

UNIT 2

Air pollution

Introduction

Air pollution refers to the release of pollutants into the air that are detrimental to human health and the planet as a whole. Air pollution is a change in the physical, chemical and biological characteristic of air that causes adverse effects on humans and other organisms. The ultimate result is a change in the natural environment and ecosystem.

Types of pollutants

An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as either primary or secondary. Usually, primary pollutants are substances directly emitted from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulphur dioxide released from factories.

Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone is one of the many secondary pollutants that causes photochemical smog.

(1) Major primary pollutants produced by human activity

i. Sulphur oxides (SO_x):

SO₂ is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide. Further oxidation of SO₂, usually in the presence of a catalyst such as NO₂, forms H₂SO₄, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.

ii. Nitrogen oxides (NO_x):

Especially nitrogen dioxide is emitted from high temperature combustion. Nitrogen dioxide is the chemical compound with the formula NO₂. It is responsible for photochemical smog, acid rain etc.

iii. Carbon monoxide:

It is a colourless, odourless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

iv. Carbon dioxide (CO₂):

A greenhouse gas emitted from combustion but is also a gas vital to living organisms. It is a natural gas in the atmosphere.

v. Volatile organic compounds:

VOCs are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane (CH₄) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming.

vi. Particulate matter:

Particulates alternatively referred to as particulate matter (PM) or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulate matter can be manmade or natural.

Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols.

Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10 per cent of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.

Sources pollutants

Sources of air pollution refer to the various locations, activities or factors which are responsible for the releasing of pollutants in the atmosphere. These sources can be classified into two major categories which are:

1. Anthropogenic sources (human activity)

It mostly related to burning different kinds of fuel:

- i. “Stationary Sources” include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices.
- ii. “Mobile Sources” include motor vehicles, marine vessels, aircraft and the effect of sound etc.
- iii. Chemicals, dust and controlled burn practices in agriculture and forestry management. Controlled or prescribed burning is a technique sometimes used in forest management, farming, prairie restoration or greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.
- iv. Fumes from paint, hair spray, varnish, aerosol sprays and other solvents.
- v. Waste deposition in landfills, which generate methane. Methane is not toxic; however, it is highly flammable and may form explosive mixtures with air. Methane is also an asphyxiate and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.

- vi. Military, such as nuclear weapons, toxic gases, germ warfare and rocketry.

2.Natural sources:

- i. Dust from natural sources, usually large areas of land with little or no vegetation.
- ii. Methane, emitted by the digestion of food by animals, for example cattle.
- iii. Radon gas from radioactive decay within the Earth's crust. Radon is a colourless, odourless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.
- iv. Smoke and carbon monoxide from wildfires.
- v. Volcanic activity, which produce sulphur, chlorine, and ash particulates.

Ozone layer and its importance Control measures

The ozone layer is a region of Earth's stratosphere that contains a relatively high concentration of ozone (O₃) molecules. It is located approximately 10 to 30 kilometers (6 to 19 miles) above Earth's surface. The ozone layer is important for several reasons:

1. Protection against Ultraviolet (UV) Radiation: One of the primary functions of the ozone layer is to absorb and block a significant portion of the Sun's harmful ultraviolet (UV) radiation, particularly the most dangerous UV-B and UV-C rays. This absorption of UV radiation helps protect life on Earth by preventing excessive exposure to these rays. UV radiation can cause various health problems in humans, including skin cancer, cataracts, and sunburn, and it can also harm ecosystems by affecting plants and marine life.
2. Preservation of Life: The ozone layer plays a crucial role in preserving life on Earth by shielding living organisms from the harmful effects of excessive UV radiation. Without the ozone layer, life as we know it would be at greater risk from the damaging effects of UV radiation.
3. Environmental Impact: Ozone in the stratosphere differs from ozone at ground level (tropospheric ozone). While ground-level ozone is considered a pollutant and harmful to human health, stratospheric ozone is essential for our well-being. Protecting the ozone layer helps maintain a healthy environment and ensures the well-being of the planet.
4. Climate Regulation: Some researchers have suggested that the ozone layer may play a role in regulating climate by influencing the distribution of solar energy in the stratosphere. Changes in the ozone layer can potentially impact climate patterns, although this is a complex and ongoing area of research.

Ozone depletion

Ozone depletion refers to the gradual reduction in the concentration of ozone (O₃) molecules in the ozone layer, particularly in the stratosphere of Earth's atmosphere. This phenomenon is primarily caused by the release of certain man-made chemicals known as ozone-depleting substances (ODS).

