GUJARAT TECHNOLOGICAL UNIVERSITY

BE- 4 SEMESTER – MID TERM – S26 – ANSWER BANK

Subject Name & Code:

ENVIRONMENTAL SCIENCE, SUSTAINABILITY AND RENEWABLE ENERGY- BE04000101

Important Question for Mid Sem Exam - Answer Bank

CO1 (3 Marks)

Q. Define Environmental Science and state its scope. List any three principles of Environmental Science.

- **Definition:** Environmental Science is an interdisciplinary academic field that integrates physical, biological, and information sciences (including ecology, biology, physics, chemistry, plant science, zoology, mineralogy, oceanology, limnology, soil science, geology, atmospheric science, and geodesy) to study the environment and find solutions to environmental problems.
- **Scope:** Its scope is vast and includes:
  - Understanding **natural processes** and ecosystems.
  - Studying the **impact of human activities** on the environment (pollution, resource depletion).
  - Developing solutions for **sustainable development** and conservation.
  - Addressing global issues like **climate change**, biodiversity loss, and public health.
- **Three Principles of Environmental Science:**
  - **Principle of Sustainability:** Natural resources must be used at a rate at which they can be replenished naturally.
  - **Principle of the Material Cycle:** Matter (resources) on Earth is finite and must be recycled to ensure continuous availability.
  - **The "Polluter Pays" Principle:** Those who cause pollution should bear the cost of mitigating its impact on human health and the environment.

Q. Explain the importance of environmental awareness for engineers.

Environmental awareness is crucial for engineers for the following reasons:

- **Sustainable Design:** It enables engineers to design projects (buildings, factories, infrastructure) that minimize resource consumption, waste, and pollution, promoting **sustainable development**.
- **Legal and Regulatory Compliance:** Engineers must ensure their projects comply with environmental laws and standards (like water/air quality norms) to avoid legal penalties and project delays.
- **Ethical Responsibility:** Engineers have a professional and ethical duty to protect public health and the environment from potential harm caused by technological or industrial projects.
- **Cost-Effectiveness:** Environmentally conscious design often leads to long-term savings through energy efficiency, waste reduction, and the use of sustainable materials.

CO2 (3 & 4 Marks)

Q. List the major sources of water pollution.

- **Point Sources:**
  - Industrial effluents discharged from factories and manufacturing plants.
  - Sewage and wastewater from municipal treatment plants.
- **Non-Point Sources:**
  - Agricultural runoff carrying fertilizers, pesticides, and animal waste.
  - Urban runoff from streets (oil, grease, heavy metals) and lawns.
- **Other Sources:**
  - Oil spills from tankers and offshore drilling.
  - Mining activities that release acids and heavy metals.
  - Improper disposal of solid waste in landfills (leachate).

Q. A residential area is located near a highway with heavy traffic. Apply the concept of noise pollution to explain its possible impact on human health.

- **Concept:** Noise pollution refers to unwanted or harmful levels of sound in the environment. The highway acts as a continuous source of this pollution.
- **Application to the Scenario:** The constant traffic from the highway generates high-intensity noise that invades the nearby residential area, disrupting the peaceful environment.
- **Impacts on Human Health:**
  - **Auditory Effects:** Prolonged exposure can lead to **permanent or temporary hearing loss**.
  - **Physiological Effects:** It triggers stress responses, leading to increased blood pressure, **hypertension**, and an elevated risk of **cardiovascular diseases**.
  - **Psychological Effects:** Causes annoyance, sleep disturbances, irritability, and reduced concentration, impacting overall **mental well-being and productivity**.

