

## Introduction and classification of air pollutants

### 1. Introduction

- Air pollution is the introduction into the atmosphere of chemicals, particulates, or biological materials that cause discomfort, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment.
- A substance in the air that can be adverse to humans and the environment is known as an air pollutant. 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 primary or secondary. Usually, primary pollutants are directly produced 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 – one of the many secondary pollutants that make up photochemical smog.

### 2. Classification of air pollutants

#### 2.1. Primary air pollutants

Major primary pollutants produced by human activity include:

#### Sulphur oxides (SO<sub>x</sub>)

- Sulphur oxides (SO<sub>x</sub>) especially sulphur dioxide (SO<sub>2</sub>) is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulphur compounds, their combustion generates sulfur dioxide.
- Further oxidation of SO<sub>2</sub> forms H<sub>2</sub>SO<sub>4</sub>, and thus acid rain that has adverse effects on the environment.

#### Nitrogen oxides (NO<sub>x</sub>)

- Nitrogen oxides (NO<sub>x</sub>) especially nitrogen dioxide (NO<sub>2</sub>) are expelled from high temperature combustion and are also produced naturally during thunderstorms by electric discharge.

- NO<sub>2</sub> is reddish-brown toxic gas with characteristic sharp, biting odor and is one of the most prominent air pollutants.

### **Carbon monoxide (CO)**

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.

### **Volatile organic compounds (VOCs)**

- VOCs are an important outdoor air pollutant. These are divided into categories of methane (CH<sub>4</sub>) and nonmethane (NMVOCs).
- Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming.
- Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukemia through prolonged exposure.

### **Particulates**

- Particulates, alternatively referred to as particulate matter (PM), atmospheric particulate matter, 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 particulates 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.

### **Persistent free radicals**

Persistent free radicals connected to airborne fine particles could cause cardiopulmonary disease. Toxic metals, such as lead and mercury, especially their compounds.

### **Chlorofluorocarbons (CFCs)**

Chlorofluorocarbons (CFCs) harmful to the ozone layer emitted from products currently banned from use.

### **Ammonia (NH<sub>3</sub>)**

Ammonia (NH<sub>3</sub>) is emitted from agricultural processes. It is normally encountered as a gas with a characteristic pungent odor. Although in wide use, ammonia is both caustic and hazardous.

### **Odors**

Such as from garbage, sewage, and industrial processes

### **Radioactive pollutants**

These are produced by nuclear explosions, nuclear events, war explosives, and natural processes such as the radioactive decay of radon.

## **2.2. Secondary pollutants**

Secondary pollutants include the following

### **Particulates**

- Particulates created from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution; the word "smog" is a portmanteau of smoke and fog.
- Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulphur dioxide.
- Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

### **Ground level ozone (O<sub>3</sub>)**

- Ground level ozone is formed from NO<sub>x</sub> and VOCs. Ozone (O<sub>3</sub>) is a key constituent of the troposphere. It is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer.

- Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities (largely the combustion of fossil fuel), it is a pollutant, and a constituent of smog.

### **3. Classification of air pollutants based on their chemical composition**

#### **3.1. Organic air pollutants**

These pollutants are mainly composed of carbon and hydrogen. In addition, oxygen, nitrogen, sulfur and phosphorus may also be present like hydrocarbons, organic sulfur compounds, aldehydes, ketones and carboxylic acids.

#### **3.2. Inorganic air pollutants**

These are purely inorganic in nature like Carbon dioxide, carbon monoxide, oxides of sulfur, oxides of nitrogen.

### **4. Criteria pollutants**

The Environmental Protection Agency has identified six common air contaminants that it calls "criteria pollutants." The Clean Air Act strictly controls allowable levels of these six contaminants, based on their effects on human health and the environment. The six criteria pollutants are:

- Lead
- Ozone
- Carbon Monoxide
- Nitrogen Oxides
- Particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>)
- Sulfur Dioxides

