Topic 7.1

Introduction to Air Pollution

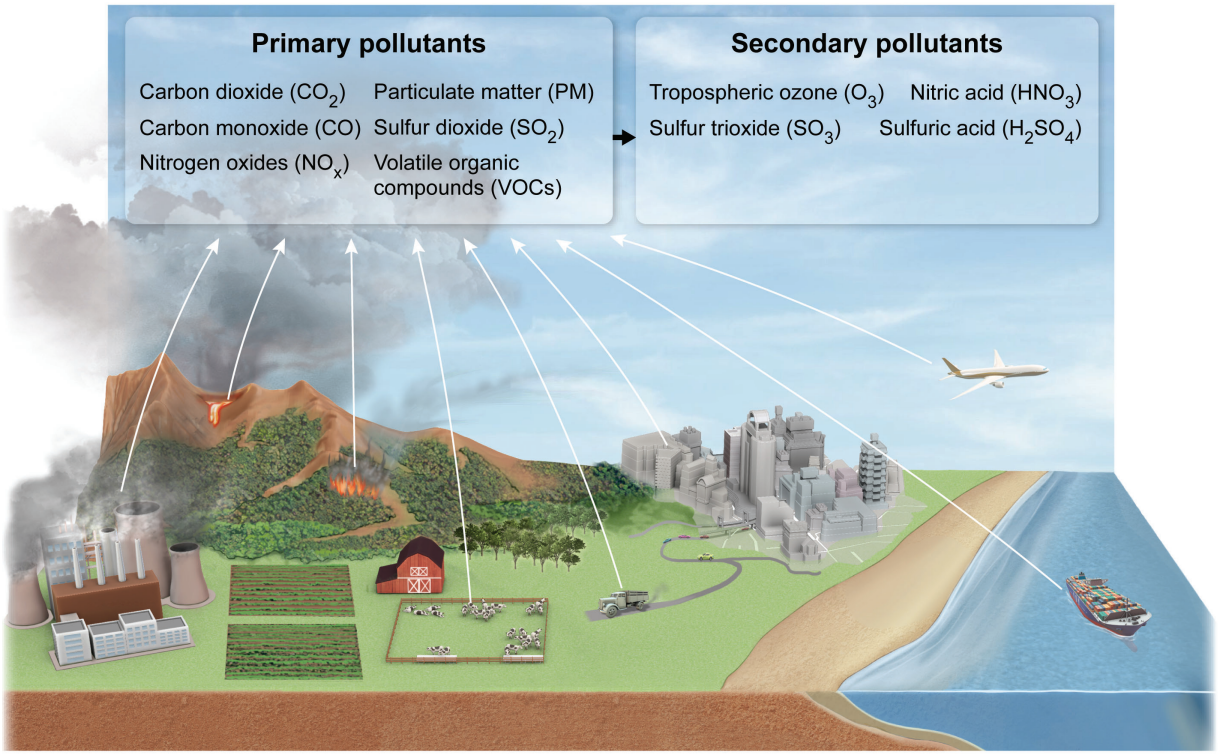
You Will Learn to:

- Identify the sources of air pollutants and describe the effects of air pollution on people and the environment.

By the End of the Topic, You Should Be Able to Answer:

- What is the difference between primary and secondary pollutants?
- What pollutants are emitted during the combustion of fossil fuels?
- How can air pollutants be reduced?

Outdoor Air Pollutants



Outdoor air pollutants are any gas or particulate in the atmosphere that causes harm to humans or the environment. These pollutants can generally be categorized as:

- **Primary pollutants**, which are emitted directly from a source.
- **Secondary pollutants**, which are generated by atmospheric chemical reactions that involve primary pollutants.

Sources and Effects of Common Primary Pollutants

Primary pollutants can be emitted from natural or anthropogenic sources and can have a range of impacts on both human health and the environment.

Primary Pollutant	Source	Effect
Carbon dioxide (CO_2)	Volcanoes, forest fires, fossil fuel combustion, and living organisms	Contributes to climate change (see Topic 9.4)
Carbon monoxide (CO)	Volcanoes, forest fires, and fossil fuel combustion	Asphyxiation and potential death (see Topic 7.5)
Nitrogen oxides (NO_x)	Volcanoes, forest fires, combustion engines, lightning, and factories	Respiratory irritation and contribute to photochemical smog and acid rain (see Topics 7.2 and 7.7)
Sulfur dioxide (SO_2)	Volcanoes, forest fires, and coal combustion	Respiratory irritation, damages plants, and contributes to acid rain (see Topic 7.7)
Particulate matter (PM)	Volcanoes, plants, forest fires, coal combustion	Reduces lung function, aggravates heart issues, and decreases productivity (see Topic 7.5)
Volatile organic compounds (VOCs)	Plants and gasoline	Contribute to photochemical smog (see Topic 7.2)

Fossil Fuel Combustion

Although there are numerous anthropogenic activities that emit primary pollutants, the combustion of fossil fuels, such as coal, is a major contributor to air pollution. When fossil fuels are combusted, the emissions can include:

- CO_2.
- CO.
- NO_x.
- SO_2.
- PM.
- Hydrocarbons, such as VOCs.
- Toxic metals, such as lead.

