**Course No 05 Air Pollution**

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**1)Definition of Air Pollution:**

Air pollution is the **presence** of **substances** ( pollutants contaminants) in the atmosphere that are harmful to human health, the environment, or the **climate**.

**These substances,** known as pollutants, can include gases, chemicals, particulate matter (PM) and biological materials.

**2)** Categories **of Air pollution**

Air pollution is generally categorised into **two types**:

* **Primary Pollutants:** Directly emitted from sources like vehicles, factories, and natural events (e.g., volcanic **eruptions**).
* **Secondary Pollutants:** they are formed through chemical reactions between primary pollutants and other atmospheric components.

One of the most well-known **secondary pollutants** is **ground-level ozone (O₃)**.

**O3** This pollutant is formed when **nitrogen oxides (NOₓ)** and **volatile organic compounds (VOCs)**—both primary pollutants—react under sunlight.

**Nitrogen oxides (NOₓ)** primarily come from vehicles, power plants, and industrial emissions.

**Volatile organic compounds (VOCs)**

**Volatile Organic Compounds (VOCs)** are a group of organic chemicals that easily vaporize at normal temperatures and enter the atmosphere as gases.

VOCs can be emitted from both natural and human-made sources, and they contribute to air pollution by reacting with other pollutants (especially nitrogen oxides) in sunlight to form ground-level ozone and **smog**.

**Smog and ground-level ozone** They are released from sources like **vehicle exhaust** (Emitted from the high-temperature combustion of fuel in engines), gasoline fumes, industrial processes, and even certain plants.

**3) Major Sources of Air Pollution**

Air pollution originates from various natural and human-made **sources**.

**1. Human-Made Sources**

1. **Transportation**:

Vehicles powered by gasoline and diesel engines emit nitrogen oxides (NOₓ), carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM), and greenhouse gases (like CO₂).

**Particulate matter (PM:**

Particulate Matter (PM) is a mixture of solid particles and liquid droplets found in the air. These particles vary in size, composition, and origin and are often classified based on their **diameter**:

* **PM10:** Particles with diameters of 10 micrometers or smaller. These can be inhaled (Breathe In) and settle in the respiratory tract, causing respiratory issues.
* **PM2.5**: Fine particles with diameters of 2.5 micrometers or smaller, which can penetrate deep into the lungs and even enter the bloodstream, posing serious health risks.

These pollutants contribute to respiratory issues, climate change, and **smog**

**Smog:** Smog is severe air pollution that appears as a foggy layer in the atmosphere, in urban areas.

It forms when sunlight reacts with pollutants such as nitrogen oxides (NOₓ) and volatile organic compounds (VOCs) in the air.

**Smog** poses significant health and environmental risks, especially in densely populated areas with heavy traffic or industrial activity.

1. **Industry and Manufacturing**:

**Factories** and **power plants** release pollutants such as sulfur dioxide (SO₂), nitrogen oxides, VOCs, and particulate matter.

**Fossil fuel** combustion is especially prevalent in sectors like electricity generation, chemical manufacturing, and cement production, which produce significant air and greenhouse gas emissions.

1. **Agriculture**:

Agricultural activities produce ammonia (NH₃) from livestock waste and fertilizers. Methane (CH₄) is also released from livestock digestion.

Both gases contribute to smog and climate change, and ammonia can form fine particulate matter PM when it reacts with other pollutants.

1. **Construction and Demolition**:

Dust and particulate matter from construction activities affect air quality, particularly in urban areas.

These particles can contribute to respiratory issues, and large-scale construction generates additional emissions from heavy machinery and transportation of materials.

1. **Residential Heating and Cooking**:

Wood, coal, and biomass burning for cooking and heating produces significant pollutants, including carbon monoxide, particulate matter, which impact health and indoor air quality.

1. **Waste Burning and Landfills**:

The open burning of waste and landfill decomposition release pollutants **like**

**Dioxins**: highly toxic chemical compounds that are byproducts of various industrial processes and combustion activities. They are considered persistent organic pollutants (POPs) because they remain in the environment for long periods.

**Dioxins** pose serious health risks even at low concentrations.

**Furans**: are related to **dioxins** and share similar toxicological properties. They are considered persistent organic pollutants (POPs) and are often found in the environment as contaminants resulting from various industrial processes and combustion activities.

**Methane**, and other harmful compounds, which degrade air quality and contribute to climate change.

**2. Natural Sources (nature-made)**

**Wildfires**: Natural wildfires produce massive amounts of smoke, including **particulate matter**, **carbon monoxide**, and VOCs. Wildfire smoke can travel long distances, affecting air quality in areas far from the fire’s origin.

* **Volcanoes**: Volcanic eruptions emit sulfur dioxide, ash, and other gases. These emissions can lead to acid rain, impact air quality, and even influence climate patterns.
* **Dust Storms**: Arid and semi-arid regions can experience dust storms, which release large amounts of particulate matter into the air. These particles can affect respiratory health and carry pathogens over long distances.
* **Biogenic Emissions**: Plants and trees emit VOCs naturally, which can contribute to the formation of ground-level ozone when they react with NOₓ in the presence of sunlight. These emissions are particularly significant in forested areas.

**Each of these sources** contributes to the complexity of air pollution.

Human-made sources, however, tend to be more concentrated and constant, leading to a greater overall impact on health, ecosystems, and climate compared to most natural sources.