

Subject Name & Code:

ENVIRONMENTAL SCIENCE, SUSTAINABILITY AND RENEWABLE ENERGY- BE04000101

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Assignment 2: Environmental Pollution (CO₂, CO₃)

A. Water Pollution (CO₂)

1. Define environmental pollution and enlist types of environmental pollution. (*Short*)

- **Environmental Pollution:** The **unfavorable alteration** of our surroundings (air, water, land) wholly or partly as a byproduct of human actions, causing harmful effects.
- **Types:**
 1. Air Pollution
 2. Water Pollution
 3. Soil (Land) Pollution
 4. Noise Pollution
 5. Radioactive Pollution
 6. Thermal Pollution

2. Define Water Pollution and what are the signs of polluted water? (*Short*)

- **Water Pollution:** The **contamination** of water bodies (rivers, lakes, oceans, groundwater) such that it becomes unsafe for drinking, recreation, agriculture, or aquatic life.
- **Signs of Polluted Water:**
 - Unpleasant **odor** (smells like rotten eggs – H₂S).
 - Unnatural **color** (green, brown, or oily sheen).
 - Presence of floating **debris** (garbage, foam).
 - **Fish kills** (dead fish floating).
 - Excessive growth of **algae** (eutrophication).

3. State the different parameters of water which are to be tested for determining the quality of water. (*Medium*)

Water quality is determined using three categories of parameters:

- **Physical Parameters:**
 - **Turbidity:** Clarity (cloudiness).
 - **Color:** Visual appearance.

- **Odor:** Smell.
- **Temperature:** Affects dissolved oxygen.
- **Total Solids:** Dissolved + Suspended solids.
- **Chemical Parameters:**
 - **pH:** Acidity/Alkalinity (6.5-8.5 is safe).
 - **Dissolved Oxygen (DO):** Oxygen available to aquatic life.
 - **BOD/COD:** Organic pollution load.
 - **Hardness:** Calcium/Magnesium content.
 - **Chlorides, Nitrates, Heavy Metals (Arsenic, Lead).**
- **Biological Parameters:**
 - **Coliform Bacteria (E. coli):** Indicates fecal contamination.

4. Give the Classification of Water pollutants. *(Medium)*

Based on their nature and effect:

1. **Infectious Agents (Pathogens):** Bacteria (Cholera), Viruses, Parasites – from sewage.
2. **Oxygen-Demanding Wastes:** Organic matter (sewage, paper mill waste) – bacteria consume O₂ to decompose it, killing fish.
3. **Plant Nutrients (Eutrophying agents):** Nitrates and Phosphates (from fertilizers/detergents) – cause algal blooms.
4. **Organic Chemicals:** Pesticides (DDT), Plastics, Petroleum (oil spills) – toxic/carcinogenic.
5. **Inorganic Chemicals:** Acids, Heavy metals (Hg, Pb), Salts – toxic to aquatic life.
6. **Sediments/Suspended Solids:** Soil particles from erosion – block sunlight and clog gills.
7. **Thermal Pollutants:** Hot water from power plants – lowers DO.

5. Write a short note on Sources of water pollution. *(Medium)*

- **Point Sources (Single identifiable location):**
 - **Industrial discharge pipes** (factories dumping chemicals).
 - **Sewage treatment plants** (overflow).
 - **Oil spills** (tanker accident).
 - *Easy to regulate because you can see the pipe.*
- **Non-Point Sources (Diffuse, widespread):**
 - **Agricultural runoff** (fertilizers, pesticides washed by rain).
 - **Urban runoff** (oil, salt, trash from streets).
 - **Atmospheric deposition** (mercury from coal plants falling into lakes).
 - **Construction sites** (soil erosion).

- *Difficult to control because it comes from everywhere.*

6. Explain the effects of water pollutants. (Medium)

- **On Human Health:**

- **Infectious diseases:** Cholera, Typhoid (from sewage).
- **Toxic poisoning:** Minamata disease (Mercury), Itai-itai disease (Cadmium), Arsenicosis.
- **Cancer:** From chlorinated solvents and pesticides.

- **On Aquatic Life:**

- **Oxygen depletion:** Organic waste kills fish due to low DO.
- **Eutrophication:** Algal blooms block sunlight; algae die and decompose, further killing fish.
- **Bioaccumulation:** Heavy metals concentrate in fish tissues; predators (including humans) get poisoned.

- **On Economy:**

- Loss of tourism (beaches closed).
- Expensive water treatment.
- Decline in fisheries.

7. Write a short note on "Eutrophication." (Medium)

- **Definition:** The natural (or accelerated) **enrichment** of a water body with nutrients (Nitrogen & Phosphorus), leading to excessive plant growth.
- **Process:**
 1. **Nutrient input:** Fertilizers/detergents enter lake.
 2. **Algal bloom:** Algae grow rapidly, turning water green.
 3. **Death:** Algae die and sink.
 4. **Decomposition:** Bacteria decompose dead algae, consuming all **Dissolved Oxygen**.
 5. **Hypoxia/Anoxia:** Oxygen level drops to zero ("Dead Zone").
 6. **Result:** Fish and other aerobic life suffocate and die.
- **Control:** Remove phosphates from detergents; treat sewage before discharge.

8. List any three water quality parameters & their importance. (Short)

- **Dissolved Oxygen (DO):**

- *Importance:* Essential for survival of fish and aquatic insects. Low DO (<4 mg/L) indicates pollution.

- **pH (Potential Hydrogen):**

- *Importance:* Most aquatic life survives at pH 6.5-8.5. High pH (basic) or low pH (acidic) is lethal (e.g., Acid Rain).
- **Biological Oxygen Demand (BOD):**
 - *Importance:* Measures the amount of oxygen bacteria need to decompose organic waste. High BOD = high organic pollution (sewage).
- 9. **Explain the effects of thermal discharge on the receiving water bodies. (Medium)**
 - **Source:** Power plants and industries use water for cooling and return it at a higher temperature (Thermal Discharge).
 - **Effects:**
 - **Decreased Dissolved Oxygen (DO):** Warm water holds less oxygen. Fish suffocate.
 - **Increased Metabolic Rate:** Organisms need more oxygen, but less is available.
 - **Thermal Shock:** Sudden temperature change kills fish eggs and larvae.
 - **Species Shift:** Cold-water fish (Trout) die; warm-water weeds and algae take over.
 - **Reproduction failure:** Even if adults survive, high temperatures prevent spawning.
 - **Control:** Use cooling towers or ponds to cool water before discharge.

10. Write the short note on control of Water Pollution. (Medium)

- **Wastewater Treatment:** Treat sewage and industrial effluents in **ETPs/STPs** before discharge (Primary, Secondary, Tertiary treatment).
- **Prevention at Source:**
 - Reduce use of chemical fertilizers (promote organic farming).
 - Ban detergents with phosphates.
- **Legal Measures:** Enforce Water (Prevention & Control of Pollution) Act. Penalize industries that violate discharge standards.
- **Public Awareness:** Do not throw garbage or plastic into rivers.
- **Cleanup:** River action plans (e.g., Namami Gange) to clean existing pollution.
- **Water Conservation:** Reduce water use to decrease volume of wastewater.

B. Air Pollution (CO₂)

1. Define Air Pollution. (Short)

- **Air Pollution:** The **presence** of one or more contaminants (dust, fumes, gas, mist, odor, smoke) in the outdoor atmosphere in such quantities and of such duration as may be **injurious** to human, plant, animal life, or property.

