They may interfere with the use of the water by clogging water intake pipes, changing the taste and odor of water and cause a buildup of organic matter.

Sources:

- ❖ Fertilizer industries
- ❖ Food and Textile industries
- ❖ Agricultural lands



A

Carla Montgomery



A

Photograph by Belinda Rain, courtesy of EPA/National Archives



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Carla Montgomery



A

Photograph by Belinda Rain, courtesy of EPA/National Archives

Eutrophication: a process where water bodies receive excess nutrients that stimulate excessive plant growth

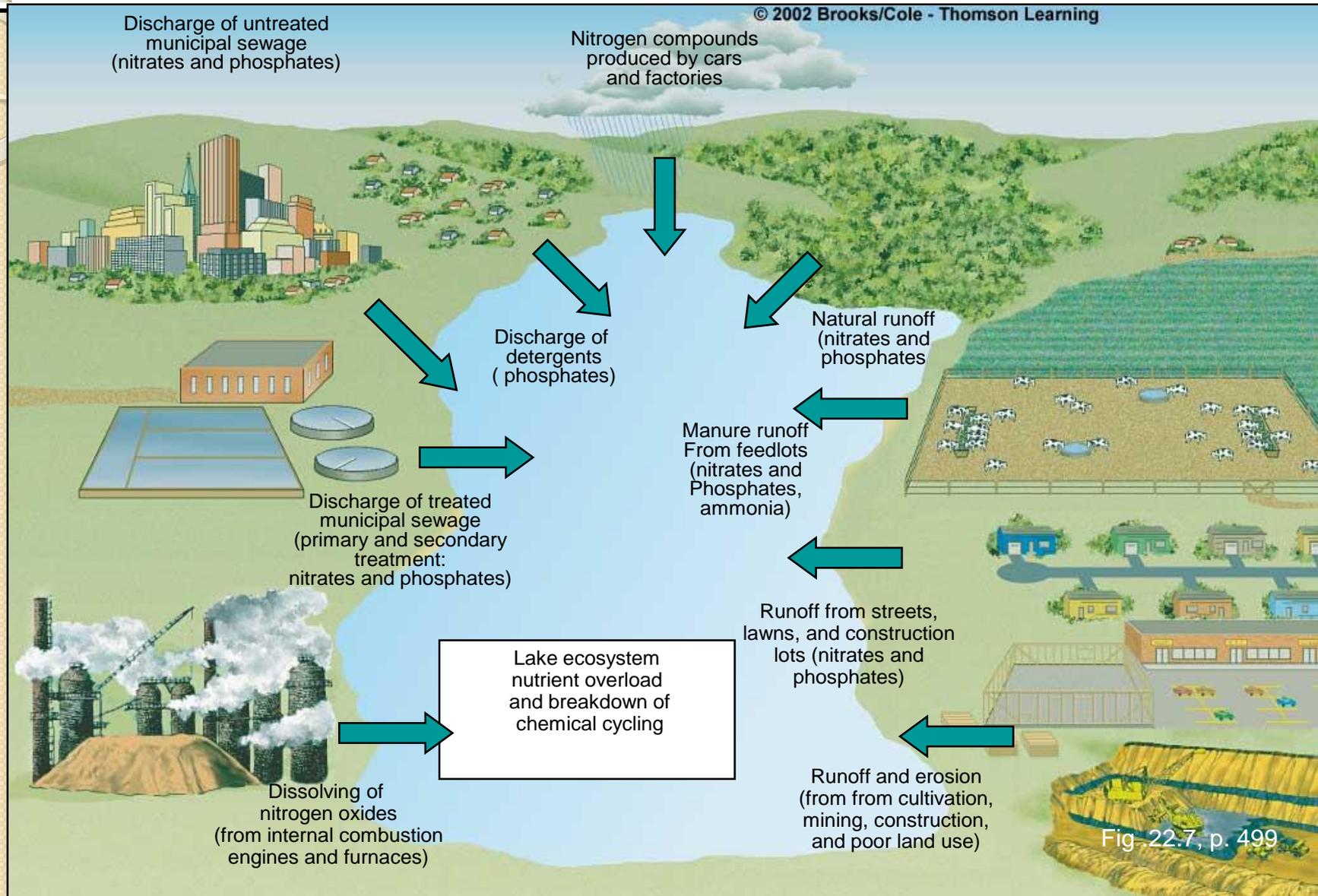


Fig. 22.7, p. 499

❖ **Water soluble inorganic chemicals**

- These are acids, salts and compounds of toxic metals such as **mercury and lead**.
- High levels of these chemicals can make the water unfit to drink, harm fish and other aquatic life, reduce crop yields and accelerate corrosion of equipment that use this water.

It includes

- ❖ Inorganic salts
- ❖ Mineral acids
- ❖ Metal compounds

Sources:

- Municipal sewage
- Industrial waste water
- Mine runoff

Cadmium

Sources

- Pigment works
- electroplating
- Chemical plating

Permissible level for drinking water -0.01 mg/l

Disease- itai-itai disease (causes softening of the bones and kidney failure. The disease is named for the severe pains (Japan) caused in the joints and spine)