The most common ODS are chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform. These chemicals contain chlorine and bromine atoms, which have the ability to break down ozone molecules when they are released into the stratosphere.

The consequences of ozone depletion are significant and include:

1. **Increased Ultraviolet (UV) Radiation:** As the ozone layer becomes thinner due to depletion, more harmful UV-B and UV-C radiation from the sun reaches the Earth's surface. Increased UV radiation can have adverse effects on human health, including an increased risk of skin cancer, cataracts, and sunburn.
2. **Harm to Ecosystems:** Elevated UV radiation can harm terrestrial and aquatic ecosystems. It can negatively impact plant growth, damage phytoplankton in the oceans (which forms the basis of marine food chains), and disrupt the health of terrestrial and aquatic organisms.
3. **Ozone Holes:** In some regions, particularly over Antarctica, a severe thinning of the ozone layer has resulted in the formation of what is commonly referred to as the "ozone hole." This hole is a seasonal phenomenon and is most pronounced during the Southern Hemisphere's spring (September to November).

Control measures of ozone depletion

Control measures for addressing ozone depletion primarily focus on reducing and eventually eliminating the production and release of ozone-depleting substances (ODS). These measures are guided by international agreements, regulations, and policies. The most significant and effective control measure for ozone depletion is the Montreal Protocol, along with its subsequent amendments and adjustments. Here are the key control measures:

1. **Substitute Chemicals:** One of the key control measures is the identification and promotion of environmentally friendly substitute chemicals that do not deplete ozone. These include hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) as replacements for CFCs and halons in various applications like refrigeration, air conditioning, and fire extinguishing.
2. **Public Awareness and Education:** Public awareness campaigns and educational initiatives help inform individuals, businesses, and industries about the importance of ozone protection and the phase-out of ODS. These efforts encourage responsible practices and the use of ozone-friendly alternatives.
3. **Montreal Protocol:** The Montreal Protocol is an international treaty signed in 1987 with the goal of phasing out the production and consumption of ODS. It has been widely successful in reducing ODS emissions and mitigating ozone depletion. The protocol has undergone several amendments and adjustments to accelerate the phase-out schedule and include more substances. Countries that are parties to the protocol commit to specific reduction targets and timelines for phasing out ODS.
4. **Technological Innovation:** Encouraging research and development of new technologies and products that are ozone-friendly is essential. This includes the design of more energy-efficient appliances and systems that use ozone-safe refrigerants and propellants.

Acid rain and Control of acid rain

Acid rain is a type of environmental pollution that occurs when certain pollutants, primarily sulfur dioxide (SO₂) and nitrogen oxides (NO_x), are released into the atmosphere and react with water vapor, oxygen, and other chemicals to form acidic compounds. These acidic compounds then fall to the Earth's surface in precipitation, such as rain, snow, sleet, or fog. The term "acid rain" refers to any form of precipitation with a pH level below 5.6, which is slightly acidic.

Causes:

Acid rain is primarily caused by human activities, such as the burning of fossil fuels (coal, oil, and natural gas) in power plants, industrial facilities, and vehicles. These activities release sulfur dioxide and nitrogen oxides into the atmosphere. Natural sources like volcanic eruptions can also contribute to acid rain but to a lesser extent.

Chemical Reactions: In the atmosphere, sulfur dioxide and nitrogen oxides react with oxygen and atmospheric moisture to form sulfuric acid (H₂SO₄) and nitric acid (HNO₃), respectively. These acids are carried by winds and can travel long distances before being deposited as acid rain.

Environmental Impact: Acid rain can have detrimental effects on the environment. It can harm aquatic ecosystems by making rivers, lakes, and streams more acidic, which can lead to the death of fish and other aquatic life. It can also damage forests by leaching important nutrients from the soil and weakening trees. Additionally, it can corrode buildings, monuments, and infrastructure made of limestone, marble, or concrete.

Health Impact: While the direct health effects of acid rain are less significant than its environmental impacts, exposure to acid rain can irritate the respiratory system and worsen existing respiratory conditions in humans, such as asthma and bronchitis.

Control Measures: Efforts to reduce acid rain have focused on reducing emissions of sulfur dioxide and nitrogen oxides from industrial sources and vehicles. This has been achieved through the implementation of regulations and technological advancements, such as the use of cleaner fuels and the installation of pollution control devices on power plants.

