

## Sulfur Dioxide

### General

Sulfur dioxide ( $\text{SO}_2$ ) is a colorless, nonflammable gas with a pungent odor. On a worldwide basis,  $\text{SO}_2$  is considered one of the major pollution problems. Man-made emissions of  $\text{SO}_2$  account for about one-third of the total emissions of sulfur compounds in the atmosphere. At concentrations from 0.3 to 1.0 parts per million (ppm),  $\text{SO}_2$  can be tasted. At concentrations above 3.0 ppm, the gas has a pungent, irritating odor.  $\text{SO}_2$  is highly soluble in water and forms sulfurous acid. In the atmosphere, sulfurous acid is easily converted to sulfuric acid, which is the major acidic component of acid rain.  $\text{SO}_2$  is emitted primarily from stationary sources, power plants and refineries that burn fossil fuels. Other sources are smelters, steel mills, and pulp and paper mills. Wood, natural gas, propane and other common fuels used for home heating do not contain significant quantities of sulfur and are not major sources of  $\text{SO}_2$ . Diesel fuel and, to a lesser extent, gasoline contain sulfur and contribute to  $\text{SO}_2$  in the ambient air.

Natural sources, such as volcanic eruptions, emit significant amounts of  $\text{SO}_2$ ; however, they rarely play an important role in the urban  $\text{SO}_2$  problem. Of the natural emissions, most are in the form of hydrogen sulfide released from the decay of organic matter or sulfate particles released in sea spray. In the presence of small concentrations of  $\text{SO}_2$  in the atmosphere, hydrogen sulfide is oxidized to  $\text{SO}_2$  and subsequently to sulfuric acid or sulfate particles. The sulfate particles released in sea spray are larger than the sulfate particles formed by the oxidation of  $\text{SO}_2$  and are less significant for human health.

### Effects

$\text{SO}_2$  is a pulmonary irritant and contributes to respiratory illness, alterations in pulmonary defenses and aggravation of existing cardiovascular disease. In addition to children and the elderly, individuals with asthma, cardiovascular disease, or chronic lung diseases are more susceptible to the effects of high  $\text{SO}_2$  concentrations. An exposure to 1.5 ppm of  $\text{SO}_2$  for only a few minutes can produce a temporary inability to breathe normally due to increased airway resistance.

Sulfate particles irritate the lower respiratory system.  $\text{SO}_2$  that is adsorbed onto the surface of inhalable particles can be carried deep into the lung where conditions favorable for the formation of sulfuric acid exist. Studies indicate that sulfuric acid droplets and metallic sulfates are much more potent lung irritants in humans and animals than  $\text{SO}_2$  at the same ambient concentration of sulfur.



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SO<sub>2</sub> can also damage plants and nonliving materials. High levels of SO<sub>2</sub> may injure the leaves of some plants, including trees and agricultural crops. Sulfur oxides can accelerate the corrosion of metals by first forming sulfuric acid, either in the atmosphere or on the metal's surface. Sulfuric acid can also attack a wide variety of building materials including limestone, marble, roofing slate, and mortar. SO<sub>2</sub> and nitrogen dioxide (NO<sub>2</sub>) are the main precursors to acid rain, which is formed when these pollutants rise high into the atmosphere and react with water and oxygen.

Acid rainfall can increase the susceptibility of aquatic and terrestrial ecosystems to various forms of environmental stress. Changes in the acidity of water bodies can produce physiological changes in various types of aquatic life.

The sulfuric acid and sulfate particles that form in the atmosphere as a result of SO<sub>2</sub> emissions are typically less than 1.0 micrometer in diameter. These small particles are effective in scattering visible light and producing haze.

## Standards

There are two National Ambient Air Quality Standards (NAAQS) for SO<sub>2</sub>:

1. The primary standard is a one-hour average of 75 parts per billion (ppb).
2. The secondary standard is a three-hour average of 0.50 ppm.

For a site to be considered in attainment, the 3-year average of annual 99th percentile one-hour average daily maximum concentrations must not exceed 75 ppb. The secondary standard must not be exceeded more than once per year.