Chromium

Sources

- Paint and dye operations
- Metal plating operations
- Aluminum anodizing

Permissible level

hexa valent -0.1 mg/l

trivalent- less than 4ppm

Lead

Sources

- Battery manufacturing
- Printing
- Painting
- Dyeing

Permissible level for drinking water -0.05mg/l

Mercury

Sources

- Paint and paper
- Chlorine and Caustic Soda
- Fertilizer and Pesticides

Permissible level for drinking water -0.002mg/l

Disease- Minamata disease

Silver

Sources

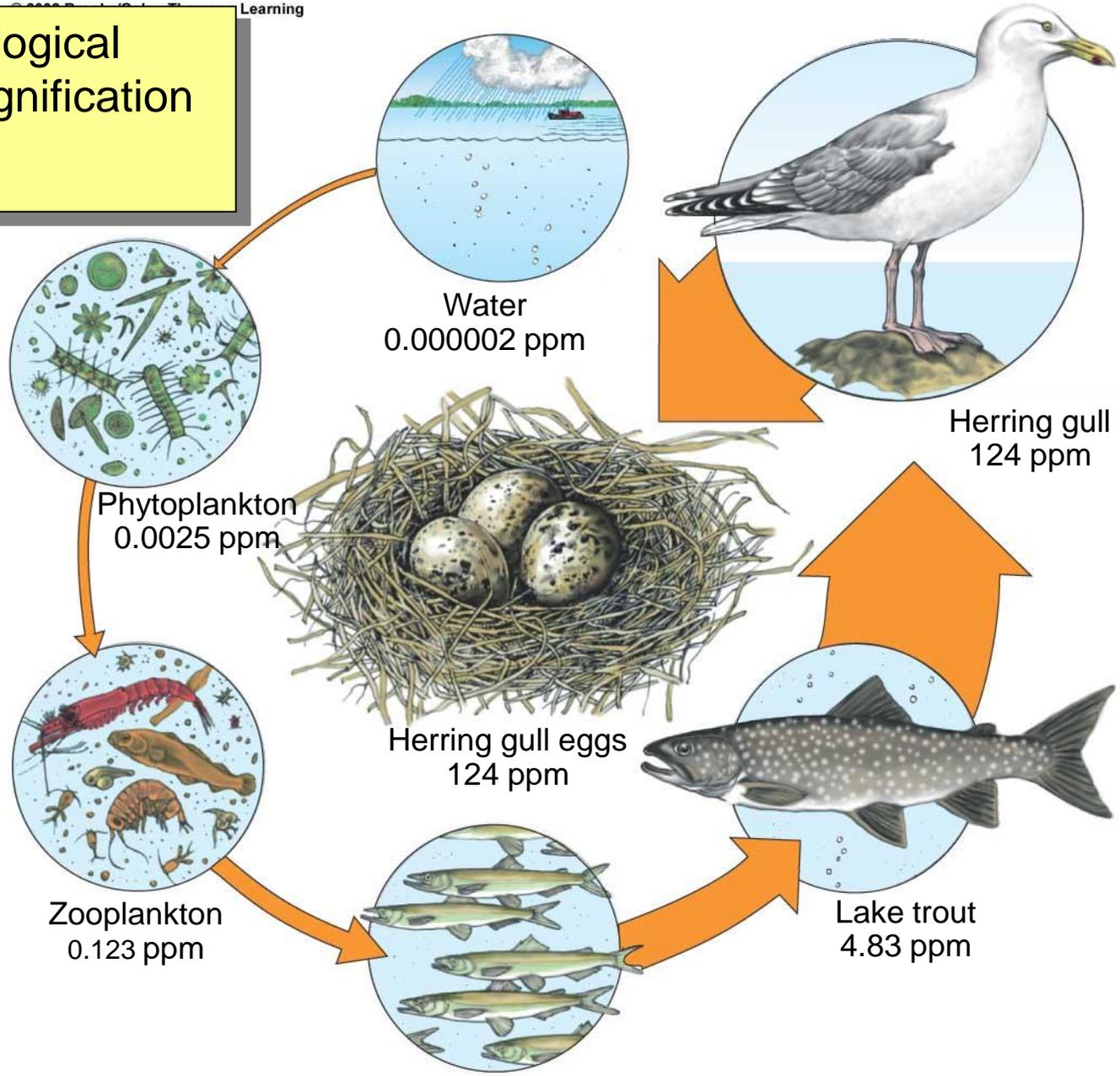
- Electroplating
- Photographic

Permissible level for drinking water -0.05mg/l

Disease- skin cancer

Biological Magnification

Learning



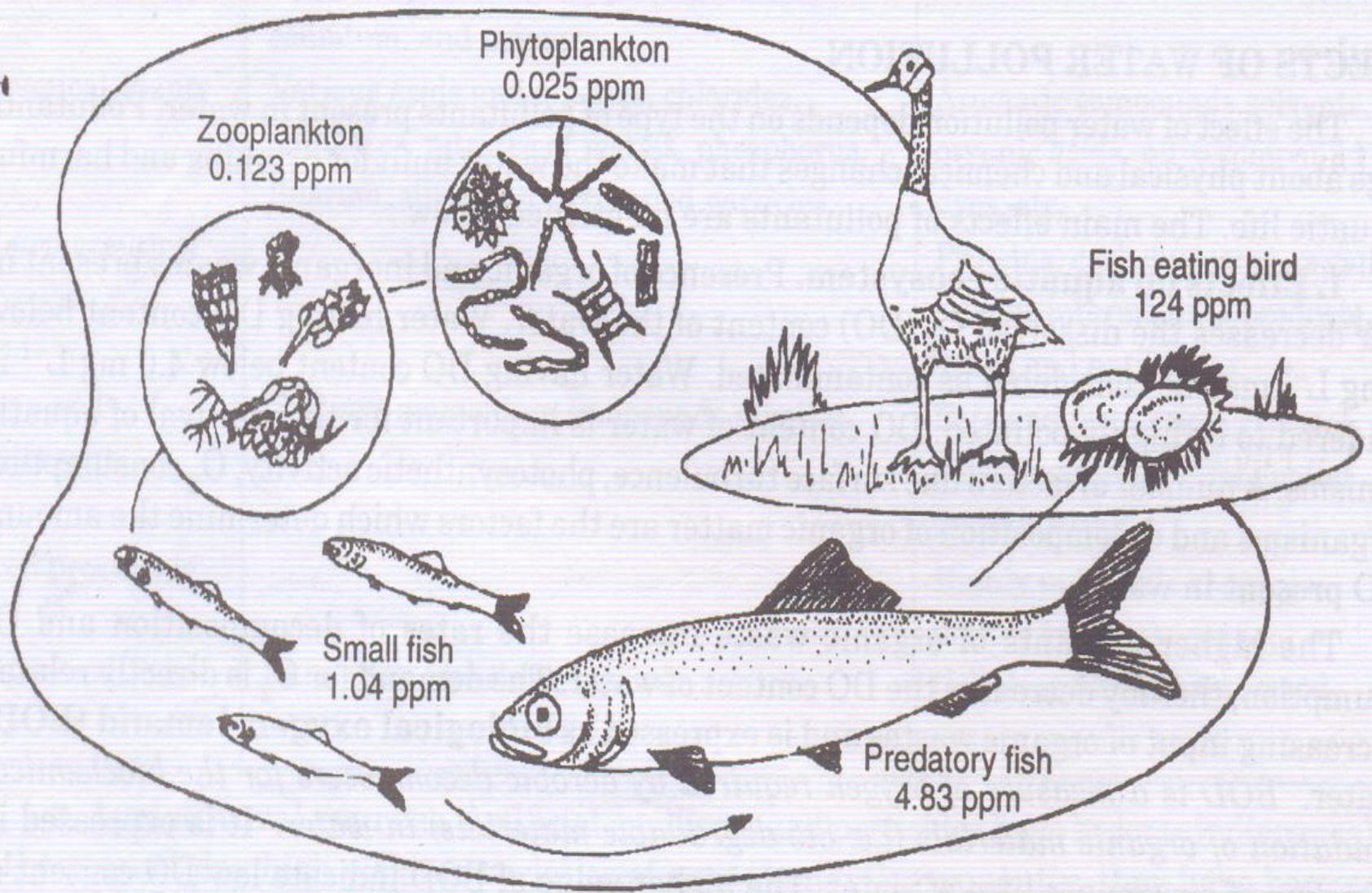


Fig. 5.10. Process of biological magnification ; DDT concentrations increase in organisms along the food chain.

3 Eutrophication

The addition of excess nutrients to a body of water leads to an increase in the growth of algae and other aquatic plants. This process is known as eutrophication.