Q. Write short notes on PM (Particulate Matter) as an air pollutant.

- **Definition:** Particulate Matter (PM) refers to a complex mixture of extremely small solid particles and liquid droplets suspended in the air.
- **Types:** It is classified by size:
  - **PM10:** Inhalable particles with a diameter of 10 micrometers or less.
  - **PM2.5:** Fine inhalable particles with a diameter of 2.5 micrometers or less, which can penetrate deep into the lungs and even enter the bloodstream.
- **Sources:** Major sources include combustion engines (vehicles), industrial processes, power plants, construction sites, and dust storms.
- **Effects:** PM causes severe health problems like **respiratory illnesses** (asthma, bronchitis), **cardiovascular issues**, and can reduce visibility (haze). It also damages ecosystems and buildings.

Q. Identify common air pollutants and their sources.

- **Carbon Monoxide (CO):** Incomplete combustion of fossil fuels in vehicles and engines.
- **Sulphur Dioxide (SO_2):** Burning of coal and oil in power plants and industrial processes.
- **Nitrogen Oxides (NOx):** Vehicle engines, power plants, and industrial furnaces.
- **Particulate Matter (PM):** Construction sites, unpaved roads, agricultural activities,

and smoke from fires and industries.
- **Lead (Pb):** Formerly from gasoline, now primarily from metal processing and waste incinerators.
- **Ground-level Ozone (O_3):** Not directly emitted, but formed by a chemical reaction between NOx and Volatile Organic Compounds (VOCs) in the presence of sunlight.

Q. Define land pollution and list its main sources.
- **Definition:** Land pollution is the degradation or destruction of the Earth's surface and soil, directly or indirectly, as a result of human activities. It refers to the deposition of solid or liquid waste materials on land or underground in a manner that contaminates the soil and groundwater, threatens public health, and causes unsightly conditions.
- **Main Sources:**
  - **Solid Waste:** Municipal garbage, non-biodegradable materials like plastic, and industrial refuse.
  - **Agricultural Activities:** Overuse of chemical fertilizers, pesticides, and herbicides.
  - **Industrial Activities:** Disposal of hazardous waste, chemicals, and by-products on land.
  - **Mining:** Extraction processes leave behind large amounts of waste rock and tailings, leading to soil degradation.
  - **Deforestation and Soil Erosion:** Removal of trees leads to loss of fertile topsoil.

CO2 (7 Marks)

Q. Describe air pollutants and their effects. Explain the sources, causes and effects of land pollution.
Part 1: Air Pollutants and Their Effects
Air pollutants are substances in the air that can cause harm to humans, animals, vegetation, or materials. They can be primary (emitted directly) or secondary (formed in the atmosphere).

Pollutant	Major Sources	Effects
Carbon Monoxide (CO)	Incomplete fuel combustion (vehicles)	Reduces oxygen delivery to organs; causes headaches, dizziness, and can be fatal in high concentrations.
Sulphur Dioxide (SO_2)	Burning coal and oil (power plants)	Forms acid rain, damages respiratory systems, harms plants and degrades buildings.
Nitrogen Oxides (NOx)	Vehicle engines, power plants	Contributes to smog and acid rain, causes respiratory problems, and damages foliage.
Particulate Matter (PM)	Dust, smoke, combustion	Penetrates deep into lungs, causing asthma, bronchitis, and cardiovascular issues; reduces visibility.

Pollutant	Major Sources	Effects
Ground-level Ozone (O_3)	Formed from NOx and VOCs + sunlight	Irritates respiratory system, reduces lung function, damages crops and other plants.

