

Particulate Matter

General

Particulate matter (PM) is the broad classification of material that consists of either tiny solid particles or fine liquid droplets found in the atmosphere. The particles or droplets have many different chemical compositions depending on the source of the emissions.

Chemical reactions can occur in the atmosphere to form new chemical compounds or change the form of chemical compounds from gases and liquids into solid particles. Globally, natural sources account for the majority of PM. Natural forms of PM include pollen and spores, sea salt, windblown dust from arid areas, volcanic dust and products of combustion from wildfires. Man-made sources of PM include motor vehicles; utility and industrial boilers; dust from roads; agricultural, construction, and mining activities; prescribed fires and other forms of open burning; as well as fugitive emissions from industry. PM is directly emitted into the air by processes such as combustion, incineration, construction, mining, metal smelting, metal processing and grinding. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as sulfur dioxide (SO₂) and volatile organic compounds (VOCs) are also considered PM.

Particulates range in size from less than 0.1 micrometer (µm) to 50 µm. To put this into perspective, human hair ranges from 50 to 70 µm. Particles larger than 50 µm tend to settle out of the air. Particles larger than 10 µm are usually fugitive dust blown by winds from roadways, fields and construction sites. Particulate matter 10 µm in diameter and smaller (PM-10) presents a health risk because the particles are fine enough to enter the respiratory system through inhalation and may become lodged in the tiny sacs of the lungs.

Particulate matter 2.5 µm in diameter and smaller is called PM-2.5 and is a major contributor to visibility-related problems in both urban and rural areas. Haze obscures the clarity, color, texture and form of what we see, and is caused by the presence of particles in the air. Visibility impairment is a complex problem caused by tiny particles of several different pollutants.

The distance PM travels from its source depends on its physical characteristics and the weather conditions. It can travel hundreds of miles before being removed from the air by settling or precipitation.

The size, shape, and density of the particles influence the rate PM settles to the surface. Particles larger than about 10 µm in diameter settle fairly quickly. Their impact is felt primarily near their source. PM-2.5, because of its small size, can remain suspended in the atmosphere for long periods of time (days or even weeks).



Effects

PM may lead to major human health effects. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular diseases, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death. Individuals with chronic obstructive pulmonary or cardiovascular disease, influenza, asthmatics, the elderly and children are highly susceptible to the effects of PM.

The extent of the effects depends on the concentration, size, and chemical composition of the PM, as well as the concentration and composition of any pollutant gases reacting in combination with the PM. Particles less than 6 μm in diameter can penetrate the bronchial passages. Particles smaller than 1 μm can be deposited in the lungs. Lung tissue becomes damaged and changes may occur in the immune system.

An inhaled particle may exert a toxic effect in three ways:

1. The particle may be intrinsically toxic due to its inherent chemical or physical characteristics.
2. The particle may interfere with one or more of the mechanisms which normally clear the respiratory tract.
3. The particle may act as a carrier of an absorbed toxic substance.

Exposure to PM in combination with other pollutants such as SO_2 produces more severe effects than does exposure to pollutants separately.

PM also affects materials, vegetation and animals. PM damages painted surfaces and textiles and can be corrosive to metals. Visibility is reduced by PM in the 0.1 – 1 μm range. The particles scatter light, which produces haze, thus decreasing the amount of sunlight reaching the ground.

Standards

There are three National Ambient Air Quality Standards for PM-2.5:

1. a primary standard of an annual arithmetic mean of 12 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$),
2. a secondary standard of 15 $\mu\text{g}/\text{m}^3$ (annual arithmetic mean) and
3. a 24-hour average not to exceed 35 $\mu\text{g}/\text{m}^3$.

For PM-10, the primary and secondary standard is a 24-hour average of 150 $\mu\text{g}/\text{m}^3$.

Attainment of the standards is based on an average of three calendar years of data. Thus, the 24-hour PM-2.5 standards are attained when the three-year expected number of exceedances per year at each monitoring site is less than or equal to one. The annual standard is attained when the three-year expected annual arithmetic mean is less than or equal to the standard.

