

Introduction to Air Pollution

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Key concepts, sources, impacts, and mitigation strategies

1. What Is Air Pollution?

Definition	Air pollution is the presence of substances in the atmosphere that are harmful to human health, ecosystems, or the climate.
Primary vs. Secondary	Primary pollutants are emitted directly from a source (e.g., CO ₂ from a factory). Secondary pollutants form in the atmosphere through chemical reactions (e.g., ozone O ₃ formed from NO _x and VOCs).
Units of Measurement	Concentrations are usually expressed as µg/m³ (micrograms per cubic meter) or ppm (parts per million).

2. Major Air Pollutants

Category	Common Examples	Typical Sources	Main Health/Environmental Effects
Particulate Matter (PM)	PM _{2.5} (<2.5µm), PM ₁₀ (<10µm)	Combustion (vehicles, power plants), dust, construction	Respiratory & cardiovascular disease, reduced visibility
Gaseous Pollutants	• Sulfur dioxide (SO₂) • Nitrogen oxides (NO_x) • Carbon monoxide (CO) • Ozone (O₃) • Volatile organic compounds (VOCs)	Fossil fuel combustion, industrial processes, vehicle exhaust, solvent use	Acid rain (SO ₂ , NO _x), smog (O ₃ , VOCs), impaired oxygen transport (CO)
Heavy Metals	Lead (Pb), Mercury (Hg), Arsenic (As)	Mining, smelting, waste incineration, coal combustion	Neurological damage, kidney dysfunction, bioaccumulation

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Greenhouse Gases (GHGs)	Carbon dioxide (CO ₂), Methane (CH ₄), Nitrous oxide (N ₂ O)	Fossil fuel use, agriculture, waste	Global warming, climate change impacts

3. Sources of Air Pollution

3.1 Natural Sources

- **Dust storms** (deserts, agricultural fields)
- **Wildfires** (combustion of biomass)
- **Volcanic eruptions** (SO₂, ash)
- **Biogenic emissions** (VOC from trees)

3.2 Anthropogenic (Human-Made) Sources

Sector	Typical Emissions	Representative Activities
Energy production	SO ₂ , NO _x , CO ₂ , PM	Coal-fired power plants, natural gas turbines
Transportation	CO, NO _x , VOC, PM _{2.5}	Cars, trucks, ships, aircraft
Industry & Manufacturing	VOC, heavy metals, PM	Steel mills, chemical plants, cement factories
Agriculture	NH ₃ , CH ₄ , N ₂ O	Livestock, fertilizer application, rice paddies
Residential	CO, PM, VOC	Cooking, heating with solid fuels, biomass burning

4. Impacts of Air Pollution

4.1 Human Health

- **Acute effects:** Irritation of eyes, nose, throat; asthma attacks; reduced lung function.
- **Chronic effects:** Lung cancer, chronic obstructive pulmonary disease (COPD), cardiovascular disease, developmental disorders in children.

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- **Vulnerable groups:** Children, elderly, people