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# Programme: M.Sc., Biotechnology(Environment)

**Course Title :AIR POLLUTION AND ITS MANAGEMENT**
**Course Code :CC05**

## Unit-III

## AIR QUALITY STANDARDS AND CONTROL OF AIR POLLUTION

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# Air Quality Standards

- Air quality standards are regulatory benchmarks established by governments or international organizations to protect human health and the environment from the harmful effects of air pollution. These standards specify permissible levels of pollutants, including particulate matter (PM2.5, PM10), nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), carbon monoxide (CO), ozone ($O_3$), and lead. Key organizations like the World Health Organization (WHO) and Environmental Protection Agencies (EPA) develop guidelines based on scientific evidence.
- **Examples of Standards:**
- WHO Air Quality Guidelines:
  - PM2.5: 5 µg/$m^3$ annual mean
  - PM10: 15 µg/$m^3$ annual mean
- National Ambient Air Quality Standards (NAAQS) in the U.S.:
  - $O_3$: 70 ppb (8-hour average)
  - CO: 9 ppm (8-hour average)

# Air Quality Index (AQI)

- The AQI is a numerical scale used to communicate the quality of air to the public in a simplified manner. It converts concentrations of air pollutants into a single value that ranges from 0 to 500. Higher values indicate worse air quality and greater health risks.
- **Categories of AQI:**
- 0–50: Good
- 51–100: Moderate
- 101–150: Unhealthy for Sensitive Groups
- 151–200: Unhealthy
- 201–300: Very Unhealthy
- 301–500: Hazardous

# Indoor Air Quality (IAQ)

- Indoor air quality refers to the condition of air within buildings and structures, affecting the health and comfort of occupants. Poor IAQ is caused by pollutants such as volatile organic compounds (VOCs), radon, carbon monoxide, mold, and dust. IAQ can be improved by ensuring proper ventilation, using air purifiers, and controlling sources of pollution.

- Control Methods for Air Pollutants
- **Absorption**
  - **Description:** A physical or chemical process where pollutants are removed from the air by dissolving them into a liquid (e.g., water or an alkaline solution).
  - **Applications:** Used in scrubbers to remove gases like $SO_2$ and $NO_2$.
  - **Advantages:** High efficiency for soluble gases, simple design.
  - **Disadvantages:** Requires disposal or treatment of the absorbent liquid.
- **Adsorption**
  - **Description:** A process where pollutants adhere to the surface of a solid material (e.g., activated carbon or silica gel).
  - **Applications:** Effective for VOCs and odors.
  - **Advantages:** High efficiency for low-concentration pollutants.
  - **Disadvantages:** Adsorbent materials require regeneration or replacement.

- **Condensation**
  - **Description:** A method where pollutants are cooled to their dew point, causing them to condense into a liquid for removal.
  - **Applications:** Common in industrial processes for controlling vapors and recovering valuable substances.
  - **Advantages:** Enables recovery of pollutants.
  - **Disadvantages:** Limited to pollutants with high boiling points.
- **Chemical Reactions**
  - **Description:** Involves chemical transformation of pollutants into less harmful substances using oxidizing or reducing agents.
  - **Applications:** Catalytic converters in vehicles transform CO and NOx into $CO_2$ and $N_2$.
  - **Advantages:** Effective for a wide range of pollutants.
  - **Disadvantages:** Requires specific catalysts or reagents.
- **Incineration**
  - **Description:** A process where combustible pollutants are burned at high temperatures, converting them into $CO_2$, water, and other harmless byproducts.
  - **Applications:** Used for VOCs, hazardous gases, and industrial emissions.
  - **Advantages:** High destruction efficiency.
  - **Disadvantages:** Expensive, generates secondary pollutants like $CO_2$.

# Devices for Air Pollution Control

- Air pollution control devices are designed to remove contaminants from exhaust gases, ensuring compliance with air quality standards. These devices are categorized based on the physical or chemical principles they employ, such as scrubbing, filtration, or electrostatic attraction. Below is a detailed note on various devices:

- Wet Scrubber
- **Principle:** Utilizes liquid (usually water or an alkaline solution) to capture particulate matter (PM) and gaseous pollutants.
- **Design:** Gas stream passes through a liquid medium, and contaminants are absorbed or trapped.
- **Applications:** Removal of $SO_2$, NOx, and particulates.
- **Advantages:** High efficiency for soluble pollutants, ability to handle hot gases.
- **Disadvantages:** Requires disposal of liquid waste.
- 2. Packed Towers
- **Principle:** Gas is passed through a packed bed (filled with solid packing materials), which increases the contact area for gas-liquid interaction.
- **Applications:** Absorption of gases like $CO_2$, $SO_2$.
- **Advantages:** High mass transfer efficiency.
- **Disadvantages:** Prone to clogging with high particulate loads.

- Plate Columns
- **Principle:** Consists of a series of perforated plates where gas and liquid interact for pollutant removal.
- **Applications:** Used for chemical absorption and gas-liquid separation.
- **Advantages:** Good contact efficiency.
- **Disadvantages:** High-pressure drop.
- 4. Spray Towers
- **Principle:** Polluted gas is sprayed with a liquid to remove particulates and gases.
- **Applications:** Common in odor control and gas cooling.
- **Advantages:** Simple design, can handle varying gas volumes.
- **Disadvantages:** Less efficient for fine particulates.