2. Give composition of air and explain the structure of atmosphere. (Medium)

- **Composition of Clean Dry Air:**
 - Nitrogen (N₂): 78.08%

- Oxygen (O₂): 20.94%
- Argon (Ar): 0.93%
- Carbon Dioxide (CO₂): 0.04%
- Trace gases: Neon, Helium, Methane.
- **Structure of Atmosphere:** (Refer to Answer 4 of Assignment 1 for detailed layers: Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere). *Key note for pollution:* Most air pollution occurs in the **Troposphere**.

3. Explain the different sources of Air Pollution. (Medium)

- **Based on Origin:**
 - **Anthropogenic (Human-made):**
 - **Mobile sources:** Cars, trucks, buses, airplanes (emit CO, NO_x, VOCs).
 - **Stationary sources:** Power plants (coal), factories, refineries (emit SO₂, PM).
 - **Domestic sources:** Biomass burning (wood/coal stoves), mosquito coils.
 - **Agricultural sources:** Crop residue burning, pesticides.
 - **Natural Sources:**
 - **Volcanic eruptions:** Ash, SO₂.
 - **Forest fires:** Smoke, CO.
 - **Dust storms:** Particulate matter (PM₁₀).
 - **Biological decay:** Methane (CH₄).

4. Give the classification of air pollutants. (Medium)

- **Based on Physical State:**
 - **Particulate Matter (PM):** Solid or liquid particles (Dust, smoke, mist, fumes).
 - **Gaseous Pollutants:** CO, SO₂, NO_x, O₃, VOCs.
- **Based on Source of Emission:**
 - **Primary Pollutants:** Emitted directly from a source (e.g., SO₂ from factory, CO from car).
 - **Secondary Pollutants:** Formed in the atmosphere by chemical reactions between primary pollutants (e.g., **Ground-level Ozone** formed from NO_x + VOCs + Sunlight; **Smog**).
- **Based on Chemical Composition:**
 - Organic (VOCs, PAHs)
 - Inorganic (CO, SO₂, NO₂, NH₃)

5. Enlist different air pollutants with their sources and effects. (Medium)

Pollutant	Major Sources	Health/Environmental Effects
CO (Carbon Monoxide)	Incomplete combustion of fuel (vehicles)	Binds to hemoglobin → reduces O ₂ in blood → headache, death.
SO₂ (Sulfur Dioxide)	Coal power plants, diesel	Respiratory irritation, acid rain formation.
NO_x (Nitrogen Oxides)	High-temperature combustion (vehicles, power plants)	Lung irritation, smog formation, acid rain.
PM 2.5/10 (Particulate Matter)	Dust, smoke, vehicles, industry	Enters lungs/blood → asthma, lung cancer, heart disease.
O₃ (Ground-level Ozone)	Formed from NO _x + VOCs (Secondary pollutant)	Damages lung tissue, harms crops (photochemical smog).
Pb (Lead)	Battery recycling, old paint, gasoline	Damages nervous system, lowers IQ in children.

6. Explain effects of air pollution on human beings and animals and plants. (Medium)

- **On Humans:**

- **Respiratory:** Asthma, bronchitis, lung cancer, emphysema.
- **Cardiovascular:** Heart attacks, stroke (due to PM entering blood).
- **Nervous:** Lead poisoning damages brain (children).
- **Irritation:** Eyes (tearing), throat (coughing).

- **On Animals:**

- Similar to humans: lung damage, poisoning (e.g., fluorosis in cattle from industrial fluorine).
- Bioaccumulation of toxins in milk/meat.

- **On Plants:**

- **Chlorosis:** Yellowing of leaves (SO₂, O₃).
- **Necrosis:** Dead spots on leaves.
- **Reduced growth & yield:** Ozone reduces crop productivity (wheat, rice).
- **Acid rain damage:** Leaches nutrients from soil, damages leaf cuticles.

7. Discuss ambient air quality standards of important air pollutants. (Medium)

- **Definition:** Legal limits on the concentration of pollutants in outdoor air to protect public health.
- **In India (NAAQS – National Ambient Air Quality Standards) – Annual Average:**

Pollutant	Time Weighted Average	Concentration Standard
PM₁₀	Annual	60 µg/m ³
PM_{2.5}	Annual	40 µg/m ³
SO₂	Annual	50 µg/m ³
NO₂	Annual	40 µg/m ³
CO	8-hour	2 mg/m ³
O₃	8-hour	100 µg/m ³
Pb	Annual	0.5 µg/m ³

(Note: Standards are stricter for "Industrial" vs "Residential/Rural" areas; values based on WHO guidelines).

8. Enlist and explain the important factors affecting air pollution. (Medium)

Meteorology plays a key role:

1. Wind Speed & Direction:

- High wind → **Disperses** pollutants (good).
- Low wind/Calm → **Accumulation** of pollutants (bad).

2. Temperature Inversion (Most important):

- Normally: Warm air rises (pollutants disperse).
- Inversion: A layer of **warm air traps cool air** near the ground.
- *Effect:* Pollutants cannot rise and get trapped at ground level → **Severe smog** (e.g., Delhi winter).

3. Atmospheric Stability:

- Unstable air (warm rising) = Good dispersion.
- Stable air (cool below, warm above) = Traps pollution.

4. Topography: Valleys and basins trap air (e.g., Los Angeles, Mexico City).

9. Discuss the controlling measures of air pollution. (Medium)

- **At Source (Prevention):**
 - **Use cleaner fuels:** CNG in vehicles, low-sulfur coal in plants.
 - **Process change:** Use water-based paints instead of solvent-based.
 - **Plant trees:** Green belts around industries absorb CO₂ and trap dust.
- **Collection Devices (for Industries):**
 - **Gravity Settling Chambers:** Remove large particles.
 - **Cyclone Separators:** Remove medium particles (dust).
 - **Bag Filters (Fabric Filters):** Trap fine particles (99% efficiency).
 - **Electrostatic Precipitators (ESP):** Use electric charge to remove fly ash (power plants).
 - **Scrubbers (Wet/Dry):** Spray water to remove SO₂ and particles.
- **For Vehicles:**
 - **Catalytic converters:** Convert CO and NO_x to harmless gases.
 - **Bharat Stage VI (BS-VI) norms:** Low-sulfur fuel.
 - **Promote EVs and public transport.**

C. Noise Pollution (CO2)

1. Differentiate between sound and noise. (Short)

Feature	Sound	Noise
Definition	Vibrations that travel as waves, detectable by ear.	Unwanted or unpleasant sound.
Pleasantness	Pleasant, musical, or informative (e.g., music, speech).	Annoying, disturbing (e.g., jackhammer, loud horn).
Physiological effect	Generally harmless (at safe levels).	Causes stress, hearing loss, irritation.
Subjectivity	Objective physical phenomenon.	Subjective psychological experience.

2. Explain sources of noise pollution. (Medium)

- **Industrial Sources:**

- Textile mills, printing presses, engineering workshops.
- Generators, compressors, fans.
- **Transportation Sources (Major contributors):**
 - **Road traffic:** Honking, engine noise, tire noise.
 - **Railways:** Train whistles, wheel-rail friction.
 - **Airports:** Aircraft takeoff/landing (very high decibels).
- **Neighborhood/Domestic Sources:**
 - Loudspeakers, DJ systems (especially during festivals).
 - Construction activities (drilling, pile driving).
 - Household appliances (mixers, vacuum cleaners).
 - Firecrackers.