Green House effect and Global warming

The greenhouse effect is a natural process that occurs in Earth's atmosphere and plays a crucial role in maintaining the planet's temperature at a level conducive to supporting life.

Here's how the greenhouse effect works:

1. **Solar Radiation:** The Sun emits energy in the form of visible light and other electromagnetic radiation. A significant portion of this solar radiation reaches the Earth.
2. **Absorption and Reflection:** When solar radiation reaches Earth, some of it is absorbed by the planet's surface (land, water, and vegetation), warming the surface. The rest of the incoming solar energy is reflected back into space by clouds, the Earth's surface, and other reflective surfaces.
3. **Infrared Radiation:** As the Earth's surface is heated by the absorbed solar energy, it emits heat in the form of infrared radiation (also known as thermal radiation). Infrared radiation has longer wavelengths than visible light.
4. **Greenhouse Gases:** Certain atmospheric gases, known as greenhouse gases (GHGs), including carbon dioxide (CO₂), methane (CH₄), water vapor (H₂O), and others, have the unique property of being transparent to incoming solar radiation but absorbing and re-emitting infrared radiation.

5. **Trapping Heat:** Greenhouse gases in the atmosphere trap some of the outgoing infrared radiation, preventing it from escaping directly into space. This trapped heat warms the atmosphere and the Earth's surface, creating a natural greenhouse effect.
6. **Temperature Regulation:** The greenhouse effect helps regulate the planet's temperature. Without it, the Earth's average surface temperature would be much colder and less hospitable to life as we know it.

Global warming

Global warming refers to the long-term increase in the average surface temperature of the Earth's climate system. It is a key aspect of climate change and is primarily driven by human activities that release greenhouse gases (GHGs) into the atmosphere. The most significant of these greenhouse gases include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O).

1. **Human-Induced Global Warming:** The current global warming trend is largely attributed to human activities, particularly the burning of fossil fuels (such as coal, oil, and natural gas) for energy production, industrial processes, and transportation. These activities release large quantities of carbon dioxide into the atmosphere.
2. **Enhanced Greenhouse Effect:** The enhanced greenhouse effect occurs when the concentration of greenhouse gases in the atmosphere increases, trapping more heat from the Sun and preventing it from escaping back into space. This leads to a rise in global temperatures.
3. **Temperature Increase:** Over the past century, Earth's average surface temperature has risen significantly. This warming is evident in rising global temperatures, increased temperatures in oceans, and temperature records being broken more frequently.
4. **Consequences:** Global warming has far-reaching consequences for the planet, including:
 - **Melting Polar Ice and Glaciers:** Rising temperatures lead to the melting of polar ice caps and glaciers, contributing to rising sea levels.
 - **Sea-Level Rise:** As ice melts and seawater expands due to warming, global sea levels rise, threatening coastal communities and ecosystems.
 - **Extreme Weather Events:** Global warming is linked to an increase in the frequency and severity of extreme weather events such as hurricanes, heatwaves, droughts, and heavy rainfall events.
 - **Ecosystem Disruption:** Changes in temperature and precipitation patterns can disrupt ecosystems, leading to shifts in the distribution of plant and animal species.
 - **Ocean Acidification:** Increased carbon dioxide in the atmosphere is absorbed by the oceans, leading to ocean acidification, which can harm marine life.
 - **Threats to Agriculture and Food Security:** Changing climate conditions can impact crop yields, water availability, and food production, posing challenges to global food security.

Photochemical smog

Photochemical smog is a type of air pollution that forms when certain pollutants in the atmosphere interact with sunlight. It is characterized by a hazy, brownish-gray appearance in the atmosphere and can have harmful effects on human health and the environment. Photochemical smog is primarily associated with urban areas and is a common issue in

regions with high levels of automobile traffic and industrial activity. Here are the key components and characteristics of photochemical smog:

Formation: Photochemical smog forms through a complex series of chemical reactions that involve pollutants, primarily nitrogen oxides (NO_x) and volatile organic compounds (VOCs), in the presence of sunlight. These reactions are most prominent on hot, sunny days.

Health Effects: Exposure to photochemical smog can have several health effects, including:

- Irritation of the eyes, nose, and throat
- Aggravation of respiratory conditions such as asthma and bronchitis
- Reduced lung function
- Increased susceptibility to respiratory infections

Environmental Impact: Photochemical smog can harm vegetation, damage buildings and materials, and contribute to the formation of acid rain when ozone interacts with other pollutants in the atmosphere.

