

DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18NTO301T - APPLICATIONS OF NANOTECHNOLOGY
Module-I, Lecture-1

Environmental pollutants in Air

Air Pollution

- The present-day atmosphere is quite different from the natural atmosphere that existed before the Industrial Revolution (1760), in terms of chemical composition.
- If the natural atmosphere is considered to be “clean”, then this means that clean air cannot be found any where in today’s atmosphere.

What is Air Pollution?

Statements & Arguments

- One could claim that air pollution started when humans began burning fuels. In other words, all man-made (**Anthropogenic**) emissions into the air can be called air pollution, because they alter the chemical composition of the natural atmosphere.
- Or refine this approach and only consider anthropogenic emissions of harmful chemicals as air pollution.
 - “Harmful” could mean an adverse effect on the health of living things, an adverse effect on anthropogenic or natural non-living structures, or a reduction in the air’s visibility. Also, a chemical that does not cause any short-term harmful effects may accumulate in the atmosphere and create a long-term harmful effect.

What is Air Pollution?

Statements & Arguments

- Eg: Anthropogenic emissions of chlorofluorocarbons (CFCs) were once considered safe because they are inert in the lowest part of the atmosphere called the troposphere. However, once these chemicals enter the stratosphere, ultraviolet radiation can convert them into highly reactive species that can have a devastating effect on stratospheric ozone.
- Similarly, anthropogenic CO₂ emissions from combustion processes were considered safe because they are not toxic, but the long-term accumulation of CO₂ in the atmosphere may lead to a climate change, which could then be harmful to humans and the ecosystem.

What is Air Pollution?

Statements & Arguments

- Another drawback of this approach is that it does not consider natural emissions as air pollution even though they can be very harmful, such as gases and particles from volcanic eruptions, and smoke from forest fires caused by natural processes (lightning strikes).
- So besides anthropogenic emissions, it is useful to also consider Geogenic emissions and Biogenic emissions as contributors to air pollution.
 - Geogenic emissions are defined as emissions caused by the non-living world, such as volcanic emissions, sea-salt emissions, and natural fires.
 - Biogenic emissions come from the living world; such as volatile organic compound (VOC) emissions from forests and CH_4 emissions from swamps.

What is Air Pollution?

Statements & Arguments

- Human activity can also influence Geogenic and Biogenic emissions.
 - For example,
 - Human applications of nitrogen fertilizers in agriculture can result in increased biogenic emissions of nitrogen compounds from the soil. Also, humans can affect the biogenic emissions of VOC by cutting down trees or planting trees. Lastly, geogenic emissions of dust from the earth's surface can be altered if the surface is changed by human activity.

“Air Pollutant”

- So taking all of the above into account, we can define:

“Air pollutant” as any substance emitted into the air from an anthropogenic, biogenic, or geogenic source, that is either not part of the natural atmosphere or is present in higher concentrations than the natural atmosphere, and may cause a short-term or long-term adverse effect.

“Air Pollutant”

- Pollutants can be classified as **PRIMARY OR SECONDARY**.
- **PRIMARY POLLUTANTS** are substances that are directly emitted into the atmosphere from sources.
- The main primary pollutants known to cause harm in high enough concentrations are the following:
 - Carbon compounds, such as CO, CO₂, CH₄, and VOCs
 - Nitrogen compounds, such as NO, N₂O, and NH₃
 - Sulfur compounds, such as H₂S and SO₂
 - Halogen compounds, such as chlorides, fluorides, and bromides

“Air Pollutant”

- **SECONDARY POLLUTANTS** are not directly emitted from sources, but instead form in the atmosphere from primary pollutants (also called “precursors”). The main secondary pollutants known to cause harm in high enough concentrations are the following:
 - NO₂ and HNO₃ formed from NO
 - Ozone (O₃) formed from photochemical reactions of nitrogen oxides and VOCs
 - Sulfuric acid droplets formed from SO₂, and nitric acid droplets formed from NO₂
 - Sulfates and nitrates aerosols (e.g., ammonium (bi)sulfate and ammonium nitrate) formed from reactions of sulfuric acid droplets and nitric acid droplets with NH₃, respectively
 - Organic aerosols formed from VOCs in gas-to-particle reactions

Size of Pollutant

- **Particulate Matter** (PM or “aerosols”), either in solid or liquid form, which is usually categorized into these groups based on the aerodynamic diameter of the particles:
 1. Particles less than 100 microns, which are also called “inhalable” since they can easily enter the nose and mouth.
 2. Particles less than 10 microns (PM₁₀, often labeled “fine” in Europe). These particles are also called “thoracic” since they can penetrate deep in the respiratory system.
 3. Particles less than 4 microns. These particles are often called “respirable” because they are small enough to pass completely through the respiratory system and enter the bloodstream.
 4. Particles less than 2.5 microns (PM_{2.5}, labeled “fine” in the US).
 5. Particles less than 0.1 microns (PM_{0.1}, “ultrafine”).

Toxic Pollutants

- Hazardous air pollutants (HAPS), also called toxic air pollutants or air toxics, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects.
- Examples of toxic air pollutants include **benzene**, which is found in gasoline; **perchloroethylene**, which is emitted from some dry cleaning facilities; and **methylene chloride**, which is used as a solvent and paint stripper by a number of industries.

Radioactive Pollutants

- **Radioactivity** is an air pollutant that is both **Geogenic and Anthropogenic**.
- **Geogenic radioactivity** results from the presence of radionuclides, which originate either from radioactive minerals in the earth's crust or from the interaction of cosmic radiation with atmospheric gases.
- **Anthropogenic radioactive** emissions originate from nuclear reactors, the atomic energy industry (mining and processing of reactor fuel), nuclear weapon explosions, and plants that reprocess spent reactor fuel. Since coal contains small quantities of uranium and thorium, these radioactive elements can be emitted into the atmosphere from coal-fired power plants and other sources.

Indoor Pollutants

- When a building is not properly ventilated, pollutants can accumulate and reach concentrations greater than those typically found outside. This problem has received media attention as **“Sick Building Syndrome”**.
- **Environmental tobacco smoke (ETS)** is one of the main contributors to indoor pollution, as are CO, NO, and SO₂, which can be emitted from furnaces and stoves.
- Cleaning or remodeling a house is an activity that can contribute to elevated concentrations of harmful chemicals such as VOCs emitted from household cleaners, paint, and varnishes.
- Also, when bacteria die, they release endotoxins into the air, which can cause adverse health effects. So ventilation is important when cooking, cleaning, and disinfecting in a building.
- A geogenic source of indoor air pollution is radon.