What Is PM 2.5 and Why Is Measuring It Important?

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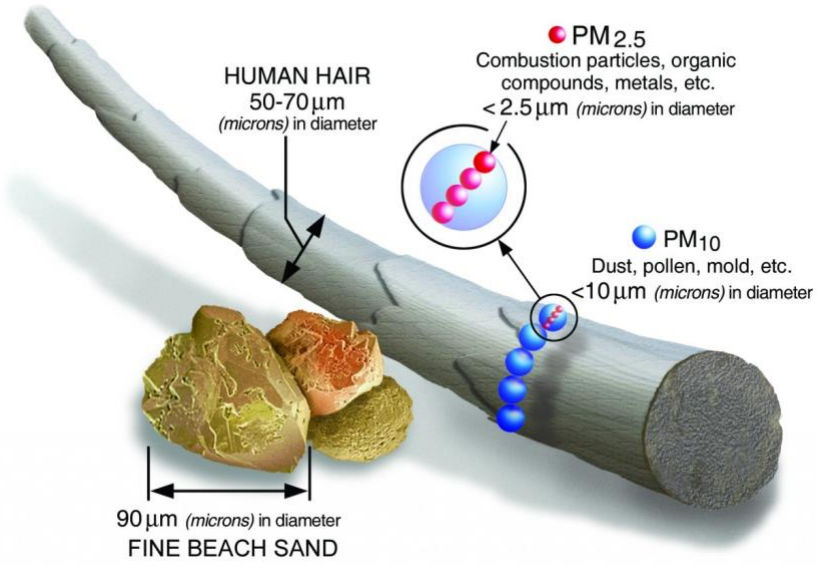
What is PM2.5, and three reasons why measuring it is important

Definition – $PM_{2.5}$ refers to particulate matter that is 2.5 micrometers (µm) or smaller in diameter—about 30 times smaller than the width of a human hair. These microscopic particles can stay suspended in the air for days or weeks and are generated as byproducts from a variety of sources: fuel combustion, industrial processes, vehicle exhaust, wildfires, construction dust, and indoor combustion (like cooking and burning candles). Because of their small size, $PM_{2.5}$ particles can penetrate deep into the lungs and enter the bloodstream, making them a critical metric in air quality monitoring.



https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

Reason 1) Respiratory and Cardiovascular Health – $PM_{2.5}$ is one of the most harmful pollutants to human health due to its ability to bypass the body's natural defense mechanisms (like nose hairs and mucus) and enter into the bloodstream through the lungs. According to the World Health Organization (WHO), exposure to elevated $PM_{2.5}$ levels is linked to increased hospital admissions for asthma, bronchitis, heart attacks, and strokes. Prolonged exposure has been shown to worsen conditions like chronic obstructive pulmonary disease (COPD) and can contribute to premature death, particularly in vulnerable populations such as children, the elderly, and those with preexisting conditions.

- In 2023, the average U.S. outdoor $PM_{2.5}$ level was 8 micrograms (µg) per cubic meter (m^3) of air. In 2024, the U.S. Environmental Protection Agency (EPA) tightened its annual average limit of 12 µg/m^3 for $PM_{2.5}$ down to 9.0 µg/m^3 for $PM_{2.5}$ under the National Ambient Air Quality Standards (NAAQS). Link

- In the U.S. average outdoor levels of $PM_{2.5}$ have decreased by 40% over the past 20 years as the Energy Sector migrates away from coal-fired energy to cleaner coal-fired energy, natural gas, and renewables. Link

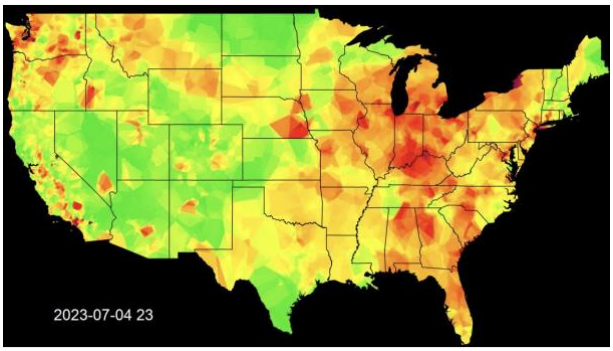
- The $PM_{2.5}$ concentration reaches up to 1,020 $\mu g/m^3$ in the NY/NJ subway system. Link

- Although the EPA has recommended limits for $PM_{2.5}$ exposure (see first bullet point above), there is no discernable "safe" threshold for $PM_{2.5}$. Lower is always better and 0.0 $\mu g/m^3$ of $PM_{2.5}$ is the ideal. Link

Below is a linked video of $PM_{2.5}$ levels in from 2-2023 to 11-2023 made by Robert Ellison. You can see the impact of Canadian wildfires and July 4th (on the static image). Click the link to see the time-lapse video. Green is less than 10.0 $\mu g/m^3$, and red is over 50.0 $\mu g/m^3$.