Organic chemicals

- ❖ **organic chemicals, which include oil, gasoline, plastics, pesticides, cleaning solvents, detergent and many other chemicals.**
- ❖ **These are harmful to aquatic life and human health.**
- ❖ **They get into the water directly from industrial activity either from improper handling of the chemicals in industries and more often from improper and illegal disposal of chemical wastes.**





Sediment of suspended matter

- ❖ These are insoluble particles of soil and other solids that become suspended in water.
- ❖ This occurs when soil is eroded from the land.
- ❖ High levels of soil particles suspended in water, **interferes with the penetration of sunlight.**
- ❖ This **reduces the photosynthetic activity of aquatic plants and algae** disrupting the ecological balance of the aquatic bodies.
- ❖ When the velocity of water in streams and rivers decreases the suspended particles settle down at the bottom as sediments.



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Water soluble radioactive isotopes

Sources

- ❖ Uranium and Thorium mining and refining
- ❖ nuclear power plants
- ❖ industrial use of radioactive materials
- ❖ Hospital waste
- ❖ Nuclear laboratories

Effects

- ❖ These can be concentrated in various tissues and organs as they pass through food chains and food webs.
- ❖ Ionizing radiation emitted by such isotopes can cause birth defects, cancer and genetic damage

Caesium-137



radiocaesium, is a radioactive isotope of caesium which is formed as one of the more common fission products by the nuclear fission of uranium-235 and other fissionable isotopes in nuclear reactors and nuclear weapons.

- ❖ It is among the **most problematic** of the short-to-medium-lifetime fission products because it easily moves and spreads in nature due to the **high water solubility** of **caesium's** most common chemical compounds, which are salts.

