

# Introduction

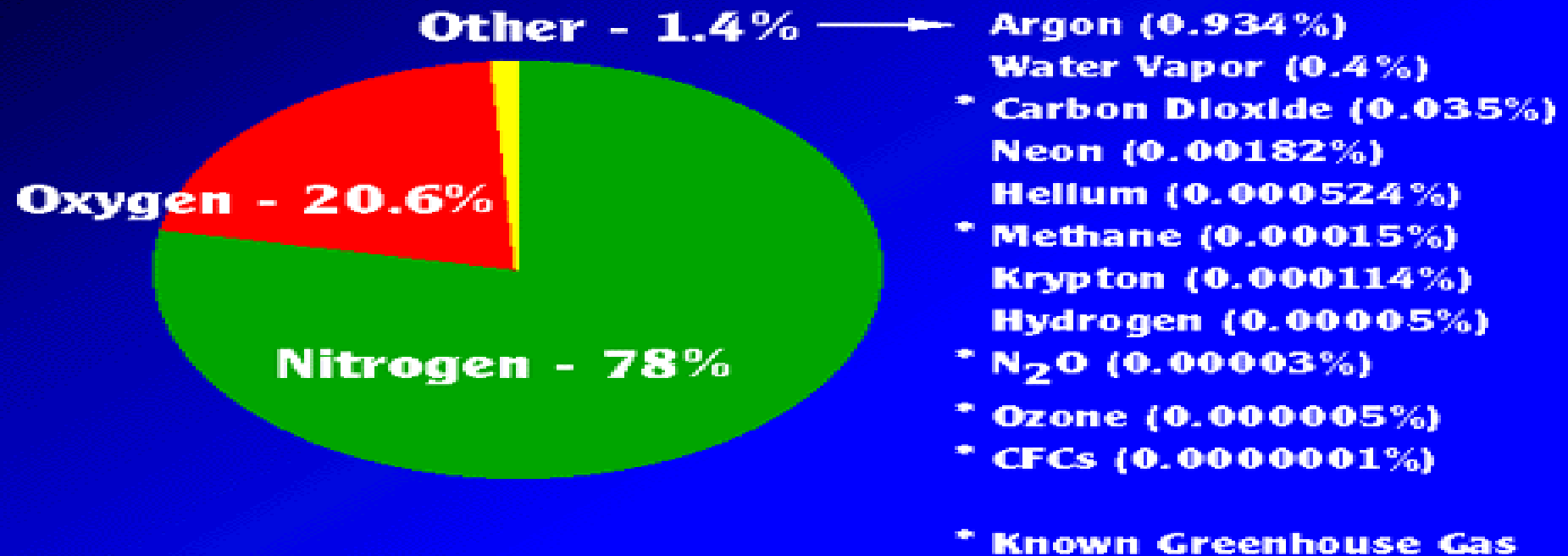
- Air pollution is not a new problem. It has been with society since at least the middle ages. In recent times, due largely to increased population and increased industrialization, it has come to the forefront of public concern. Where the style and pace of modern life have placed heavy demands on certain forms of energy and raw materials.
- **Pollution** is the release of chemical, physical, biological or radioactive contaminants to the [environment](#).

# Principal forms of pollution

- Principal forms of pollution include:
- [air pollution](#)
- [water pollution](#)
- [soil contamination](#)
- [radioactive contamination](#)
- [noise pollution](#)
- [light pollution](#)
- [visual pollution](#)

# Composition of clean, dry air

## Composition of the Earth's Atmosphere (Gases - Percent by Volume)



# Air pollution

- Air pollution is a broad term applied to any chemical, physical (e.g. particulate matter), or biological agent that modifies the natural characteristics of the atmosphere. The atmosphere is a complex, dynamic natural system that is essential to support life on planet earth.
- Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the earth's ecosystems.

# Sources and Classification of Air Pollution

- Most researchers commonly are classified air pollution on the basis of the followings :
- 1) differences in their physical or chemical characteristics:
- Aerosols are tiny particles dispersed in gases and include both liquid and solid particles. Air pollution terminology relating to atmospheric aerosols includes dusts, fog, fumes, hazes, mists, particulate matter, smog, smoke, and soot. Gases and vapors are composed of widely separated freely moving molecules which will expand to fill a larger container and exert a pressure in all directions.

2) by their origin : The origin or source of an air pollutant has a great effect on the way it can be controlled.