- Dry Scrubbers
- **Principle:** Uses a dry sorbent material to react with and neutralize pollutants.
- **Applications:** Effective for $SO_2$, acid gases.
- **Advantages:** Does not generate liquid waste.
- **Disadvantages:** Lower efficiency compared to wet scrubbers.
- 6. Gravity Separators
- **Principle:** Removes larger particulates by allowing them to settle under the influence of gravity.
- **Applications:** Pre-cleaning of air streams in industries.
- **Advantages:** Low cost, no moving parts.
- **Disadvantages:** Ineffective for fine particulates.

- 7. Baffle Chambers and Dust Louvers
- **Principle:** Gas flow is directed through baffles or louvers to reduce velocity, allowing particulates to settle.
- **Applications:** Pre-treatment for air pollution control systems.
- **Advantages:** Simple design, low energy requirement.
- **Disadvantages:** Limited efficiency for small particles.
- 8. Cyclones
- **Principle:** Uses centrifugal force to separate particulates from the gas stream.
- **Applications:** Effective for coarse particulates in industrial settings.
- **Advantages:** Low maintenance, no moving parts.
- **Disadvantages:** Inefficient for fine particulates.

- 9. Electrostatic Precipitators (ESPs)
- **Principle:** Ionizes gas stream to charge particulates, which are then attracted to oppositely charged collection plates.
- **Applications:** Widely used in power plants, cement industries.
- **Advantages:** High efficiency for fine particles.
- **Disadvantages:** High initial cost and maintenance.
- 10. Venturi Scrubber
- **Principle:** Gas is accelerated through a narrow venturi throat, where liquid droplets are introduced to capture particulates.
- **Applications:** Removal of fine particulates and gaseous pollutants.
- **Advantages:** High collection efficiency.
- **Disadvantages:** High energy consumption.

# The Air (Prevention and Control of Pollution) Act, 1981

- The Air (Prevention and Control of Pollution) Act, 1981, is a significant legislation enacted by the Government of India to combat air pollution and ensure the protection of air quality. It provides a framework for the prevention, control, and reduction of air pollution across the country.

- *Key Features of the Air Act, 1981*
- **Objective:**
  - To prevent, control, and abate air pollution.
  - To maintain and restore the quality of air.
- **Applicability:**
  - The Act applies to the entire country, with provisions extending to industrial and vehicular pollution sources.
- **Definitions:**
  - Air Pollution: The presence of pollutants in the atmosphere in quantities that harm human health, other living organisms, or the environment.
  - Pollutants: Substances like dust, fumes, gases, mist, odor, smoke, or vapors.
- **Central and State Boards:**
  - The Act establishes the **Central Pollution Control Board (CPCB)** and **State Pollution Control Boards (SPCBs)**.
  - **Functions of CPCB:**
    - Advising the government on air pollution control.
    - Coordinating activities of SPCBs.
    - Conducting research and monitoring air quality.
  - **Functions of SPCBs:**
    - Implementing the Air Act at the state level.
    - Issuing consents for establishing and operating industries.
    - Monitoring and inspecting industries for compliance.

- **Control of Emissions:**
  - The Act empowers SPCBs to set standards for air pollutants emitted by industries and vehicles.
  - Industries must obtain consent from SPCBs before discharging emissions into the air.
- **Declaration of Air Pollution Control Areas:**
  - The government can declare certain areas as air pollution control zones, prohibiting the use of specific fuels and restricting industrial activities.
- **Penalties for Non-Compliance:**
  - Violation of the Act can result in imprisonment up to six years and fines.
- **Amendments:**
  - The Act was amended in 1987 to strengthen enforcement mechanisms and increase penalties.

# Ministry of Environment, Forest, and Climate Change (MoEF&CC) Regulations

- The MoEF&CC is the apex body in India for implementing policies and programs related to environmental protection, including air quality management. The ministry formulates regulations, standards, and guidelines under various environmental laws.

- *Key MoEF&CC Regulations on Air Quality*
- **National Ambient Air Quality Standards (NAAQS):**
  - Established permissible limits for air pollutants like PM2.5, PM10, $SO_2$, $NO_2$, CO, $O_3$, and lead.
  - Updated periodically to align with global best practices.
- **Environmental Impact Assessment (EIA):**
  - Industries and infrastructure projects must conduct EIAs to assess air pollution impacts and propose mitigation measures before commencing operations.
- **Emission Standards for Industries:**
  - The MoEF&CC sets sector-specific emission standards for industries like power plants, cement factories, and steel plants.
  - Industries are required to install pollution control devices like ESPs, scrubbers, and bag filters.

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- **Vehicular Emission Norms:**
  - Implementation of Bharat Stage (BS) emission standards to regulate vehicular pollution.
  - Transition to BS-VI standards in 2020, aligning with European standards.

- **National Clean Air Programme (NCAP):**
  - Launched in 2019 to reduce PM2.5 and PM10 levels by 20-30% by 2024 in 122 cities.
  - Focuses on improving air quality through city-specific action plans.
- **Ban on Polluting Fuels:**
  - Prohibition of certain fuels like pet coke and furnace oil in industrial processes.
- **Control of Construction Dust:**
  - Guidelines for controlling dust emissions from construction and demolition activities.
- **Monitoring and Reporting:**
  - Continuous Emission Monitoring Systems (CEMS) mandated for industries to report real-time emissions data to regulatory authorities.

# Enforcement and Challenges

- **Enforcement:**
  - SPCBs and CPCB monitor compliance through inspections and audits.
  - Non-compliance leads to penalties, closure notices, or legal action.
- **Challenges:**
  - Lack of infrastructure and manpower for monitoring.
  - Poor enforcement in rural and peri-urban areas.
  - Increasing vehicular population and industrial activities.

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Thank You!