Part 2: Land Pollution - Sources, Causes, and Effects

- **Definition:** Land pollution is the contamination of the soil and the degradation of the land surface through the misuse of land by human activities.
- **Sources and Causes:**
    1. **Solid Waste Accumulation:** The primary cause is the generation of massive amounts of municipal solid waste (MSW) like plastics, glass, paper, and food waste, which is often dumped unscientifically in landfills.
    2. **Agricultural Practices:** The overuse of chemical fertilizers, pesticides, and insecticides contaminates the soil, killing beneficial microorganisms and altering soil chemistry.
    3. **Industrial Activities:** Industries discharge hazardous chemicals, heavy metals, and effluents directly onto the ground, leading to long-term soil contamination.
    4. **Mining and Quarrying:** These activities expose huge amounts of waste rock and toxic tailings to the surface, leading to soil erosion and contamination.
    5. **Deforestation:** Removal of tree cover leads to soil erosion by wind and water, washing away the fertile topsoil and turning land barren.
- **Effects of Land Pollution:**
    1. **Loss of Soil Fertility:** Contamination and erosion reduce the soil's ability to support plant life, impacting agriculture.
    2. **Health Hazards:** Toxic chemicals and pathogens from waste can enter the food chain or leach into groundwater, causing serious diseases in humans and animals.
    3. **Contamination of Groundwater:** Rainwater percolating through polluted land (leachate) carries contaminants into the groundwater, making it unsafe for drinking.
    4. **Disruption of Ecosystems:** Land pollution destroys the habitats of many organisms, leading to a loss of biodiversity in the affected area.
    5. **Aesthetic Degradation:** Uncontrolled dumping and littering create unsightly and foul-smelling environments, reducing the quality of life.

Q. Explain water quality standards and their significance.

- **Definition:** Water quality standards are regulatory guidelines or criteria that set the permissible limits of physical, chemical, and biological parameters in water for its intended use. These standards are established by governmental or international bodies (like the WHO, BIS, or CPCB).
- **Key Parameters Monitored:**
    - **Physical:** Turbidity, color, taste, odor, temperature, total dissolved solids (TDS).
    - **Chemical:** pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), hardness, chlorides, heavy metals (lead, mercury, arsenic), and nutrients (nitrates, phosphates).
    - **Biological:** Presence of coliform bacteria (especially *E. coli*), which indicates fecal contamination.

- **Types of Standards:** Standards differ based on the intended use, such as:
    - **Drinking Water Standards:** Most stringent, ensuring water is safe for human consumption (e.g., IS 10500 in India).
    - **Surface Water Standards:** Classify water bodies based on their suitability for uses like bathing, fishing, or irrigation.
    - **Effluent Standards:** Set limits for the discharge of pollutants from industries and sewage treatment plants into water bodies.
- **Significance:**
    1. **Protection of Public Health:** By ensuring drinking water is free from harmful pathogens and toxic chemicals, standards prevent waterborne diseases (cholera, typhoid) and long-term health issues.
    2. **Environmental Protection:** Standards help maintain the health of aquatic ecosystems by ensuring sufficient DO levels and preventing eutrophication (excessive nutrient enrichment) in rivers and lakes.
    3. **Regulatory Compliance:** They provide a legal benchmark for controlling pollution. Industries are legally bound to treat their wastewater to meet effluent standards before discharge.
    4. **Uniformity and Benchmarking:** Standards provide a common framework for monitoring and comparing water quality across different regions and over time, helping in effective water resource management.
    5. **Sustainable Use:** They ensure that water is fit for its designated use (e.g., irrigation, recreation), promoting the sustainable utilization of water resources.

CO5 (3 & 4 Marks)

Q. Explain the need for renewable energy in sustainable development.
The need for renewable energy is central to achieving sustainable development for the following reasons:

- **Combating Climate Change:** Unlike fossil fuels, renewable sources (solar, wind, hydro) produce little to no greenhouse gas emissions, helping to mitigate **global warming**.
- **Energy Security and Independence:** They reduce dependence on finite, imported fossil fuels, enhancing a nation's **energy security** and protecting it from price volatility.
- **Resource Conservation:** Renewable energy sources are naturally replenished, ensuring that the energy needs of the present are met without compromising the ability of **future generations** to meet their own needs.
- **Environmental Protection:** They cause minimal environmental damage (e.g., no air/water pollution from extraction and burning), preserving **biodiversity and ecosystems**.