Control Measures: Strategies to reduce photochemical smog include:

- **Reducing Emissions:** Implementing regulations to reduce emissions of nitrogen oxides and volatile organic compounds from vehicles and industrial sources.
- **Promoting Cleaner Transportation:** Encouraging the use of public transportation, electric vehicles, and carpooling to reduce traffic-related emissions.
- **Air Quality Alerts:** Issuing air quality alerts and advisories on days when high levels of photochemical smog are expected, prompting people to take precautions.

Effects of pollution on plants and human beings

Effects of Pollution on Plants:

1. **Reduced Photosynthesis:** Air pollution, particularly the presence of ground-level ozone (a component of smog) and other pollutants, can interfere with the process of photosynthesis in plants. This results in reduced plant growth and crop yields.
2. **Leaf Damage:** Air pollutants like sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) can cause visible damage to plant leaves. They can lead to stippling, necrosis, and discoloration, which hinder the plant's ability to photosynthesize effectively.
3. **Stunted Growth:** Pollution can lead to stunted growth in plants by disrupting nutrient uptake and altering soil pH levels. Contaminants like heavy metals in soil can also negatively impact plant health.
4. **Weakened Immune Systems:** Prolonged exposure to pollution weakens a plant's immune system, making it more susceptible to diseases, pests, and other stressors.
5. **Altered Reproduction:** Pollutants can affect the reproductive processes of plants, leading to decreased seed production and fruit yield.

Effects of Pollution on Human Beings:

1. **Respiratory Problems:** Exposure to air pollutants such as particulate matter (PM), ground-level ozone (O₃), and nitrogen oxides (NO_x) can lead to a range of respiratory problems in humans, including asthma, bronchitis, and reduced lung function. Long-term exposure may increase the risk of chronic respiratory diseases.

2. **Cardiovascular Issues:** Air pollution has been linked to an increased risk of cardiovascular diseases, including heart attacks, strokes, and hypertension.
3. **Cancer:** Some air pollutants, like benzene, formaldehyde, and polycyclic aromatic hydrocarbons (PAHs), are carcinogenic and can increase the risk of cancer, particularly lung cancer.
4. **Neurological Effects:** Emerging research suggests that air pollution may have adverse effects on the central nervous system and cognitive function. It has been linked to conditions like cognitive decline and neurodevelopmental disorders in children.
5. **Pregnancy Complications:** Pregnant women exposed to air pollution may experience complications such as preterm birth, low birth weight, and developmental issues in their children.
6. **Skin Problems:** Air pollutants can cause or exacerbate skin conditions such as acne, dermatitis, and allergies.
7. **Waterborne Diseases:** Water pollution, which can result from the discharge of contaminants into rivers, lakes, and oceans, can lead to the spread of waterborne diseases like cholera and dysentery.
8. **Toxic Chemical Exposure:** Exposure to hazardous chemicals in the environment, such as heavy metals (e.g., lead, mercury) and industrial pollutants, can result in poisoning and serious health problems.
9. **Endocrine Disruption:** Some pollutants, known as endocrine-disrupting chemicals (EDCs), can interfere with the body's hormonal systems, potentially leading to reproductive problems, developmental issues, and other health concerns.
10. **Mental Health:** Poor air quality and environmental pollution can contribute to stress and mental health issues, potentially exacerbating conditions like anxiety and depression.

Control of air pollution

Controlling air pollution is essential to protect human health, the environment, and the quality of the air we breathe. Various strategies and measures have been implemented worldwide to reduce and prevent air pollution. These control measures can be grouped into several categories:

1. **Waste Management:**
 - **Recycling and Waste Reduction:** Promoting recycling and waste reduction efforts can reduce emissions from landfills and incineration.
 - **Waste-to-Energy:** Utilizing waste-to-energy technologies can reduce the environmental impact of waste disposal.
2. **Regulations and Standards:**
 - **Emission Standards:** Governments set and enforce limits on the amount of pollutants that industries, vehicles, and other sources can release into the atmosphere. These standards are designed to reduce emissions of harmful substances, such as sulfur dioxide (SO₂), nitrogen oxides (NO_x), and particulate matter (PM).
 - **Vehicle Emission Standards:** Strict regulations on vehicle emissions, including tailpipe emissions and fuel quality, can significantly reduce air pollution from the transportation sector.
3. **Clean Energy Sources:**

- **Transition to Renewable Energy:** Promoting and incentivizing the use of renewable energy sources like solar, wind, and hydropower can reduce emissions from power plants that burn fossil fuels.
- **Energy Efficiency:** Encouraging energy-efficient technologies and practices in homes, industries, and transportation can reduce energy consumption and emissions.