3. What do you understand by acceptable noise level? Briefly describe the effects of noise pollution. (Medium)

- **Acceptable Noise Level (WHO/CPCB Standards):**
 - **Residential (Day/Night):** 55 dB / 45 dB.
 - **Commercial (Day/Night):** 65 dB / 55 dB.
 - **Industrial (Day/Night):** 75 dB / 70 dB.
 - **Silence Zone (Near hospitals/schools):** 50 dB / 40 dB.
 - *(Note: "Day" = 6 AM to 10 PM; "Night" = 10 PM to 6 AM)*.
- **Effects of Noise Pollution:**
 - **Auditory effects:**
 - **Temporary Threshold Shift (TTS):** Temporary hearing loss after exposure.
 - **Permanent hearing loss (NIHL):** Damage to hair cells in inner ear (exposure to >85 dB for long periods).
 - **Non-Auditory effects:**
 - **Physiological:** Increased heart rate, blood pressure (hypertension), headaches, insomnia (lack of sleep).
 - **Psychological:** Irritability, anxiety, reduced work efficiency.

4. Discuss the different noise rating system. (Short)

- **dB (Decibel):** Logarithmic unit for sound pressure level. *Reference:* 0 dB is threshold of hearing.
- **dBA (A-Weighted decibel):** Most common rating. Adjusts dB to match human ear sensitivity (less sensitive to low frequencies). Used for community noise standards.

- **Leq (Equivalent Continuous Sound Level):** Average noise level over a period (accounts for varying noise).
- **L10, L50, L90:** Statistical levels. L10 = noise exceeded 10% of time (peak), L90 = background noise.
- **Noise Pollution Level (NPL):** Includes Leq and variability.

5. Write a short note on control of noise pollution. (Medium)

- **Control at Source (Most effective):**
 - **Maintenance:** Lubricate and repair machinery to reduce vibration.
 - **Silencers/Mufflers:** Install on engines, generators, and exhausts.
 - **Regulations:** Ban horns in silent zones; restrict loudspeakers at night.
- **Control along the Path:**
 - **Soundproofing:** Use acoustic tiles, foam, or glass wool on walls/ceilings.
 - **Barriers:** Build high walls or **green belts** (thick trees) between noise source and receiver.
 - **Distance:** Locate industries away from residential areas.
- **Protection at Receiver:**
 - Use **earplugs** or **earmuffs** for workers in factories.
 - Design buildings with double-glazed windows.
- **Legal:** Enforce Noise Pollution (Regulation and Control) Rules.

6. Explain measurement of noise. (Short)

- **Instrument: Sound Level Meter (SLM).**
- **Working principle:**
 1. **Microphone:** Captures sound waves and converts them into electrical signals.
 2. **Amplifier:** Increases the signal strength.
 3. **Weighting network (A, C, Z):** Filters sound to specific frequencies (usually **A-weighting - dBA** for human hearing).
 4. **Display:** Shows the sound level in **decibels (dB)**.
- **Procedure:**
 - Hold SLM at arm's length, at ear height.
 - Measure at different times (day/night) and locations.
 - Take multiple readings (e.g., Leq over 1 hour).
- **Mobile Apps:** Many smartphone apps can approximate noise levels, but professional SLMs are accurate.

D. Land Pollution (CO2)

1. Define land pollution. *(Short)*

- **Land Pollution:** The **degradation of the Earth's land surface** through human activities, resulting in the contamination of soil and groundwater, loss of fertility, and visual blight (dumping of waste).

2. List any four sources of land pollution. *(Short)*

1. **Municipal Solid Waste (MSW):** Household garbage, plastics, food waste dumped in landfills.
2. **Industrial Waste:** Chemicals, heavy metals, and sludge from factories.
3. **Agricultural Activities:** Excessive use of chemical fertilizers, pesticides, and herbicides.
4. **Mining:** Overburden (waste rock), tailings, and toxic chemicals (cyanide) left on land.

3. Name two effects of land pollution on agriculture. *(Short)*

1. **Reduced Soil Fertility:** Toxic chemicals kill beneficial microorganisms (bacteria, earthworms), making soil less productive.
2. **Crop Contamination:** Plants absorb heavy metals (Cadmium, Lead) from polluted soil, which enter the food chain and harm humans/animals.

4. State two preventive measures for land pollution. *(Short)*

1. **Reduce, Reuse, Recycle (3R's):** Minimize waste generation at source (use cloth bags instead of plastic).
2. **Proper Waste Disposal:** Treat industrial waste before dumping; promote composting of organic waste.

9. Describe the effects of land pollution on human health. *(Medium)*

- **Direct Contact:** Touching contaminated soil can cause skin rashes, dermatitis, and infections.
- **Inhalation:** Wind blows dust from polluted land. Inhaling particles containing **asbestos**, **silica**, or heavy metals causes lung diseases (asbestosis, silicosis, cancer).
- **Food Chain Contamination:**
 - Crops grown in polluted soil absorb toxins (Cadmium, Lead, Arsenic).
 - Eating these crops leads to chronic poisoning: **Kidney damage** (Cadmium), **neurological disorders** (Lead in children), **cancer** (Arsenic).
- **Groundwater Contamination:** Rainwater percolates through polluted soil (leachate), contaminating drinking water wells → causes **gastrointestinal diseases** (cholera) and **liver damage** (chemicals).

10. Explain the impact of land pollution on soil fertility. *(Medium)*

- **Definition of Fertility:** The ability of soil to supply essential nutrients (N, P, K) and support plant growth.
- **Negative Impacts:**

- **pH Imbalance:** Industrial waste (acids/alkalis) changes soil pH. Most crops need pH 6.5-7.5. Outside this range, nutrients become unavailable.
- **Heavy Metal Toxicity:** Lead, Mercury, Cadmium kill soil microbes (bacteria/fungi) and earthworms that aerate the soil and decompose organic matter.
- **Salt Accumulation:** Excessive fertilizer use causes **salinization** (salt build-up). High salt pulls water out of plant roots (reverse osmosis), causing "fertilizer burn."
- **Reduced Organic Matter:** Landfills and dumping cover the soil, preventing natural decomposition cycles.
- **Result:** Soil becomes **barren**, unable to grow crops without expensive remediation.

11. Discuss the role of solid waste management in controlling land pollution. (Medium)

- **Proper SWM is the #1 solution to land pollution.**
- **Role of SWM:**
 - **Collection & Segregation:** Separating wet (organic), dry (plastic/paper), and hazardous waste prevents toxic materials from mixing with soil.
 - **Treatment before disposal:**
 - **Composting:** Converts organic waste into manure (improves soil, doesn't pollute).
 - **Recycling:** Plastic, glass, metal are recycled → reduces need for landfilling.
 - **Sanitary Landfilling:** Instead of open dumping, modern landfills have:
 - **Liner systems** (clay + plastic) to prevent leachate from seeping into soil.
 - **Leachate collection** pipes to treat contaminated water.
 - **Daily cover** of soil to prevent litter and pests.
 - **Incineration:** Burning waste at high temperature reduces volume by 90%, leaving inert ash (less land occupation).

12. Describe agricultural practices that contribute to land pollution. (Medium)

- **Overuse of Chemical Fertilizers (NPK):**
 - Excess nitrates leach into soil, causing **acidification**.
 - Kills beneficial fungi and bacteria.
- **Pesticides and Herbicides (DDT, Atrazine):**
 - Persist in soil for decades (non-biodegradable).
 - Kill non-target organisms (bees, earthworms).
 - Enter food chain → biomagnification.
- **Irrigation without drainage:**
 - Causes **waterlogging** (roots rot) and **salinization** (salt accumulation on surface).
- **Crop Residue Burning:**

- Farmers burn stubble (wheat/paddy) to clear fields quickly.
- Destroys soil organic matter and beneficial soil microbes; causes severe air pollution (smog in Delhi).
- **Animal Waste over-application:** Too much manure can overload soil with phosphorus and pathogens (E. coli).