Thermal discharges

Sources:

- ❖ Coal fired and Nuclear power plants
- ❖ Industrial effluents
- ❖ Hydro electric power plants

Effects :

- ❖ Reduction in DO
- ❖ Change in water properties
- ❖ Increase in toxicity
- ❖ Interference with biological activities
- ❖ Food shortage for fish
- ❖ Effects water quality

Oil

Sources

- ❖ Industrial effluents
- ❖ oil refineries
- ❖ Storage tanks
- ❖ Automobile waste oil
- ❖ Petrochemical units
- ❖ Accidental oil spills from large transport tankers at sea



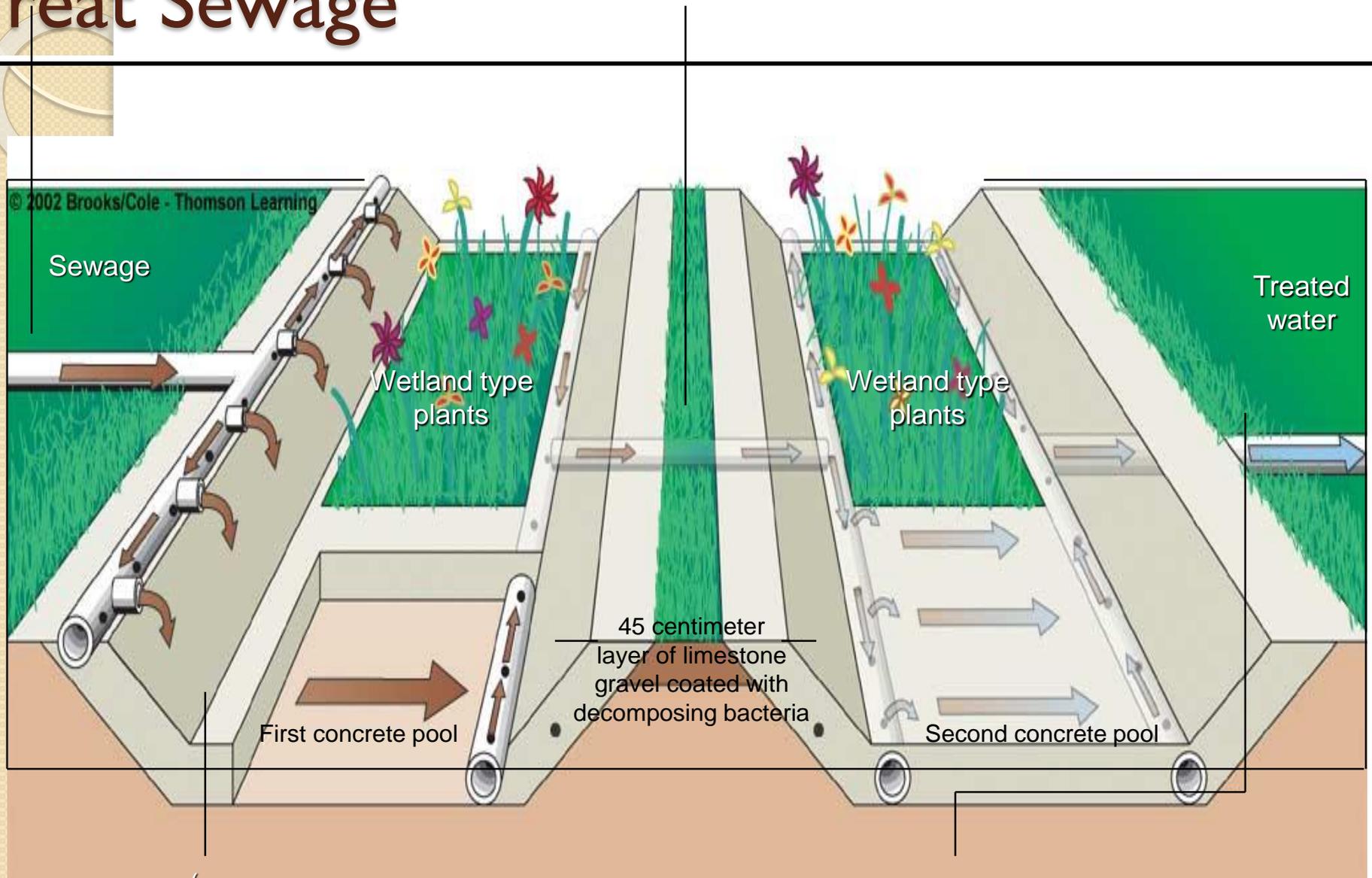
Effects

- ❖ Oil bearing liquid wastes form a thin layer over the surface of the receiving water bodies cutting down sunlight and oxygen necessary for flora and fauna.
- ❖ It is also nuisance aesthetically and impedes the photosynthesis of plants.
- ❖ It leads to the fouling of beaches, sea resorts and boats
- ❖ Affects adversely the performance of water treatment plants and is a fire hazard.