4. **Industrial and Technological Improvements:**

- **Use of Cleaner Technologies:** Industries can adopt cleaner production processes and technologies, such as scrubbers and filters, to reduce emissions of pollutants.
- **Best Available Technology:** Implementing the best available control technology (BACT) helps industries meet emission standards and minimize pollution.

5. **Transportation Strategies:**

- **Public Transportation:** Promoting the use of public transportation, cycling, and walking can reduce the number of vehicles on the road, leading to lower emissions.
- **Electric Vehicles (EVs):** Supporting the adoption of electric vehicles can reduce emissions from the transportation sector.
- **Urban Planning:** Well-planned cities with efficient public transportation systems can reduce the need for private vehicles and mitigate traffic-related pollution.

Noise Pollution

Noise pollution, also known as sound pollution, is the presence of unwanted or harmful sound in the environment that disrupts normal activities, causes annoyance, or has adverse effects on human health and well-being. Noise pollution can originate from various sources and can manifest in both outdoor and indoor environments. Here are key aspects of noise pollution:

Sources of Noise Pollution:

1. **Transportation:** Traffic noise, including road traffic (cars, trucks, motorcycles), railway noise, and airport noise, is a significant source of noise pollution in urban areas.
2. **Industrial Activities:** Factories, manufacturing plants, construction sites, and heavy machinery generate substantial noise pollution.
3. **Construction and Demolition:** Construction activities, including excavation, drilling, and pile driving, produce loud and continuous noise.
4. **Recreational Activities:** Recreational sources of noise include loud music, sporting events, and entertainment venues.
5. **Commercial Activities:** Noise from commercial establishments such as bars, restaurants, and nightclubs can disrupt nearby residents.
6. **Agricultural Machinery:** Farm machinery, including tractors and combine harvesters, generates noise pollution in rural areas.
7. **Household Appliances:** Noisy household appliances like vacuum cleaners, lawn mowers, and power tools can contribute to indoor noise pollution.

8. **Outdoor Events:** Public gatherings, festivals, and outdoor concerts can produce high levels of noise pollution.

Effects of Noise Pollution:

1. **Health Effects:** Prolonged exposure to high noise levels can have adverse health effects, including stress, increased blood pressure, sleep disturbances, and hearing impairment.
2. **Psychological Impact:** Noise pollution can lead to irritation, anxiety, and reduced overall quality of life.
3. **Cognitive Impairment:** Persistent noise can impair concentration and cognitive performance, particularly in children and students.
4. **Communication Interference:** Excessive noise can interfere with effective communication, both in social settings and at workplaces.
5. **Hearing Loss:** Noise pollution can lead to temporary or permanent hearing loss, particularly among individuals exposed to loud occupational or recreational environments.
6. **Impact on Wildlife:** Noise pollution can disrupt wildlife behavior, leading to changes in mating, feeding, and migration patterns. It can also interfere with echolocation in marine animals.

Control Measures for Noise Pollution:

1. **Regulations and Standards:** Governments often establish noise limits and zoning regulations to control noise emissions from various sources, including transportation and industrial activities.
2. **Urban Planning:** Careful urban planning, such as designing noise barriers along highways, locating noisy facilities away from residential areas, and implementing green spaces, can help mitigate noise pollution in cities.
3. **Noise Barriers:** Installing noise barriers or sound walls along highways and railways can reduce the transmission of noise to nearby communities.
4. **Improved Technology:** The development and use of quieter technologies in transportation, construction, and industrial machinery can help reduce noise pollution.
5. **Noise Insulation:** Soundproofing techniques, such as double-glazed windows, acoustic panels, and insulation materials, can be applied to buildings to reduce indoor noise levels.
6. **Public Awareness:** Raising public awareness about the impact of noise pollution and promoting responsible behavior, such as reducing unnecessary noise, can contribute to mitigation efforts.
7. **Community Initiatives:** Local communities and neighborhood associations can work together to address noise concerns and advocate for noise reduction measures.
8. **Noise Monitoring:** Regular monitoring of noise levels in urban areas helps identify sources of noise pollution and assess the effectiveness of control measures.