**Table: National ambient air quality standards for criteria pollutants**

National Ambient Air Quality Standards for Criteria Pollutants			
Pollutant	Primary Standard	Secondary Standard	Regulation Allowance
Ozone (O <sub>3</sub> )	8-hour average concentration 0.070 parts per million (ppm)	Same as primary	3-year average of the annual fourth-highest daily maximum concentration at or below the standard.
Carbon Monoxide (CO)	8-hour average concentration 9 ppm	N/A	Not to be exceeded more than once per year
	1-hour average concentration 35 ppm	N/A	Not to be exceeded more than once per year
Nitrogen Dioxide (NO <sub>2</sub> )	1-hour average concentration 100 parts per billion (ppb)	N/A	3-year average of 98 <sup>th</sup> percentile concentration at or below the standard
	Annual Arithmetic Mean 53 ppb	Same as primary	Annual Mean
Particulate Matter (PM <sub>10</sub> )	24-hour average concentration 150 micrograms per cubic meter (µg/m <sup>3</sup> )	Same as primary	Not to be exceeded more than once per year on average over a 3-year period.
Particulate Matter (PM <sub>2.5</sub> )	24-hour average concentration 35 µg/m <sup>3</sup>	Same as primary	3-year average of 98 <sup>th</sup> percentile concentration at or below the standard
	Annual Arithmetic Mean: 12 µg/m <sup>3</sup>	Annual Arithmetic Mean: 15 µg/m <sup>3</sup>	3-year average at or below the standard
Sulfur Dioxide (SO <sub>2</sub> )	1-hour average concentration 75 ppb	Maximum 3-Hour concentration 0.5 ppb	3-year average of 99 <sup>th</sup> percentile of 1 hr daily maximum conc. at or below standard (primary). Not to be exceeded more than once per year (secondary)
Lead	Rolling 3-month average 0.15 µg/m <sup>3</sup>	Same as primary	Not to be exceeded.

## 5. Causes of air pollution

Air pollution can result from both human and natural actions.

### 5.1. Man-made sources

Man-made sources mostly related to burning different kinds of fuel.

- 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. In developing and poor countries, traditional biomass burning is the major source of air pollutants; traditional biomass includes wood, crop waste and dung.
- Mobile sources include motor vehicles, marine vessels, aircraft and the effect of sound etc. 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.

- Fumes from paint, hair spray, varnish, aerosol sprays and other solvents.
- Waste deposition in landfills, which generate methane. Methane is highly flammable and may form explosive mixtures with air.
- Military, such as nuclear weapons, toxic gases, germ warfare and rocketry.

### 5.2. Natural sources

- Dust from natural sources, usually large areas of land with few or no vegetation.
- Methane, emitted by the digestion of food by animals, for example cattle.
- Smoke and carbon monoxide from wildfires.
- Vegetation, in some regions, emits environmentally significant amounts of VOCs on warmer days. These VOCs react with primary anthropogenic pollutants – specifically, NO<sub>x</sub>, SO<sub>2</sub>, and anthropogenic organic carbon compounds – to produce a seasonal haze of secondary pollutants.
- Volcanic activity, which produce sulfur, chlorine, and ash particulates.

Table 21.1 MAJOR NATURAL AND HUMAN-PRODUCED COMPONENTS OF SELECTED AIR POLLUTANTS

AIR POLLUTANTS	EMISSIONS (% OF TOTAL)		MAJOR SOURCES OF HUMAN-PRODUCED COMPONENTS	PERCENT
	NATURAL	HUMAN-PRODUCED		
Particulates	85	15	Fugitive (mostly dust)	85
			Industrial processes	7
			Combustion of fuels (stationary sources)	8
Sulfur oxides (SO <sub>x</sub> )	50	50	Combustion of fuels (stationary sources, mostly coal)	84
			Industrial processes	9
Carbon monoxide (CO)	91	9	Transportation (automobiles)	54
Nitrogen dioxide (NO <sub>2</sub> )		Nearly all	Transportation (mostly automobiles)	37
			Combustion of fuels (stationary sources, mostly natural gas and coal)	38
Ozone (O <sub>3</sub> )	A secondary pollutant derived from reaction with sunlight NO <sub>2</sub> , and oxygen (O <sub>2</sub> )		Concentration present depends on reaction in lower atmosphere involving hydrocarbons and thus automobile exhaust	
Hydrocarbons (HC)	84	16	Transportation (automobiles)	27
			Industrial processes	7