Control measures for preventing water pollution

- ❖ Setting up of effluent treatment plants and treating waste through these can reduce the pollution load in the recipient water.
- ❖ The treated effluent can be reused for either gardening or cooling purposes wherever possible.
- ❖ **Root Zone Process** developed by Thermax:
 - This system involves running contaminated water through the root zones of specially designed reed beds.
 - The reeds, which are essentially wetland plants have the capacity to absorb oxygen from the surrounding air through their stomatal openings.
 - The oxygen is pushed through the porous stem of the reeds into the hollow roots where it enters the root zone and creates conditions suitable for the growth of numerous bacteria and fungi.

Technological Approach: Using Wetlands to Treat Sewage



What Can You Do?

Water Pollution

- Fertilize garden and yard plants with manure or compost instead of commercial inorganic fertilizer.
- Minimize your use of pesticides.
- Do not apply fertilizer or pesticides near a body of water.
- Grow or buy organic foods.
- Do not drink bottled water unless tests show that your tap water is contaminated. Merely refill and reuse plastic bottles with tap water.
- Compost your food wastes.
- Do not use water fresheners in toilets.
- Do not flush unwanted medicines down the toilet.
- Do not pour pesticides, paints, solvents, oil, antifreeze, or other products containing harmful chemicals down the drain or onto the ground.

Soil Pollution



Soil Pollution

- ❖ Soil is a **thin covering over the land**
- ❖ consisting of a **mixture of minerals, organic material, living organisms, air and water** that together support the growth of plant life.
- ❖ We may enhance/improve the soil by helping its processes along, but we can never recreate what we destroy.
- ❖ The soil is a resource for which there is no substitute.
- ❖ Mature soils are arranged in a series of zones called soil horizons/spheres.
- ❖ Each horizon has a distinct texture/quality and composition that varies with different types of soils.

- 
- ❖ The top layer or the surface litter/waste layer called the **O horizon** consists mostly of freshly fallen and partially decomposed leaves, twigs, animal waste, fungi and other organic materials. Normally it is brown or black.
 - ❖ The uppermost layer of the soil called the **A horizon** consists of partially decomposed organic matter (humus) and some inorganic mineral particles.
 - ❖ The **B horizon** often called the subsoil contains less organic material and fewer organisms than the A horizon.
 - ❖ The area below the subsoil is called the **C horizon** and consists of weathered parent material.

Causes of soil degradation

❖ Erosion

- Soil erosion can be defined as the movement of surface litter and topsoil from one place to another.
- While erosion is a natural process often caused by **wind** and **flowing water** it is greatly accelerated by human activities such as farming, construction, overgrazing by livestock, burning of grass cover and deforestation.
- Loss of the topsoil makes a soil less fertile and reduces its water holding capacity.
- **Proper soil conservation measures are essential to minimize the loss of top soil.**
- There are several techniques that can protect soil from erosion.
 - **Area treatment which involves treating the land**
 - **Drainage line treatment which involves treating the natural water courses**



Area Treatment

Purpose	Treatment Measure	Effect
Reduces the impact of rain drops on the soil	Develop vegetative cover on the non arable land	Minimum disturbance and displacement of soil particles
Infiltration of water where it falls	Apply water infiltration measures on the area	In situ soil and moisture conservation
Minimum surface run off	Store surplus rain water by constructing bunds, ponds in the area	Increased soil moisture in the area, facilitate ground water recharge
Ridge to valley sequencing	Treat the upper catchment first and then proceed towards the outlet	Economically viable, less risk of damage and longer life of structures of the lower catchments