13. Explain how industrial activities cause land pollution. (*Medium*)

- **Industrial Waste Dumping:** Factories (chemical, textile, tannery, steel) produce solid waste and sludge containing toxic chemicals (chromium, lead, acids, oils). Often dumped directly on open land.
- **Fly Ash from Thermal Power Plants:** Millions of tons of fine ash particles. Dumped in large ash ponds/landfills. Contains heavy metals (Arsenic, Mercury) that leach into soil.
- **Mining Activities:**
 - **Overburden:** The rock/soil removed to access minerals is dumped on land (deforestation + erosion).
 - **Tailings:** The crushed rock left after extracting minerals (e.g., uranium, copper). Often acidic (Acid Mine Drainage) and contains cyanide (gold mining).
- **Spills and Leaks:** Underground storage tanks (petrol, chemicals) corrode and leak → contaminates surrounding soil for decades.
- **Example: Bhopal Gas Tragedy** left soil contaminated with toxic chlorinated compounds for 40+ years.

15. Explain land pollution with its sources, effects, and control measures. (*Long*)

- **Definition:** Deterioration of earth's land surfaces due to human waste disposal and chemical contamination.
- **Sources:**
 1. Municipal Solid Waste (garbage, plastics).
 2. Industrial waste (chemicals, heavy metals).
 3. Agricultural chemicals (pesticides, fertilizers).
 4. Mining overburden and tailings.
 5. Construction debris.
- **Effects:**
 1. **On Health:** Skin diseases, cancer, heavy metal poisoning.
 2. **On Agriculture:** Loss of fertility, salinization, crop contamination.
 3. **On Environment:** Groundwater pollution (leachate), habitat destruction, release of methane (landfill gas).
 4. **Aesthetic:** Visual blight, foul odors, breeding ground for pests (rats, flies).
- **Control Measures:**

1. **Waste Management Hierarchy:** Reduce > Reuse > Recycle > Recovery > Disposal.
2. **Sanitary Landfilling:** Engineered landfills with liners and leachate treatment.
3. **Composting:** Biodegradable waste → organic manure.
4. **Phytoremediation:** Using plants (e.g., sunflowers, mustard) to absorb heavy metals from soil.
5. **Legal:** Hazardous Waste (Management & Handling) Rules; penalize illegal dumping.
6. **Public Awareness:** Avoid single-use plastics; segregate waste at home.

16. Discuss land pollution caused by hazardous and electronic waste. (Medium)

- **Hazardous Waste (HW):** Waste that is toxic, corrosive, flammable, or reactive.
 - *Sources:* Chemical plants, batteries, paint, pesticides.
 - *Land pollution impact:* Leaks **heavy metals (Pb, Hg, Cd)** and solvents into soil. Contamination persists for centuries. *Example:* Union Carbide waste (Bhopal) still poisons groundwater.
- **E-Waste (Electronic Waste):** Discarded electronics (phones, computers, TVs, refrigerators).
 - *Constituents:* Lead (solder), Mercury (switches), Cadmium (batteries), Beryllium, Brominated flame retardants (plastics).
 - *Land pollution impact (Improper disposal):*
 - **Open burning** (to recover copper) releases dioxins and furans into soil.
 - **Acid leaching** (to recover gold) spills highly toxic acids onto land.
 - **Landfilling:** Heavy metals leach from landfills into groundwater.
 - *Control:* Formal recycling (e.g., E-waste Rules 2022, Extended Producer Responsibility - EPR).

E. Solid Waste: Generation and Management (CO3)

1. Define the terms. (1) Solid waste (2) Garbage (3) Rubbish (4) Putrefaction (5)

Leachate (Short)

- **Solid waste:** Any **unwanted or discarded solid material** from human or animal activities that is not liquid or gas.
- **Garbage:** **Putrescible (decaying) solid waste** from food preparation (vegetable peels, meat scraps). Attracts flies and rats.
- **Rubbish:** **Non-putrescible solid waste** (combustible: paper, wood; non-combustible: glass, metals).
- **Putrefaction:** The **biological decomposition** of organic matter (proteins) by anaerobic bacteria, producing foul-smelling gases (H₂S, NH₃, methane).
- **Leachate:** The **contaminated liquid** that percolates through a landfill, extracting dissolved and suspended materials (organic matter, heavy metals, pathogens).

2. Discuss different types and sources of solids waste. *(Medium)*

- **Types (Based on Source & Nature):**

1. **Municipal Solid Waste (MSW):** Household garbage, street sweeping, park waste.
2. **Industrial Waste:** Scrap, chemicals, packaging, sludge.
3. **Hazardous Waste:** Toxic, flammable, corrosive (e.g., batteries, pesticides).
4. **Bio-medical Waste:** Syringes, bandages, body parts (hospitals).
5. **E-waste:** Discarded electronics.
6. **Construction & Demolition (C&D) Waste:** Concrete, wood, steel, drywall.
7. **Agricultural Waste:** Crop residues, animal manure, pesticide containers.

- **Sources:**

- **Residential:** Homes (food waste, packaging).
- **Commercial:** Shops, restaurants, offices.
- **Institutional:** Schools, colleges, hospitals.
- **Industrial:** Factories, power plants.
- **Municipal:** Street sweepings, sewage sludge.

3. Explain causes and effects of solid waste pollution. *(Medium)*

- **Causes:**

- **Overpopulation:** More people = more waste.
- **Urbanization:** Concentrated waste generation in cities.
- **Consumerism:** Excessive packaging (plastic), single-use items.
- **Lack of segregation:** Mixing biodegradable with non-biodegradable waste.
- **Improper disposal:** Open dumping instead of sanitary landfilling.

- **Effects:**

- **Environmental:**
 - **Land pollution:** Visual blight, leachate contaminates soil/water.
 - **Air pollution:** Burning waste releases CO, dioxins, and particulate matter.
 - **Water pollution:** Leachate drains into rivers and groundwater.
- **Health:**
 - Breeding ground for vectors (mosquitoes - malaria; rats - plague).
 - Respiratory diseases (from burning).
 - Skin infections (from contact with garbage).
- **Economic:** Costly cleanup; decreased property values near dumps.

4. What are the factors affecting the generation rate of solids waste? Explain them in brief. (Medium)

- **Factors:**

- **Geographic location:** Urban areas generate more than rural areas; tourism increases waste.
- **Seasonal variation:** More packaging waste during holidays (Diwali/Christmas); more vegetable waste during harvest.
- **Population growth:** Directly proportional.
- **Economic status (Income):** Higher income = more packaging, electronics, and food waste.
- **Lifestyle:** Fast food culture increases plastic waste; "zero waste" lifestyle decreases it.
- **Collection frequency:** Regular collection doesn't change rate, but irregular collection leads to illegal dumping.
- **Legislation:** Plastic bans or landfill taxes reduce waste generation.

5. Why a proper solid waste management system is required for urban areas? (Medium)

- **Reasons:**

- **Public health:** Prevents outbreaks of diseases (cholera, dengue, plague) by eliminating breeding grounds for vectors.
- **Environmental protection:** Prevents leachate from polluting groundwater and rivers.
- **Aesthetics:** Clean cities attract tourism and improve quality of life.
- **Resource recovery:** Urban waste contains recyclables (paper, plastic, metal) and organics (for composting). SWM extracts value from waste.
- **Climate change mitigation:** Reduces methane emissions from landfills (methane is 25x worse than CO₂).
- **Legal compliance:** Cities are legally required under SWM Rules 2016 to manage waste properly.
- **Land scarcity:** Urban land is expensive; proper SWM (recycling/incineration) reduces the land needed for dumping.