- Mobile sources of emissions include automobiles, trains, and airplanes while
- stationary sources include all other sources. Like electric power plants, chemical manufacturing industries, air strippers, and soil vapor extraction operations

- A direct source emits pollutants directly while
- indirect sources do not themselves emit pollutants but attract mobile sources (e.g. a shopping mall, athletic stadium).
- Air pollution sources may also be divided into :
- combustion or non-combustion sources.
- A point source is defined as a stationary source whose emissions significantly impact air quality. Area sources are those that, individually do not have significant impact on air quality but, are significant when viewed together (e.g. dry cleaners, open burning).

3) by the nature of the response they elicit: How pollutants reach the atmosphere has an impact on how they are regulated.

Air pollutants are considered

1) **primary pollutants** if they are directly emitted from a source, such as the [carbon monoxide](#) or [sulfur dioxide](#), all of which are byproducts of [combustion](#);

2) **Secondary pollutants** are formed as a result of chemical reactions in the atmosphere. In the case of secondary pollutants, the precursors to the pollutant are generally regulated.



- A major component of urban smog, ozone, is a secondary pollutant which is formed as a result photochemical reactions between oxides of nitrogen, VOCs, and other atmospheric constituents.
- 4) by their legal status. Understanding how pollutants are classified will often give some insight into the problems associated with them.

# Causes of Air Pollution

- Undesirable materials can be emitted to the atmosphere from either natural or human (**Anthropogenic**) sources. Also the air pollution caused by nature is generally small, compared to anthropogenic pollution.
- **Anthropogenic sources** (human activity) related to burning different kinds of fuel :
  - \* Dust storm
  - \* Using a controlled burn
  - \* Combustion-fired power plants.

- \* Controlled burn practices used in agriculture and forestry management
- \* Motor vehicles generating air pollution emissions.
- \* Marine vessels, such as container ships or cruise ships, and related port air emissions
- \* Wood, coal, fuel oil or natural gas burning fireplaces, stoves, furnaces and incinerators, and any **Other anthropogenic sources.**

- **Natural Sources :**

- \* Dust from natural sources, usually large areas of land with little or no vegetation.
- \* Methane, emitted by the digestion of food by animals, for example cattle.
- \* Pine trees, which emit volatile organic compounds (VOCs).
- \* Radon gas from radioactive decay within the Earth's crust.

- \* Smoke and carbon monoxide from wildfires.
- \* Volcanic activity, which produce sulfur, chlorine, and ash particulates.

# Summarization

\*\* Air pollution classification :

according to chemical composition:

- **Sulfur-containing compounds.**
- **Nitrogen-containing compounds.**
- **Carbon-containing compounds.**
- **Halogen-containing compounds.**
- **Toxic substances (any of about).**
- **Radiative compounds.**

- according to physical state:
  1. Gaseous.
  2. Liquid (aqueous).
  3. Solid.
- according to the manner in which they reach the atmosphere:
  1. Primary pollutants (those emitted directly from the sources).
  2. Secondary pollutants (those formed in the atmosphere by chemical interactions among primary pollutants and normal atmospheric conditions).

- according to the space scales of their effects:
  1. Local (or indoor).
  2. Regional.
  3. Global.



# Criteria air pollutants

- Criteria air pollutants are six major pollutants defined by EPA (Environmental Protection Agency) for which ambient air standards have been set to protect human health and welfare.

Criteria pollutants (defined by EPA):

1. Ozone,  $O_3$ .
2. Carbon monoxide, CO.
3. Sulfur dioxide,  $SO_2$ .
4. Nitrogen oxides,  $NO_x$ .
5. Lead, Pb.
6. Particulates, PM10.

# Major air pollutants

- Ozone as a pollutant.
- Ozone, O<sub>3</sub>, is a gas.
- At ground level, ozone is a hazard ('bad' ozone) - it is a major constituent of photochemical smog. However, in the stratosphere, it serves to absorb some of the potentially harmful UV radiation from the sun, which is believed to cause skin cancer, among other things ('good' ozone).
- Sources: ozone is not emitted into the atmosphere; ozone is formed from the ozone precursors, VOCs, and nitrogen oxides

- Major sulfur-containing compounds :
- Sulfur dioxide,  $\text{SO}_2$ , is a colorless gas with a sharp odor, primary pollutant, has anthropogenic (man-made) and natural sources.
- Anthropogenic sources: industries burning sulfur-containing fossil fuels, ore smelters, oil refineries.
- Sulfur is present in many fuels (e.g., coal, crude oils) over a wide range of concentrations. Combustion causes its oxidation to sulfur dioxide.
- Natural sources: marine plankton, sea water, bacteria, plants, volcanic eruption.