Drainage line treatment

Purpose	Treatment measure	Effect
Stop further deepening of gullies and retain sediment run-off	Plug the gullies at formation	Stops erosion, recharges groundwater at the upper level.
Reduce run-off velocity, pass cleaner water to the downstream side	Crates temporary barriers in nalas	Delayed flow and increased groundwater recharge
Minimum sedimentation in the storage basins	Use various methods to treat the catchments	
Low construction cost	Use local material and skills for constructing the structures	Structures are locally maintained

❖ **Excess use of fertilizers & pesticides**

- Approx. 25% of the world's crop yield is estimated to be directly attributed to the use of chemical fertilizers.
- Fertilizers are very valuable as they replace the soil nutrients used up by plants.
- The three primary soil nutrients are potassium, phosphorus and nitrogen.
- In addition to fertilizers a large amount of pesticides are also used to ensure a good yield.
- Pesticides not only kill the pests but also a large variety of living things including humans.

- 
- Persistent pesticides once applied are effective for a long time.
 - Persistent pesticides may also accumulate in the bodies of animals, and over a period of time increase in concentration if the animal is unable to flush them out of its system called **bioaccumulation**.
 - When an affected animal is eaten by another carnivore these pesticides are further concentrated in the body of the carnivore. This phenomenon of acquiring increasing levels of a substance in the bodies of higher trophic level organisms is known as **biomagnification**.

- 
- ❖ **Sustainable agriculture** - the use of methods to produce adequate safe food in an economically viable manner while maintaining the state of the ecosystem.
 - ❖ Organic agriculture - avoiding the use of chemical fertilizers and pesticides.
 - ❖ Techniques used to reduce the negative impact of agriculture:
 - Leaving crop residue on the soil and incorporating it into the soil reduces erosion and increase soil organic matter.
 - Use of integrated pest management.



POLLUTION CASE STUDIES

Groundwater pollution in India

- ❖ An example of groundwater pollution caused by excessive extraction is that fluoride contamination.
- ❖ Fluorosis is not a localized problem.
- ❖ It has spread across 19 states and across a variety of ecological regions ranging from the Thar desert, the Gangetic plains and the Deccan plateau.
- ❖ High fluoride concentration in groundwater is a natural phenomenon in several countries such as China, Sri Lanka, West Indies, Spain, Holland, Italy and Mexico.
- ❖ Fluoride mainly enters the human body through drinking water where 96 to 99 percent of it combines with the bones as it has an affinity for calcium phosphate in the bones.

- 
- ❖ Excess intake of fluoride can lead to dental fluorosis, skeletal fluorosis or non-skeletal fluorosis.
 - ❖ Dental fluorosis is characterized by discoloured, blackened, mottled or chalky white teeth.
 - ❖ Skeletal fluorosis leads to severe and permanent bone and joint deformities.
 - ❖ Non-skeletal fluorosis leads to gastro-intestinal problems and neurological disorders.
 - ❖ Once fluoride is detected in water, the only solution is to defluoridate it.
 - ❖ Various technologies are available for this process. However the type of technology to be selected depends upon the fluoride levels in the water and the volume of water to be defluoridated.

Pesticide pollution in India

- ❖ One of the most terrifying effects of pesticide contamination of ground water came to light when pesticide residues were found in bottled water.
- ❖ Between July and December 2002, the Pollution Monitoring Laboratory of the New Delhi based Center for Science and Environment (CSE) analyzed 17 brands of bottled water both packaged drinking water and packaged natural mineral water.
- ❖ Pesticide residues of organochlorine and organophosphorus pesticides which are most commonly used in India were found in all the samples.

Contd...