6. Enlist and explain different method of solid waste collection. (Medium)

- **Methods:**

- **Household to Household Collection:** Workers go door-to-door with handcarts or tricycles. *Best for segregated waste.*
- **Community Bin (Dustbin) System:** Residents deposit waste in large shared bins; trucks collect from bins. *Common in Indian cities.*
- **Curbside Collection:** Residents place bins at curb on scheduled days; automated trucks lift and empty bins. *Used in developed countries.*

- **Pneumatic Collection:** Waste moves through underground vacuum tubes to central station. *Expensive, high-tech (e.g., Disney World).*
- **Self-delivery:** Residents bring waste directly to transfer station. *Not efficient for large cities.*

7. Explain different methods used for solid waste disposal. (Long)

- **A. Open Dumping (Unsanitary):** Crude disposal in low-lying areas. *Not recommended – causes severe pollution.*
- **B. Sanitary Landfilling (Most common in India):**
 - Waste is spread in thin layers, compacted, and covered daily with soil.
 - **Components:** Liner (clay/HDPE), leachate collection, gas recovery (methane).
 - *Pros:* Relatively cheap, handles large volumes. *Cons:* Requires land, long-term monitoring.
- **C. Incineration (Thermal treatment):**
 - Burn waste at high temperatures (900-1100°C).
 - *Pros:* Reduces volume by 80-90%; generates electricity (Waste-to-Energy).
 - *Cons:* Expensive; produces toxic ash & air emissions (dioxins).
- **D. Composting (Biological):**
 - Aerobic decomposition of organic waste (food, garden waste) into humus (manure).
 - *Pros:* Produces useful fertilizer; reduces methane.
 - *Cons:* Only for organic waste; requires segregation.
- **E. Anaerobic Digestion:**
 - Bacteria break down organic waste in absence of oxygen → produces **biogas (methane)** and digestate (fertilizer).
 - *Pros:* Generates renewable energy. *Cons:* Sensitive to toxic materials.
- **F. Recycling:** Reprocessing waste (paper, plastic, glass, metal) into new products.
 - *Pros:* Saves resources & energy. *Cons:* Requires clean, segregated waste.

8. Write a short note on landfilling. (Medium)

- **Definition:** A engineered method of disposing solid waste by burying it in a controlled manner.
- **Types:**
 - **Sanitary Landfill:** Modern, with environmental controls.
 - **Bioreactor Landfill:** Recirculates leachate to speed up decomposition.
- **Key Components of a Sanitary Landfill:**
 1. **Bottom Liner System:** Clay layer + HDPE plastic sheet to prevent leachate from escaping into groundwater.

2. **Leachate Collection System:** Pipes at bottom collect dirty water and send it to treatment plant.
 3. **Gas Collection System:** Vertical wells extract methane (CH₄) which can be burned to generate electricity (LFGTE).
 4. **Daily Cover:** Soil or foam sprayed on waste each day to control odors, pests, and litter.
 5. **Final Cover:** When landfill is full, capped with clay, topsoil, and vegetation.
- **Advantages:** Relatively low cost; can handle mixed waste; generates methane gas as energy.
 - **Disadvantages:** Requires large land area; risk of liner failure (leak); long-term liability (100+ years).

F. Bio-medical Waste: Generation and Management (CO3)

1. Define bio-medical waste and infectious waste. (Short)

- **Bio-medical Waste (BMW):** Any waste generated during the **diagnosis, treatment, or immunization** of human beings or animals, or in research activities (as per BMW Rules 2016).
- **Infectious Waste:** BMW that is **capable of transmitting communicable diseases** (e.g., bandages with blood, used needles, pathological tissues). It contains pathogens (bacteria, viruses).

2. Enlist different sources of bio-medical waste. (Short)

1. **Hospitals & Clinics (Major source).**
2. **Laboratories (Pathology, research).**
3. **Blood banks & Dialysis centers.**
4. **Veterinary hospitals & Animal houses.**
5. **Mortuaries & Autopsy centers.**
6. **Home healthcare** (insulin needles, diabetic lancets).

3. Give classification of bio-medical waste. *(Medium - as per Schedule I of BMW Rules 2016)*

Category	Type	Color Coding	Example
Yellow	Anatomical, pathological, chemical, pharmaceutical	Yellow	Human tissues, organs, animal carcasses, expired medicines, cytotoxic drugs

Category	Type	Color Coding	Example
Red	Contaminated plastics (recyclable)	Red	IV tubes, catheters, syringes (without needles), gloves
White (Translucent)	Sharps	White/Puncture-proof	Needles, scalpels, blades, broken glass
Blue	Glassware & metallic implants	Blue	Medicine vials, ampoules, metal body parts
Black	Municipal waste (non-hazardous)	Black	Food wrappers, office paper, general trash

4. Explain how bio-medical waste should be segregated before disposal. (Medium)

- **Principle:** Segregation is the **most critical step**. It must be done **at the point of generation** (bedside, OT, lab) and NOT at the disposal site.
- **Steps:**
 - **Color-coded bags/bins** are placed in different locations.
 - **Yellow bag:** Place anatomical, pathological, and chemical waste. *No plastics.*
 - **Red bag:** Place contaminated plastic waste (tubing, gloves). *No needles.*
 - **White sharps container (puncture-proof):** Place needles, scalpels directly. *Do not recap needles.*
 - **Blue box:** Place glass vials and metal implants.
 - **Black bin:** Place general office waste (food wrappers, paper).
- **Do's:** Fill bags only 3/4th full; tie securely; label with source (ward/OT).
- **Don'ts:** Never mix categories (e.g., needle in red bag). Never put anatomical waste in black bin.

5. Enlist and explain different methods used for treatment of bio-medical waste. (Medium)

- **A. Incineration (Thermal):**
 - Burns waste at 800-1000°C. For **yellow category** (anatomical, pathological, infectious).
 - *Result:* Ash (reduces volume by 90%). *Note:* Cannot incinerate plastics (PVC releases HCl and dioxins).

- **B. Autoclaving (Steam sterilization):**
 - Uses saturated steam at 121°C, 15 psi for 30-60 minutes. For **red and white** categories (plastic waste, sharps).
 - *Result:* Waste is sterilized (pathogens killed). Can be shredded and disposed as general waste.
 - **C. Microwaving:**
 - Uses microwave radiation to heat water inside waste, killing pathogens. Similar to autoclaving.
 - **D. Chemical Disinfection (Liquid chemicals):**
 - Uses sodium hypochlorite (bleach), chlorine, or peracetic acid. For liquid waste (blood, lab cultures) and sharps.
 - **E. Shredding & Mutilation:**
 - Physical destruction (shredder) after sterilization. Prevents reuse of syringes.
- 6. Explain different thermal processes for bio-medical waste treatment. (Medium)**
- **Incineration (High-temperature thermal):**
 - **Process:** Waste fed into primary chamber (800°C) → gases go to secondary chamber (1050°C) to burn unburnt hydrocarbons and dioxins.
 - **Types:** Single chamber (for pathological), double chamber (for mixed infectious waste).
 - **Residue:** Bottom ash (landfill) and fly ash (hazardous).
 - **Pyrolysis (Low-oxygen thermal):**
 - Waste heated in absence of oxygen (300-700°C). Produces **syngas** (H₂, CO) and char.
 - *Advantage:* Lower emissions than incineration; produces fuel.
 - **Plasma Pyrolysis (Very high temperature):**
 - Uses plasma torch (3000-7000°C) to molecularly dissociate waste.
 - *Result:* Converts organic waste into syngas; inorganic waste into vitrified slag (inert, safe).
 - *Disadvantage:* Very expensive, high energy.