- Major nitrogen-containing compounds
- Nitrogen,  $N_2$ , is a dominant gas of the atmosphere about 78% by volume
- (discussed in Lecture 3).
- $NO_x$  stands for an indeterminate mixture of nitric oxide, NO, and nitrogen dioxide,  $NO_2$ . Nitrogen oxides,  $NO_x$ , are formed mainly from  $N_2$  and  $O_2$  during high-temperature combustion of fuel in cars.
- Anthropogenic sources: motor vehicles, biomass burning
- Natural sources: bacteria, lightning, biomass burning

- Major carbon-containing compounds
- Carbon monoxide, CO, is a colorless odorless flammable gas, major pollutant of an urban air, produced from incomplete combustion.
- Anthropogenic sources: petrol engined motor cars, cigarette smoke, biomass burning
- Natural sources: biomass burning
- NOTE: CO is also produced by atmospheric oxidation of methane gas and other hydrocarbons.

- Carbon dioxide, CO<sub>2</sub>, is a key greenhouse gas.
- Principal sources: fossil fuel combustion, deforestation, cement production.

- Hydrocarbons and volatile organic carbons (VOCs):
- organic gases are those that contain both hydrogen and carbon, but may also contain other atoms; hydrocarbons (HCs) are organic gases that contain only hydrogen and carbon. Volatile organic compounds (VOCs) are non-methane hydrocarbons (NMHC) and oxygenated hydrocarbons (which are hydrocarbons plus oxygenated functional groups).

- Methane, CH<sub>4</sub>, is the most abundant hydrocarbon in the atmosphere, found in exhaust gas from automobiles, biomass burning, agriculture activities (e.g., rice paddies).
- Anthropogenic sources: indoor sources (e.g., formaldehyde emission), fossil fuel combustion, evaporation of gasoline (e.g., petroleum refineries; during fueling of cars),
- Natural sources: HCs produced from decomposition of organic matter; emitted by certain types of plants (e.g., pine trees, creosote bushes).