Q. List different types of renewable energy sources.

- **Solar Energy** (from sunlight)
- **Wind Energy** (from moving air)
- **Hydropower** (from flowing or falling water)
- **Biomass Energy** (from organic matter)
- **Geothermal Energy** (from heat inside the earth)
- **Tidal and Wave Energy** (from ocean currents and waves)

Q. Write a short note on biomass energy.

- **Definition:** Biomass energy is a renewable energy source derived from organic matter, known as biomass. This includes wood, agricultural crops and residues, animal manure, and municipal organic waste.
- **Principle:** The energy stored in biomass can be released by **direct combustion** (burning to produce heat) or by converting it into other fuels. Conversion methods include:
    - **Thermochemical:** Combustion, gasification (producing syngas), and pyrolysis (producing bio-oil).
    - **Biochemical:** Anaerobic digestion (producing biogas) and fermentation (producing ethanol).
- **Advantages:** It is widely available, carbon-neutral (the CO_2 released is absorbed during plant growth), and helps in waste management.
- **Disadvantages:** Can lead to deforestation if not managed sustainably, requires large land areas, and its combustion can still produce some air pollutants.

Q. List four advantages of tidal energy.

1. **Predictable and Reliable:** Tides are highly predictable due to gravitational forces, making energy generation more reliable compared to intermittent sources like solar or wind.
2. **High Energy Density:** Water is dense, so even at low speeds, tidal currents can carry a tremendous amount of energy, leading to high power output potential.
3. **Long Lifespan:** Tidal power plants, especially barrage systems, are known to have very long operational lifespans (75-100 years), making them a durable investment.

4. **Zero Emissions (Operational):** Once built, tidal power plants produce no greenhouse gases or other polluting emissions during operation.

CO5 (7 Marks)

Q. In desert regions where sunlight is available throughout the year, apply the principle of solar energy generation to explain how solar power plants can be used effectively.

- **Principle of Solar Energy Generation:** Solar power plants work on the principle of converting sunlight into electricity. This is done either **directly** using photovoltaics (PV) or **indirectly** using concentrated solar power (CSP). The core idea is to capture the sun's radiant energy and convert it into a usable form (electricity).
- **Application in Desert Regions:** Deserts possess ideal conditions for both technologies, making them highly effective locations for solar power plants.
    1. **High Solar Irradiance:** Deserts receive intense and consistent direct sunlight for most of the year. This maximizes the energy input for both PV panels and CSP mirrors, leading to a much higher **capacity factor** and electricity output compared to cloudier regions.
    2. **Vast, Flat, and Unused Land:** Deserts offer enormous expanses of flat, barren land with little competition for agriculture or habitation. This allows for the installation of **utility-scale solar farms** (like the ones in the Sahara or Thar Desert) covering hundreds of acres without land-use conflicts.
    3. **Effectiveness of Solar PV:** Photovoltaic panels in deserts can generate massive amounts of electricity during peak daylight hours. This power can be fed directly into a grid to support high daytime demand (e.g., from air conditioning).
    4. **Effectiveness of Concentrated Solar Power (CSP):** CSP plants use mirrors to concentrate sunlight to heat a fluid, which then creates steam to drive a turbine. Deserts are particularly suited for CSP because they require **direct normal irradiance** (DNI). A key advantage is that CSP plants can be equipped with **thermal energy storage** (e.g., molten salt tanks). This allows them to store heat during the day and continue generating electricity for several hours after sunset, addressing the challenge of intermittency and providing **dispatchable power**.
    5. **Reduced Efficiency Losses:** While high heat can slightly reduce PV efficiency, the overall annual energy yield in a desert is still vastly superior to most other locations. For CSP, the high ambient temperatures are beneficial for the thermal cycle.
- **Conclusion:** By leveraging their abundant sunlight and available land, desert regions can become global powerhouses for renewable energy, using a mix of PV and CSP with storage to provide clean, reliable electricity for local use and even for export via high-voltage direct current (HVDC) transmission lines.

Q. Define wind energy and list its advantages and limitations.

- **Definition:** Wind energy is a form of renewable energy that converts the kinetic energy of moving air (wind) into mechanical or electrical power. This conversion is typically done using **wind turbines**, where the wind turns the blades, which spin a shaft connected to a generator to produce electricity.
- **Advantages:**
    1. **Clean and Green:** It is a source of clean energy, producing no air pollution or

greenhouse gas emissions during operation.