7. Enlist the factors affecting generation rate of bio-medical waste and discuss the overall scenario in India. (Medium)

- **Factors affecting generation rate:**
 - **Bed occupancy** in hospitals.
 - **Type of hospital** (Teaching hospital generates more than nursing home).
 - **Use of disposables** (more syringes/gloves = more waste).
 - **Local practices** (reusable vs disposable bed sheets).

- **Outpatient volume.**
- **Indian Scenario (approx. data):**
 - India generates ~550-750 **tonnes per day** of BMW.
 - **Before 2016 rules:** Only ~50% was treated properly; rest dumped openly.
 - **After BMW Rules 2016:** Mandatory segregation, common treatment facilities (CBWTFs). Treatment rate improved to ~70-80%.
 - **Issues:** Lack of CBWTFs in rural areas; illegal dumping by small clinics; manual scavenging of waste.

8. Why proper management of bio-medical waste is required? (Medium)

- **Reasons:**
 - **Prevent Hospital-Acquired Infections (HAIs):** Patients and staff can get Hepatitis B, C, HIV from needle sticks or contact with infected waste.
 - **Prevent Community spread:** Ragpickers and waste workers are at high risk if waste is dumped openly. *Example:* HIV transmission via unsorted needles.
 - **Environmental Protection:** BMW dumped in landfills leads to **drug-resistant bacteria** entering groundwater and soil.
 - **Aesthetics & Safety:** Needles and body parts in municipal waste are traumatic and dangerous.
 - **Legal compliance:** BMW Management Rules 2016 mandate it; violation leads to fines/jail for hospital administrators.
 - **Prevent reuse of disposables:** Proper shredding ensures syringes are not resold illegally.

9. Explain in brief about the functional elements of bio-medical waste management. (Medium)

The key steps (elements) in sequence:

1. **Segregation:** Separating waste into color-coded bags **at the point of generation** (ward, OT).
2. **Collection & Storage:** Using dedicated trolleys (not used for general waste) to transport bags to a temporary storage room. Storage should be cool, dry, and inaccessible to animals.
3. **Transport:** Moving waste from hospital storage to **Common Bio-medical Waste Treatment Facility (CBWTF)** or on-site treatment plant. Use GPS-tracked vehicles.
4. **Treatment:** Applying technology (incineration, autoclaving, microwaving) to destroy pathogens.
5. **Disposal:** Final disposal of treated residues:
 - Incineration ash → Sanitary landfill (hazardous ash cell).
 - Autoclaved/shredded plastic → Sent for recycling (only after sterilization).
 - Liquid waste → Treated in ETP before draining.

6. **Monitoring & Record-keeping:** Maintain manifests (tracking documents) for every kg of waste from cradle to grave.
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G. E-waste Generation and Management (CO3)

1. Define e-waste. *(Short)*

- **E-waste (Electronic Waste):** All discarded **electrical and electronic equipment (EEE)** and its components that have reached the end of their useful life. This includes computers, mobile phones, televisions, refrigerators, ACs, and washing machines.

2. Give the classification of the e-waste. Also give the constituent material of e-waste. *(Medium)*

- **Classification (by product type):**
 - **Large Household Appliances:** Refrigerators, washing machines, ACs, microwaves.
 - **Small Household Appliances:** Toasters, irons, vacuum cleaners.
 - **IT & Telecom Equipment:** Computers, laptops, printers, phones, routers.
 - **Consumer Electronics:** TVs, cameras, stereos, video games.
 - **Lighting Equipment:** Fluorescent tubes (CFLs, LEDs).
 - **Medical Devices:** Monitors, MRI machines.
 - **Toys & Sports:** Electronic games, drones.
- **Constituent Materials:**
 - **Precious metals (1%):** Gold (in connectors), Silver, Platinum, Palladium.
 - **Base metals (60%):** Copper (wires), Aluminum (heat sinks), Steel (cases).
 - **Plastics (20%):** Brominated Flame Retardants (BFRs) – toxic.
 - **Hazardous materials (10%):**
 - Lead (solder, CRT glass).
 - Mercury (switches, LCD backlights).
 - Cadmium (batteries).
 - Beryllium (power supply).
 - **Glass (9%):** CRT monitors (leaded glass).

3. What is the environmental and health impact of improper disposal of e-waste? *(Medium)*

- **Health Impacts (on workers/recyclers):**
 - **Lead (Pb):** Neurological damage (lowered IQ in children), anemia, kidney damage.
 - **Mercury (Hg):** Minamata disease (neurological, birth defects).
 - **Cadmium (Cd):** Itai-itai disease (bone pain), lung cancer.

- **Brominated Flame Retardants (BFRs):** Endocrine disruption, thyroid problems, cancer.
- **Acid burns:** From backyard recycling (acid leaching).
- **Environmental Impacts:**
 - **Soil contamination:** Heavy metals leach into soil from open dumps. Soil becomes toxic for plants.
 - **Water contamination:** Leachate carries Lead, Mercury into groundwater and rivers.
 - **Air pollution: Open burning** of wires to recover copper releases **dioxins and furans** (highly carcinogenic) into the air.
 - **Bioaccumulation:** Heavy metals enter food chain via crops/water → humans.

4. Explain how the e-waste should be managed? *(Medium - Proper recycling process)*

- **Step 1: Collection & Segregation:** Collection centers (authorized) separate working vs non-working items.
- **Step 2: Refurbishment & Reuse:** Working electronics are cleaned, repaired, and resold (best option).
- **Step 3: Dismantling:** Non-working items are manually disassembled into components (PCB, plastic case, wires, CRT, battery).
- **Step 4: Mechanical Separation (Shredding):** Shredder breaks material into small pieces. Separators (magnetic for steel, eddy current for aluminum, density for plastic) sort materials.
- **Step 5: Material Recovery (Advanced):**
 - **Pyrometallurgy:** Smelting at high temperature to recover copper and precious metals (gold/silver).
 - **Hydrometallurgy:** Using cyanide or acid to leach gold from PCBs (controlled conditions, unlike backyard).
- **Step 6: Disposal of residues:** Hazardous ash/plastic sent to incinerator or hazardous landfill.

5. Explain the role of government in e-waste management. *(Medium)*

- **Legislation:** Enacted **E-waste (Management) Rules, 2022.**
 - **Extended Producer Responsibility (EPR):** Manufacturers (Dell, Samsung, Apple) are legally responsible for collecting and recycling e-waste equivalent to their sales.
- **Authorization:** Grants licenses to authorized recyclers/dismantlers. Shuts down illegal backyard recyclers.
- **Awareness campaigns:** "Swachh Digital Bharat" – educating public not to throw phones in trash.
- **Funding:** Provides financial support for setting up formal recycling facilities (under Swachh Bharat Mission).
- **International cooperation:** Ratifies **Basel Convention** to prevent illegal export of e-waste from developed to developing countries.

- **Monitoring:** CPCB (Central Pollution Control Board) monitors EPR compliance; imposes environmental compensation for defaulters.