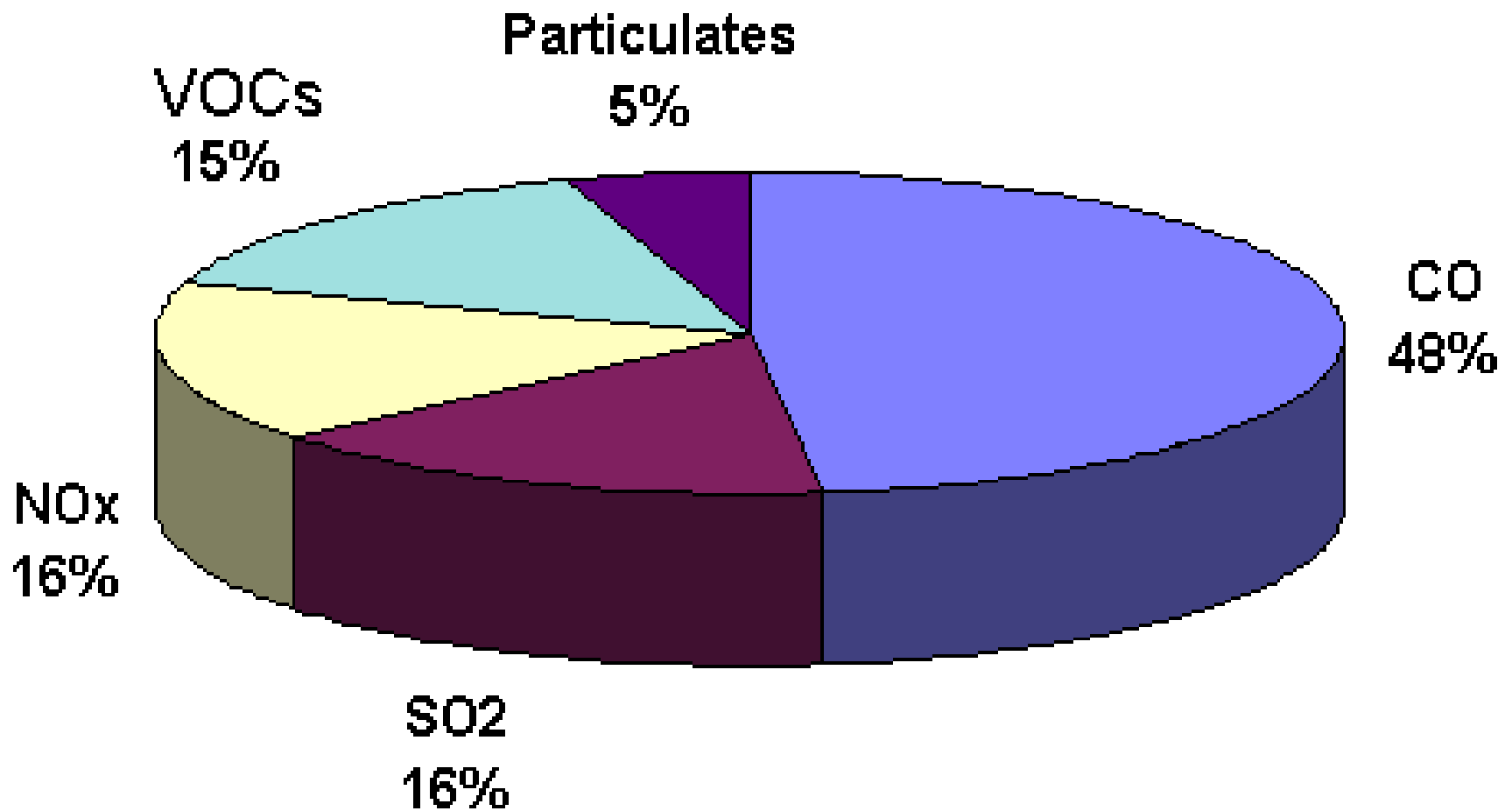
- Major halogen- containing compounds
- Chlorofluorocarbons, CFCs, are artificial gases, used as the coolants in refrigerators and air conditioners,; they are neither toxic nor flammable. The most abundant CFCs are CFC-11 (or  $\text{CFCl}_3$ ), and CFC-12 (or  $\text{CF}_2\text{Cl}_2$ ).
- CFCs are artificial halocarbons, therefore they are not biodegradable. CFCs are not water-soluble, therefore they are not washed from the atmosphere by rain. In the stratosphere, UV radiation destroys CFCs breaking them down to a few chemicals (including atomic chlorine and atomic bromine which efficiently destroy ozone).

- Metals as the pollutants.
- Metals (such as lead, mercury, cadmium, chromium, nickel) found as impurities in fuels.
- Anthropogenic sources: emitted by metal mining and processing facilities; motor vehicle.
- Example: lead is a very useful metal, has been mined for thousand of years.

- Particulate matters (aerosols) are solid or aqueous particles composed of one or several chemicals and small enough to remain suspended in the air Examples: dust, soot, smoke, sulfates, nitrates, asbestos, pesticides, bioaerosols (e.g., pollen, spores, bacterial cells, fragments of insects, etc.)
- PM(10) are particles with diameter < 10 micrometers ( $\mu\text{m}$ ).
- Anthropogenic sources: various (biomass burning, gas to particle conversion; industrial processes; agriculture's activities)
- Natural sources: various (sea-salt, dust storm, biomass burning, volcanic debris, gas to particle conversion)

Figure 2: Primary pollutant emissions in the United States.

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# Effects of Air Pollution

- Exposure to polluted air does have serious health effects. These effects can be seen in the damage to tissues, such as lungs, and in tests such as the determination of carbon monoxide in blood.
- **Major emission sources are :**
  - 1. Transportation;
  - 2. Industrial and domestic fuel burning;
  - 3. Industrial processes.

- **And the kinds of Receptors for these emission are :**
- 1. Humans;
- 2. Animals;
- 3. Plants;
- 4. Materials.

- The effects of pollutants on the human health based on the followings factors :
- a- factors associated with the receptor including :
  - 1- age of the receptors.
  - 2- Health state of the receptor .
- b- factors associated with pollutants including :
  - 1- Nature of the pollutants .
  - 2- Concentration of the pollutants .
  - 3- Duration of the exposure .