Once released into the atmosphere, these primary pollutants can have direct long-term or short-term impacts on the environment and human health (see Topics 7.2 and 7.5). For example, diesel, which is a liquid fuel derived from fossil fuels, releases SO_2 and decreases air quality.

Additionally, the primary pollutants can react to produce secondary pollutants that then impact the environment, including:

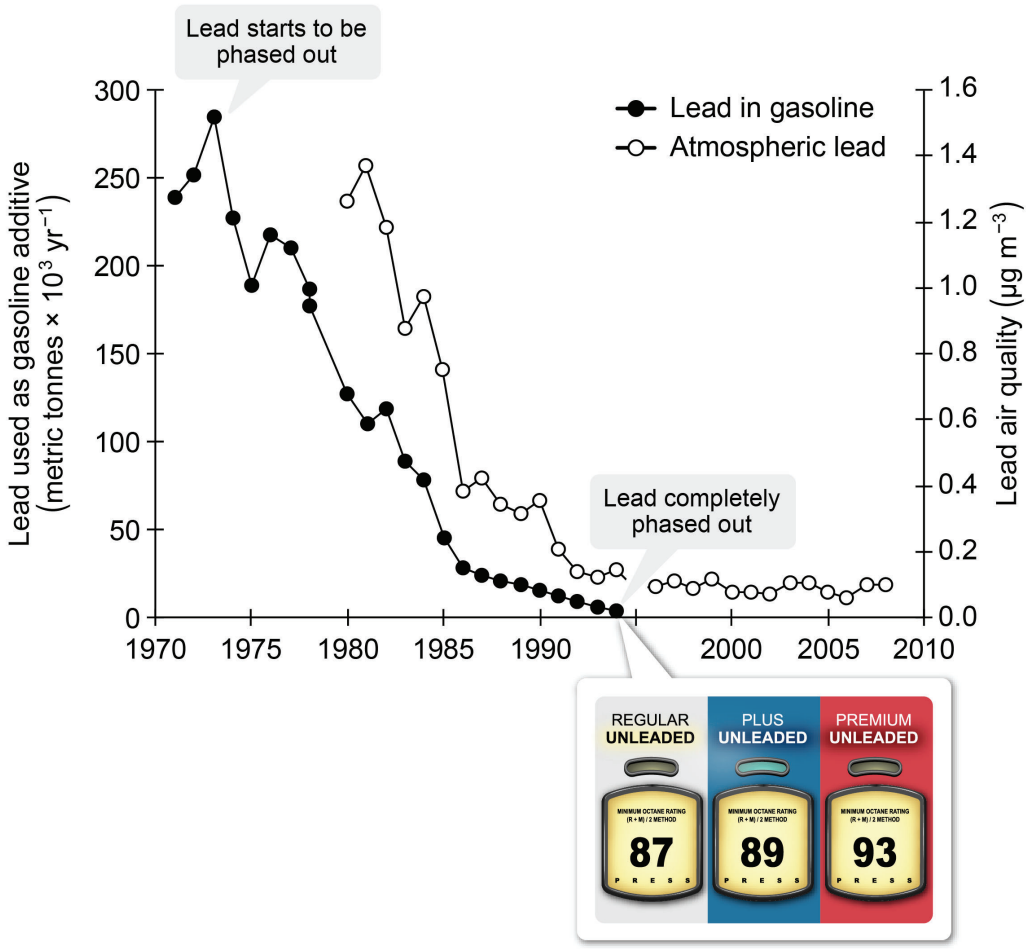
- The production of tropospheric ozone (O_3), a secondary pollutant, which contributes to photochemical smog (see Topic 7.2).
- The production of two secondary pollutants, sulfuric acid and nitric acid, which contribute to acid rain (see Topic 7.7).

Reducing Air Pollution

In 1970, the United States implemented the **Clean Air Act** to reduce emissions and presence of the six most harmful outdoor air pollutants, called **criteria air pollutants**, which include:

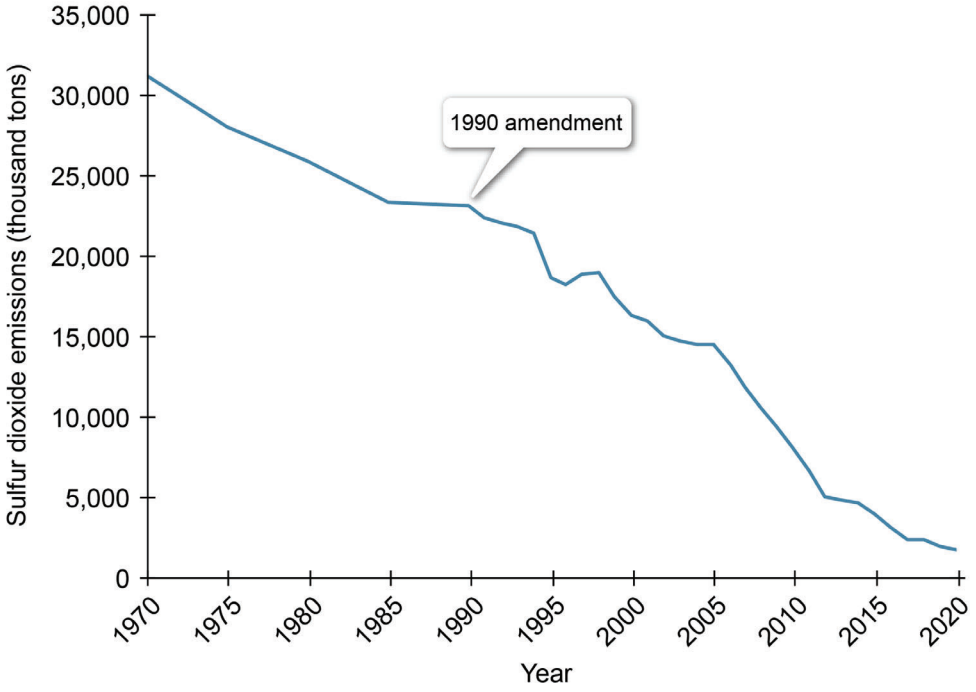
- CO.
- Lead.
- Tropospheric O_3.
- Nitrogen dioxide.
- PM.
- SO_2.

The act authorized the Environmental Protection Agency (EPA) to reduce these pollutants by developing the National Ambient Air Quality Standards, which established acceptable atmospheric levels.



As part of the enforcement of the Clean Air Act, the EPA began phasing out the use of lead as an additive to gasoline and completely banned it in the 1990s. Because the combustion of gasoline was the primary source of lead entering the atmosphere, the Clean Air Act resulted in improved air quality and a significant reduction of atmospheric lead.

Case Study



In 1990, an amendment to the Clean Air Act set up a **cap-and-trade** program that set limits on pollution and enabled power plants to buy and sell allowances for SO_2 emissions. Power plants that emitted less SO_2 than allowed made a profit from selling the remainder of their allowance, which encouraged many power plants to reduce emissions. This allowed the cap-and-trade program to successfully lower total SO_2 emissions over time.

Things to Remember

- Air pollutants can be categorized as either primary pollutants or secondary pollutants.
- Air pollutants, such as carbon dioxide, sulfur dioxide (SO_2), particulate matter (PM), and toxic metals are emitted during the process of coal combustion.
- Fossil fuel combustion results in the emission of nitrogen oxides, volatile organic compounds, PM, and carbon monoxide. Once in the atmosphere, these primary pollutants can react to produce secondary pollutants, such as nitric acid and tropospheric ozone, which lead to the formation of acid rain and photochemical smog.
- Burning fossil fuels, such as diesel, releases SO_2, a chemical that decreases air quality.
- Enforcement of the Clean Air Act by the Environmental Protection Agency decreased atmospheric pollutants, such as lead and SO_2.

7.1 Vocabulary

Cap-and-trade	Program that sets limits on pollution emissions and enables businesses to buy and sell their set amount of pollutants that they can emit.
Clean Air Act	United States law that regulates the emissions of air pollutants.
Criteria air pollutants	The most harmful outdoor air pollutants, including carbon monoxide, lead, tropospheric ozone, nitrogen dioxide, particulate matter, and sulfur dioxide, that are regulated under the Clean Air Act.
Outdoor Air pollutants	Any gas or particulate in the atmosphere that causes harm to humans or the environment.
Primary pollutants	Outdoor air pollutants that are emitted directly from a source.
Secondary pollutants	Outdoor air pollutants that are generated by atmospheric chemical reactions involving primary pollutants.

7.1 Check for Understanding

1. **What is the difference between primary and secondary air pollutants?**

   A. Primary pollutants are generated by reactions between secondary pollutants, while secondary pollutants are emitted directly from a source.

   B. Primary pollutants are emitted directly from a source, while secondary pollutants are generated by reactions between primary pollutants.

   C. Primary pollutants have a direct impact on the environment, while secondary pollutants have an indirect impact on the environment.

   D. Primary pollutants have an indirect impact on the environment, while secondary pollutants have a direct impact on the environment.

2. **Which of the following is a primary pollutant?**

   A. Nitric acid

   B. Tropospheric ozone

   C. Sulfur dioxide

   D. Smog

3. **Which of the following was the main source of atmospheric lead targeted by the Clean Air Act?**

   A. Gasoline

   B. Paint

   C. Pipes

   D. Batteries