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Course Title :Air Pollution and its Management
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Unit-I

Air pollutants and Chemical reactions in the atmosphere

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Air pollutants are classified based on their origin, state, chemical composition, and source.

- ***1. Classification by Origin***
- **Primary Pollutants:** Directly emitted from sources (e.g., CO, SO_2, NO).
- **Secondary Pollutants:** Formed in the atmosphere by chemical reactions (e.g., ozone, peroxyacetyl nitrate).
- ***2. Classification by State***
- **Gaseous Pollutants:** Exist in the gaseous state (e.g., CO, NO_2, SO_2).
- **Particulate Pollutants:** Suspended as solid or liquid particles (e.g., dust, smoke, aerosols).

• *3. Classification by Chemical Composition*

- **Organic Pollutants:** Contain carbon (e.g., hydrocarbons, volatile organic compounds).
- **Inorganic Pollutants:** Do not contain carbon (e.g., oxides of sulfur, nitrogen).

• *4. Classification by Source*

- **Natural Sources:** Volcanoes, forest fires, and natural decay.
- **Anthropogenic Sources:** Industrial activities, vehicles, and fossil fuel combustion.

Sources and Effects of Major Air Pollutants

- *1. Oxides of Carbon (CO and CO_2)*
- **Sources:**
  - Incomplete combustion of fossil fuels (CO).
  - Combustion of organic matter (CO_2).
  - Vehicle emissions and industrial processes.
- **Effects:**
  - **CO:** Binds with hemoglobin, reducing oxygen transport in the body, causing fatigue and respiratory issues.
  - **CO_2:** Contributes to global warming and climate change by enhancing the greenhouse effect.

2. Oxides of Nitrogen (NO and NO_2)

- **Sources:**
  - High-temperature combustion processes (vehicles, power plants).
  - Lightning and microbial action in soil.
- **Effects:**
  - Formation of photochemical smog and acid rain.
  - Irritation of respiratory systems and reduced lung function.
  - Contributes to eutrophication in water bodies.

3. Oxides of Sulfur (SO_2 and SO_3)

- **Sources:**
  - Burning of sulfur-containing fossil fuels (coal, oil).
  - Industrial emissions (smelting, refineries).
- **Effects:**
  - Respiratory and cardiovascular diseases.
  - Formation of acid rain, leading to soil and water acidification.
  - Damage to vegetation, buildings, and ecosystems.

4. Halogenated Compounds

- **Sources:**
  - Industrial chemicals (e.g., chlorofluorocarbons - CFCs, halons).
  - Solvents, refrigeration, and aerosol propellants.
- **Effects:**
  - Depletion of the ozone layer, increasing UV radiation exposure.
  - Toxicity to humans and ecosystems, contributing to climate change.

Ions in the Atmosphere

- Atmospheric ions are charged particles formed by ionization processes in the Earth's atmosphere. They play a critical role in atmospheric chemistry, weather phenomena, and pollution dynamics.
- ***Types of Atmospheric Ions***

1. **Positive Ions (Cations):**
    - Formed by the loss of electrons from atoms or molecules (e.g., Na^+, K^+, H_3O^+).
2. **Negative Ions (Anions):**
    - Formed by the gain of electrons (e.g., O_2^-, OH^-, Cl^-).

Sources of Atmospheric Ions

- **Natural Sources:** Cosmic rays, UV radiation, lightning, and radioactive decay.
- **Anthropogenic Sources:** Combustion processes, industrial activities, and pollutants.
- ***Importance of Ions***
- Facilitate cloud condensation and precipitation.
- Influence the electrical conductivity of the atmosphere.
- Participate in chemical reactions, such as ozone formation and pollutant transformation.

Meteorological Parameters

Meteorological conditions significantly influence atmospheric composition, pollution dispersion, and chemical reactions.

- ***1. Wind Speed***

- Determines the dispersion and transport of pollutants.
- Higher wind speeds reduce local pollution concentrations but can spread pollutants over large areas.

- ***2. Wind Direction***

- Affects pollutant transport and deposition.
- Helps identify pollutant sources and areas at risk of contamination.

Photochemical Processes

Photochemical processes involve the interaction of sunlight with atmospheric constituents, leading to the formation or transformation of pollutants.

- ***Oxidation Processes***

- Involve the reaction of atmospheric compounds with oxidizing agents (e.g., ozone, hydroxyl radicals).
- Example: CH4+OH→CH3+H2OCH_4 + OH \rightarrow CH_3 + H_2O
- These reactions degrade pollutants but can also produce secondary pollutants.

- ***Acid-Base Reactions***

- Occur between acidic oxides (SO_2, NO_x) and water vapor, forming acids.
- Example: SO2+H2O→H2SO3SO_2 + H_2O \rightarrow H_2SO_3
- Contribute to the formation of acid rain.

Photochemical Smog

- Photochemical smog is a mixture of pollutants formed under sunlight, primarily in urban areas.
- ***Components***
- Ground-level ozone, peroxyacetyl nitrate (PAN), aldehydes, and fine particulates.
- ***Formation Mechanism***
- Involves the reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight: NO2+UV→NO+ONO_2 + UV \rightarrow NO + O O+O2→O3O + O_2 \rightarrow O_3
- Secondary reactions produce smog components.
- ***Effects***
- Reduces visibility and causes respiratory and cardiovascular issues.
- Damages crops, vegetation, and materials.

Smog-Forming Reactions

1. **Ozone Formation:**
   - $NO+O3 \rightarrow NO2+O2NO + O_3 \backslash rightarrow NO_2 + O_2$
2. **PAN Formation:**
   - VOCs react with NO_x and oxygen under sunlight to form PAN:
     $RCHO+O2+NO2 \rightarrow RC(O)OONO2RCHO + O_2 + NO_2 \backslash rightarrow RC(O)OONO_2$

- ## Acid Rain

- Acid rain occurs when acidic oxides (SO_2, NO_x) react with atmospheric water, oxygen, and other chemicals to form acidic compounds.
- ***Key Reactions***

- $SO2+OH \rightarrow HOSO2SO_2 + OH \rightarrow HOSO_2$
- $HOSO2+O2 \rightarrow HO2+SO3HOSO_2 + O_2 \rightarrow HO_2 + SO_3$
- $SO3+H2O \rightarrow H2SO4SO_3 + H_2O \rightarrow H_2SO_4$
- $NO2+OH \rightarrow HNO3NO_2 + OH \rightarrow HNO_3$

- ***Effects***

1. **Environmental:**
    - Acidifies water bodies, harming aquatic life.
    - Damages forests and soil by leaching nutrients.
2. **Structural:**
    - Corrodes buildings, monuments, and infrastructure.
3. **Health:**

- Aggravates respiratory and cardiovascular diseases

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