H. Global Environmental Issues (CO3)

1. Which are the important global Environmental effects and what are the main causes of these effects? (*Medium*)

- **Important Global Effects:**
 1. **Global Warming / Climate Change**
 2. **Ozone Layer Depletion**
 3. **Acid Rain**
 4. **Biodiversity Loss**
 5. **Ocean Acidification**
- **Main Causes (Common thread = Human activity):**
 - **Burning of fossil fuels** (coal, oil, gas): Releases CO₂ (global warming), SO₂ & NO_x (acid rain).
 - **Industrial emissions:** Chlorofluorocarbons (CFCs) – ozone depletion.
 - **Deforestation:** Reduces CO₂ absorption, increases atmospheric CO₂.
 - **Agriculture & Livestock:** Methane (CH₄) – global warming.
 - **Overconsumption:** Resource extraction, waste generation.

2. What is acid rain? How it is formed? (*Medium*)

- **Definition:** Rain, snow, fog, or dry deposition with a **pH less than 5.6** (normal rain is slightly acidic pH 5.6 due to CO₂). Acid rain typically has pH 4.0–4.5.
- **Formation Process:**
 1. **Sources:** Burning of coal (power plants) and vehicle fuels releases **Sulfur Dioxide (SO₂)** and **Nitrogen Oxides (NO_x)**.
 2. **Atmospheric reaction:**
 - $SO_2 + O_2 \rightarrow SO_3$
 - $SO_3 + H_2O \rightarrow H_2SO_4$ (Sulfuric acid)
 - $NO_x + OH \rightarrow HNO_3$ (Nitric acid)
 3. **Wet deposition:** These acids dissolve in cloud droplets and fall as rain/snow.
 4. **Dry deposition:** Acidic gases and particles settle directly on surfaces (buildings, leaves).

3. Write a short note on causes and effects of acid rain. (*Medium*)

- **Causes:**

- **Anthropogenic (Major):** Power plants (coal burning), industrial boilers, smelters (SO₂). Vehicles (NO_x).
- **Natural (Minor):** Volcanic eruptions (SO₂), lightning (NO_x), decaying vegetation.
- **Effects:**
 - **On Aquatic ecosystems:** Lakes become acidic (pH <5) → fish eggs fail to hatch; fish die (aluminum leached from soil clogs fish gills).
 - **On Forests:** Leaches essential nutrients (Calcium, Magnesium) from soil; damages waxy coating on leaves (brown spots, defoliation). "Waldsterben" (forest death) in Germany.
 - **On Buildings/Materials:** Corrodes metals (iron, bronze); dissolves limestone and marble (statues – Taj Mahal, Parthenon).
 - **On Human health:** Sulfates and nitrates (particulate matter) aggravate asthma and bronchitis.

4. Explain ozone depletion. *(Long)*

- **Definition:** The gradual **thinning of the stratospheric ozone layer** (O₃) over the Earth, particularly over Antarctica (Ozone Hole).
- **What is Ozone Layer?** A region 15-30 km above Earth in the stratosphere that absorbs 97-99% of the Sun's harmful **Ultraviolet-B (UV-B)** radiation.
- **Cause (The CFC Mechanism):**
 1. **Source: Chlorofluorocarbons (CFCs)** – used in refrigerators (Freon), ACs, aerosol sprays (hairspray), and foam blowing.
 2. **Transport:** CFCs are inert in the troposphere, so they slowly drift up to the stratosphere.
 3. **Photodissociation:** In the stratosphere, UV radiation breaks CFCs apart, releasing **Chlorine (Cl)** atoms.
 4. **Catalytic destruction:**
 - $Cl + O_3 \rightarrow ClO + O_2$ (Chlorine destroys ozone).
 - $ClO + O \rightarrow Cl + O_2$ (Chlorine is regenerated to destroy more ozone).
 - *One single chlorine atom can destroy 100,000 ozone molecules.*
- **Effects of Ozone Depletion:**
 - **Human:** Increased UV-B → skin cancer (melanoma), cataracts (eye damage), immune suppression.
 - **Environment:** Reduced crop yields (wheat, rice), damage to phytoplankton (base of ocean food chain), increased degradation of plastics.

5. What can be done for the protection of ozone layer? *(Medium)*

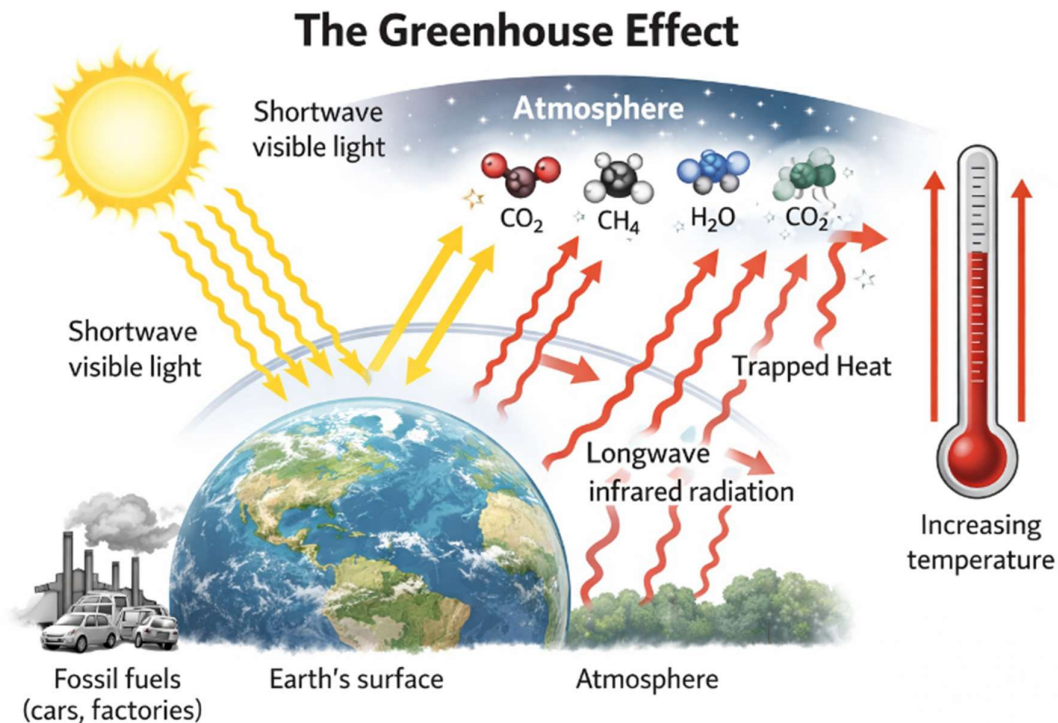
- **International Action (Montreal Protocol 1987):**

- The most successful environmental treaty in history. Phased out 99% of ozone-depleting substances (ODS).
- **Banned CFCs** in refrigerators, aerosols, and foams (by 2010 in developed nations).
- **Phased out Halons** (fire extinguishers).
- **Alternatives (Substitutes):**
 - **HCFCs** (less damaging but still phased out) → **HFCs** (no ozone depletion, but high global warming potential) → now moving to **HFOs** and natural refrigerants (CO_2 , Ammonia, Propane).
 - **Hydrofluoroolefins (HFOs)**: Zero ODP, low GWP.
- **Individual Action:**
 - Ensure old ACs/refrigerators are disposed of at authorized e-waste centers (to recover CFCs).
 - Avoid aerosol sprays with propellants (look for "CFC-free").
 - Support recovery and recycling of refrigerants.

6. Explain by drawing sketch greenhouse effect. (Medium)

- **Definition:** The natural process by which certain gases (greenhouse gases) trap heat in the Earth's atmosphere, keeping the planet warm enough for life.

