

# Sulfate & Health

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## CATEGORIES

**Topics** Health, Air Pollution

**Programs** Outdoor Air Quality Standards, Exposure

**Type** Information

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## What are sulfates?

Sulfates are a family of chemicals that contain the fully oxidized ionic form of sulfur ( $\text{SO}_4^{2-}$ ), in combination with metal and/or hydrogen ions. In California, emissions of sulfur-containing compounds occur primarily from the combustion of petroleum-derived fuels (e.g., gasoline and diesel fuel) that contain sulfur. A small amount of sulfate is directly emitted from combustion of sulfur-containing fuels, but most ambient sulfate is formed in the atmosphere. First, emitted sulfur in the fuel is oxidized to sulfur dioxide ( $\text{SO}_2$ ) during the combustion process and subsequently converted to sulfate particulate matter through chemical reactions in the atmosphere. Thus, sulfates are a sub-fraction of ambient particulate matter. The conversion of  $\text{SO}_2$  to sulfates takes place comparatively rapidly and completely in urban areas of California due to regional meteorological characteristics.

## Why does CARB focus on sulfates?



Sulfates can be a significant portion of fine particulate matter (particles that are equal to or less than 2.5 microns in diameter, called PM<sub>2.5</sub>), and they can induce a wide range of adverse health effects, as described below. In addition, sulfates contribute to acidification of surface water and soil, and contribute to acid rain and fog that damage ecosystems, forests and plants. Because sulfates are light colored, they reflect energy from sunlight back into space. This means that sulfates have a cooling influence on climate change.

## What kinds of harmful effects can sulfates cause?

Sulfate particles are part of PM<sub>2.5</sub>, and so they have health effects similar to those from exposure to PM<sub>2.5</sub>. These include reduced lung function, aggravated asthmatic symptoms, and increased risk of emergency department visits, hospitalizations, and death in people who have chronic heart or lung diseases.

## Who is at the greatest risk from exposure to sulfates?

Groups having higher risk of experiencing adverse health effects with sulfates exposure include children, asthmatics, and older adults who have chronic heart or lung diseases.

## How do sulfates affect the environment?

Sulfates are particularly effective in degrading visibility by scattering light before it reaches an observer. This light scattering reduces visual clarity, mutes colors, and reduces the distance one can see. Sulfate particles are usually acidic and when dissolved in water they form sulfuric acid. Deposition of this sulfuric acid is usually through acid rain or snow, which damages a variety of ecosystems and materials. Acid rain can increase the acidity of waterways and lakes, inhibiting fertility, growth, and development of fish and other aquatic species, strip aluminum from the soil and alter essential nutrient availability to trees and plants, thereby inhibiting tree and plant growth. Acid rain can also physically damage tree leaves and needles so that they have reduced capacity for photosynthesis. Dry deposition of acidic sulfates can cause acid damage to buildings, paint, metals and stone that leads to premature deterioration.



## Are sulfates a problem indoors?

There are no significant sulfates emissions sources indoors. Indoor sulfate levels are related to infiltration of sulfate from outdoor air.

## What is the Ambient Air Quality Standard for sulfates?

### 24-Hour Average

**National Ambient Air Quality Standard**

None

**California Ambient Air Quality Standard**

25  $\mu\text{g}/\text{m}^3$

## Additional Information

- CARB's acid deposition research program
- U.S. EPA information on acid rain

## RELATED RESOURCES

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**Mobile Monitoring Research  
Studies**

**Verification Procedure: Installers  
& Distributors**

**Car & Bus Exposure Studies**

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