- ❖ The low concentration of pesticide residues in bottled water do not cause acute or immediate effect.
- ❖ However repeated exposure even to extremely miniscule amounts can result in chronic effects like cancer, liver and kidney damage, disorders of the nervous system, damage to the immune system and birth defects.
- ❖ Similarly six months after CSE reported pesticide residues in bottled water it also found these pesticides in popular cold drink brands sold across the country.
- ❖ The BIS (Bureau of Indian Standards) certification mark became mandatory for bottled water from March 29, 2001.

River pollution in India

- ❖ Almost all the rivers in India are polluted.
- ❖ This is a case study of the river Damodar as reported in Down to Earth.
- ❖ The 563 km long Damodar river originates near Chandwa village in the Chhotanagpur hills in Bihar's Palamau district.
- ❖ Coal based industries of all types dot the area because of locational advantages and the easy availability of water and power.
- ❖ In addition various industries such as the steel, cement, fertilizer and explosive plants are also located here. The river Damodar is polluted with minerals, mine rejects and toxic effluents.

Contd...

- ❖ There are seven thermal power plants in the Damodar valley.
- ❖ The states of Bihar and West Bengal depend almost entirely on this area for their power requirements.
- ❖ These power plants not only consume a lot of water but also dump ash in the valley.
- ❖ The river and its tributaries are the largest source of drinking water for the huge population that lives in the valley.
- ❖ On April 2, 1990 about 200,000 litres of furnace oil spilled into the river from the Bokaro Steel Plant.

The 2004 Asian Tsunami

- ❖ The Indian ocean earthquake, which occurred on December 26, 2004, is one of the deadliest disasters in modern history known as the Asian Tsunami.
- ❖ It was a devastating undersea earthquake measuring between 9.1 and 9.3 on the Richter scale.
- ❖ It triggered a series of tsunamis with waves up to 30m, spreading throughout the Indian Ocean, killing more than 1.86 lakh people and inundating coastal communities across south and south-east Asia including parts of Indonesia, Sri Lanka, India and Thailand.
- ❖ No Tsunami warning systems exist in the Indian ocean to warn the public living around the ocean.
- ❖ Tsunami detection is very difficult because tsunami originates in deep water and has a little height.
- ❖ The human destruction of coral reefs is supposed to have played a significant role in the destruction caused by the tsunami.

Hurricane Katrina – Case Study

- ❖ It was formed on August 23, 2005 in the Atlantic ocean.
- ❖ It was a category V hurricane with extremely high wind speed of 280km/h.
- ❖ It was one of the most damaging hurricanes that caused more than 1800 deaths and resulted in economic loss of 75 billion US dollars.
- ❖ Serious damage to the economy was caused by interruption of the oil supply and exports of commodities such as grain.
- ❖ The Hurricane also had profound environmental impacts.
- ❖ Erosion of beach was caused due to the storm, which, in some areas completely devastated the coastal parts.



❖ **SOIL POLLUTION: SOURCES, EFFECTS AND CONTROL MEASURES**

SOURCES	EFFECTS	CONTROL MEASURES
INDUSTRIAL EFFLUENTS	<ul style="list-style-type: none"> i) Alter/affect the chemical or biological properties of soil ii) Toxic chemicals undergoes Bio-magnification 	Stringent application of pollution control acts
Un-scientific DISPOSAL OF URBAN SOLID WASTE	<ul style="list-style-type: none"> i) Leachates will percolate into ground water table , causing a No. of health hazards to human ii) Decomposed material causes/effects the soil 	Urban wastes are to be treated/disposed off in scientific /by Integrated solid waste management(adopting 3R's principles)
POOR AGRICULTURAL PRACTICES	<ul style="list-style-type: none"> i) Turns soil into Acidic/Alkali ii) Toxic pesticides affecting Micro-organisms present in the soil 	<ul style="list-style-type: none"> i) By using natural manure/bio-pesticides ii) By cultivating Leguminous plants

SOURCES	EFFECTS	CONTROL MEASURES
NUCLEAR FALL OUT ON VEGETATION	<ul style="list-style-type: none">i) Enters the food chain, passes into human, replaces Ca of our Bonesii) Bones will become brittle	Nuclear wastes are to be disposed properly