Diagram:



- **Explanation:**
 1. Solar radiation (shortwave) passes through the atmosphere and warms the Earth.

2. Earth emits infrared radiation (longwave heat).
 3. **Greenhouse Gases (GHGs)** – CO₂, CH₄, N₂O, H₂O – absorb this infrared radiation.
 4. They re-radiate heat back in all directions, including back to Earth's surface.
 5. This **traps heat**, keeping the global average temperature at ~15°C instead of -18°C.
- **Enhanced Greenhouse Effect:** Human activities (burning fossil fuels) increase GHG concentrations → more heat trapped → **Global Warming**.

7. What are the effects of global warming? (*Long*)

- **Rising Temperatures:** Global average temperature has risen ~1.2°C since pre-industrial times. Heatwaves become more frequent and intense.
- **Melting Ice & Glaciers:** Himalayan glaciers (source of Ganga, Indus) are retreating. Greenland and Antarctic ice sheets melting → contributes to sea level rise.
- **Sea Level Rise:**
 - Due to thermal expansion (water expands as it warms) and melting ice.
 - **Impact:** Submersion of coastal cities (Mumbai, Kolkata, Shanghai, Miami); salinization of freshwater aquifers; displacement of millions (climate refugees).
- **Extreme Weather Events:**
 - More intense cyclones (e.g., Tauktae, Amphan).
 - Increased flooding (heavy rainfall) and severe droughts.
- **Ecosystem Collapse:**
 - **Coral bleaching:** Warmer oceans kill coral reefs (Great Barrier Reef).
 - **Forest fires:** Drier conditions increase wildfires (Australia, California, Uttarakhand).
 - **Species extinction:** Polar bears (loss of sea ice), amphibians (chytrid fungus spread by warming).
- **Agriculture & Food Security:** Heat stress reduces crop yields (wheat, maize). Changing monsoon patterns disrupt planting seasons.

8. Which measures can be adopted for controlling global warming? (*Medium*)

- **Mitigation (Reduce GHG emissions):**
 - **Switch to Renewable Energy:** Solar, wind, hydro instead of coal/gas.
 - **Energy Efficiency:** LED bulbs, star-rated appliances, green buildings.
 - **Sustainable Transport:** Electric vehicles (EVs), public transit, cycling.
 - **Reforestation:** Plant trees to absorb CO₂ (carbon sinks).
 - **Waste management:** Composting (reduces methane from landfills).
- **Adaptation (Adjust to changes):**
 - Build sea walls for coastal cities.

- Develop drought-resistant crop varieties.
- Early warning systems for heatwaves and cyclones.
- **International Agreements:**
 - **Paris Agreement (2015):** Limit warming to 1.5°C above pre-industrial levels. Countries submit Nationally Determined Contributions (NDCs).
 - **Carbon pricing:** Carbon tax or cap-and-trade to make polluters pay.

9. What is climate? Which are the key signs of climate change? *(Medium)*

- **Climate:** The **long-term average** of weather patterns (temperature, rainfall, wind) over at least 30 years for a specific region. ("Climate is what you expect; weather is what you get.")
- **Key Signs of Climate Change (observed evidence):**
 - **Rising global temperatures:** 19 of the 20 warmest years have occurred since 2001.
 - **Melting cryosphere:** Shrinking Arctic sea ice, retreating glaciers worldwide.
 - **Sea level rise:** Global mean sea level has risen 8-9 inches since 1880.
 - **Ocean acidification:** CO₂ absorbed by oceans makes them 30% more acidic (threatens shellfish).
 - **Extreme events:** Increased frequency of droughts, floods, wildfires, and intense cyclones.
 - **Shifting seasons:** Earlier spring, later autumn; changes in bird migration.

10. State the impact of climate change on environment and human beings. *(Medium)*

- **On Environment:**
 - **Biodiversity loss:** 1 million species at risk of extinction.
 - **Ecosystem shifts:** Forests turning to savannas; coral reefs dying.
 - **Permafrost thaw:** Releases methane (positive feedback loop).
- **On Human Beings:**
 - **Health:** Heatstroke deaths; spread of vector-borne diseases (Malaria, Dengue, Zika) to new regions; respiratory illness from wildfires.
 - **Water & Food:** Water scarcity (glacier melt); crop failures → hunger.
 - **Displacement:** Climate refugees from coastal flooding (Bangladesh) and desertification (Africa).
 - **Economic:** Damage to infrastructure (roads, buildings) from floods/storms; loss of tourism (ski resorts, beaches).

11. What is carbon footprint? How carbon footprint is calculated for individuals as well as organization. *(Medium)*

- **Carbon Footprint:** The total amount of **Greenhouse Gases (GHGs)** (expressed as CO₂ equivalents - CO₂e) emitted directly or indirectly by an individual, organization, event, or product over a given period.

- **Calculation for Individuals:**
 - **Components measured:**
 - **Home energy:** Electricity (kWh) × grid emission factor (kg CO₂/kWh). Natural gas/propane usage.
 - **Transport:** Car fuel (liters of petrol × 2.3 kg CO₂/l); Flight (distance × emission factor per km).
 - **Waste:** Amount of waste sent to landfill (methane).
 - **Food:** Meat consumption (high footprint) vs plant-based.
 - **Tools:** Online calculators (e.g., [Carbonfootprint.com](https://carbonfootprint.com)) ask for monthly bills and travel.
- **Calculation for Organizations (Corporate Footprint - Scope 1,2,3):**
 - **Scope 1 (Direct):** Emissions from owned sources (company vehicles, boilers, furnaces).
 - **Scope 2 (Indirect - Energy):** Emissions from purchased electricity, steam, heating/cooling.
 - **Scope 3 (Other Indirect):** Supply chain, business travel, employee commuting, waste disposal.
 - **Formula:** Sum of (Activity data × Emission factor) for all sources.

12. What are the benefits of calculation of carbon footprints? (Short)

- **Identify hotspots:** Pinpoints the largest sources of emissions (e.g., "80% of my footprint is from flights").
- **Set reduction targets:** Allows setting specific, measurable goals (e.g., "Reduce footprint by 20% by 2025").
- **Cost savings:** Reducing energy/fuel use saves money.
- **Marketing/Competitive advantage:** Companies can label products "Carbon Neutral" to attract eco-conscious customers.
- **Regulatory compliance:** Some countries mandate carbon reporting for large companies.
- **Offsetting:** Allows you to buy carbon credits (e.g., fund tree planting) to compensate for unavoidable emissions.

13. Explain about CDM and its limitations. (Medium)

- **CDM (Clean Development Mechanism):** A flexible mechanism under the **Kyoto Protocol**.
- **How it works:**
 - A developed country (with emission reduction target) invests in a **low-carbon project** (e.g., wind farm, solar plant, methane capture) in a developing country.
 - The project earns **Certified Emission Reductions (CERs)** – each CER = 1 tonne of CO₂ reduced.
 - The developed country buys CERs to meet its own emission targets.

- *Win-Win*: Developed country gets cheaper compliance; Developing country gets clean technology and investment.
 - **Limitations of CDM:**
 - **Additionality issue**: Many projects would have happened anyway (business as usual) but claimed CDM credits.
 - **Long approval process**: Bureaucratic and slow.
 - **Leakage**: Emissions reduced in one place may increase elsewhere.
 - **Concentration in big countries**: Most CDM projects went to China and India; Africa was neglected.
 - **Price crash**: After Kyoto Protocol ended, CER prices collapsed, reducing incentive.
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