2. **Renewable and Sustainable:** Wind is an inexhaustible resource, making it a key component of sustainable energy strategies.
3. **Cost-Effective:** Once a wind farm is built, the operational and maintenance costs are relatively low, making it one of the most competitive sources of electricity.
4. **Land-Friendly:** Turbines and the surrounding land can often be used for multiple purposes, such as agriculture (e.g., farming or grazing can continue around the turbine bases).
5. **Energy Independence:** It reduces reliance on imported fossil fuels, enhancing a nation's energy security.

- **Limitations:**
  1. **Intermittency and Variability:** Wind is not constant. Electricity generation fluctuates with wind speed, making it an **intermittent** source that cannot be dispatched on demand.
  2. **Visual and Noise Pollution:** Wind farms can be considered visually intrusive on landscapes and seascapes. Mechanical and aerodynamic noise from turbines can be a concern for nearby residents.
  3. **Threat to Wildlife:** Turbine blades can pose a collision risk for birds and bats.
  4. **Geographic Limitations:** Ideal locations for wind farms are often in remote areas (offshore or on mountain passes), which may require significant investment in new transmission lines to connect to the power grid.
  5. **High Initial Cost:** The upfront capital investment for manufacturing, transporting, and installing large wind turbines is substantial.

Q. Explain the principle of geothermal energy generation with advantages and limitations.

- **Principle of Geothermal Energy Generation:**
  Geothermal energy generation is based on the principle of harnessing the Earth's internal heat. This heat originates from the planet's formation and the radioactive decay of minerals. The process involves:
  1. **Accessing the Heat Source:** Wells are drilled deep into underground reservoirs of hot water or steam, often located near tectonic plate boundaries or volcanic regions.
  2. **Bringing the Energy to the Surface:** The high-pressure hot water or steam from the reservoir rises up through the production well to the surface.
  3. **Powering a Turbine:** The steam is directed through pipes to a turbine, causing its blades to spin. This converts thermal energy into mechanical energy. In some cases (flash steam plants), the hot water is "flashed" into steam by reducing its pressure.
  4. **Generating Electricity:** The spinning turbine shaft is connected to a generator, which converts the mechanical energy into electrical energy.
  5. **Re-injection (Closed-Loop):** After passing through the turbine, the steam is condensed back into water and re-injected into the reservoir via a separate injection well. This helps to sustain the reservoir pressure and makes the process more sustainable.
- **Advantages:**
  1. **Reliable and Consistent:** Unlike solar or wind, geothermal energy provides a **constant and predictable** baseload power supply, 24/7, regardless of weather conditions.

2. **Environmentally Friendly:** It emits very low levels of greenhouse gases compared to fossil fuels. The land footprint for a geothermal plant is relatively small.
3. **High Capacity Factor:** Modern geothermal plants can operate at a capacity factor of over 90%, meaning they are running at maximum power for most of the time.
4. **Sustainable:** With proper reservoir management and re-injection, the heat extracted can be replenished, making it a sustainable energy source.

- **Limitations:**
  1. **Location-Specific:** Geothermal resources are not universally available. Suitable sites are often limited to tectonically active regions (e.g., the "Ring of Fire"), requiring extensive and expensive exploration.
  2. **High Initial Costs:** Exploration, drilling, and plant construction require a very high upfront capital investment.
  3. **Potential for Induced Seismicity:** The process of drilling and fluid injection can sometimes trigger minor earthquakes.
  4. **Release of Harmful Gases:** While minimal, geothermal reservoirs can contain trapped gases like hydrogen sulfide (H_2S) and carbon dioxide (CO_2), which may be released during operation if not properly managed.
  5. **Reservoir Depletion:** If not managed carefully, the rate of heat extraction can exceed the rate of natural recharge, leading to a cooling of the reservoir over time.

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