Link to amazing visualization

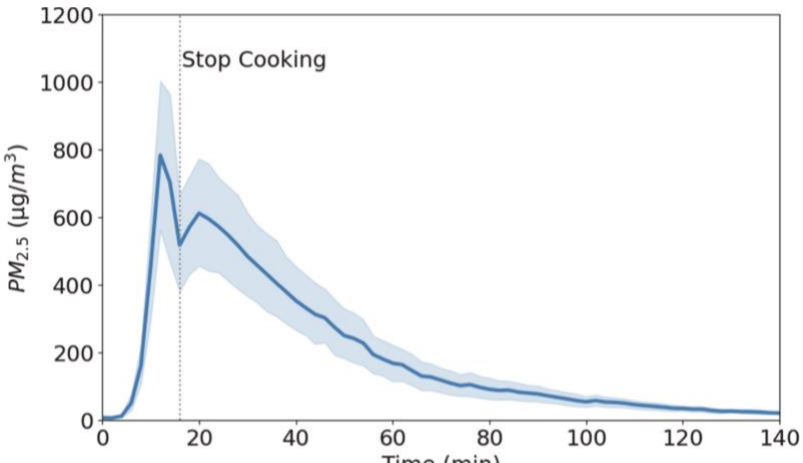
Make sure your volume is low or off



Monitoring $PM_{2.5}$ enables timely decisions on ventilation, filtration, and personal exposure—especially during air pollution events such as wildfires or smog episodes.

Reason 2) Indoor Air Quality and Building Use – $PM_{2.5}$ isn't just an outdoor problem. Indoor levels can often match or exceed outdoor concentrations, especially when generated from activities like cooking, burning candles, or using fireplaces. Modern buildings that are tightly sealed for energy efficiency may also trap fine particles indoors or introduce $PM_{2.5}$ from outside through mechanical ventilation systems.

• Many studies have shown the negative impact cooking in residential homes has on indoor air quality and specifically $PM_{2.5}$ concentrations. Below is a graph from one study that shows the increase of $PM_{2.5}$ levels due to cooking. Link

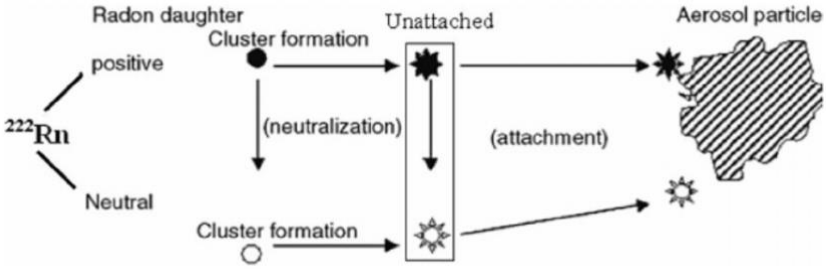


• According to the EPA, “Indoor concentrations of pollutants may be 2 to 5 times—and occasionally more than 100 times—higher than outdoor concentrations.” Link

Monitoring $PM_{2.5}$ in indoor spaces—especially schools, hospitals, and high-density commercial buildings—helps ensure proper HVAC operation, filter performance, and occupant safety. Real-time data can guide interventions like increasing air exchanges or upgrading to HEPA filtration.

Reason 3) Reducing Exposure to Radon Decay Products

Radon gas itself is inert and typically passes through the lungs without causing harm. The real health risk comes from its **radioactive decay products (RDP)** - like polonium-218 and lead-214. These decay products are not a solid or a gas in the traditional sense; rather they are primarily positively charged ions that form small clusters which **attach to airborne particles**, especially fine particles like $PM_{2.5}$. (Link) Below is a graphic of this process. Link

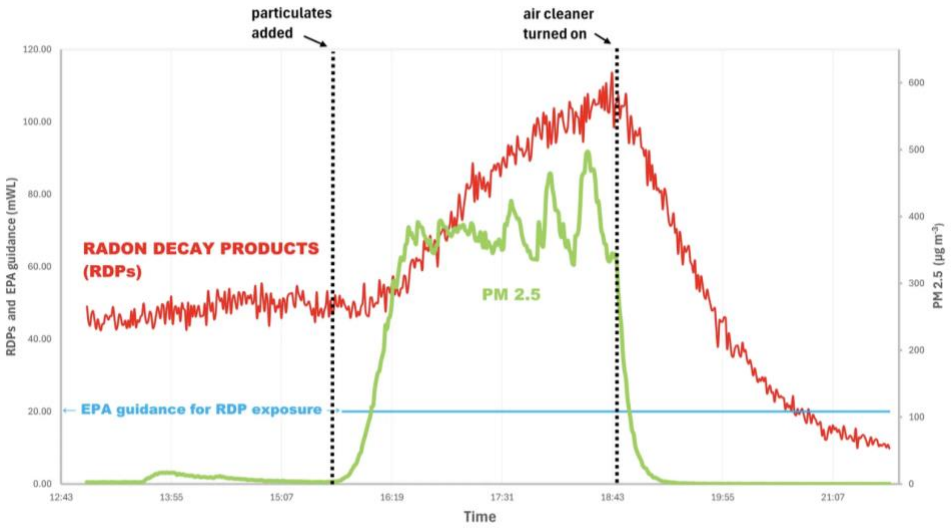


When these radioactive-laden particles are inhaled, they can lodge in the lungs and expose tissue to alpha radiation—**a leading cause of lung cancer**, particularly in non-smokers. According to the EPA, radon is the **second leading cause of lung cancer** in the United States. Link

By reducing indoor $PM_{2.5}$ levels through filtration and source control, you **limit the surfaces available for radon decay products to attach to**, thereby **lowering the risk of radioactive particle inhalation**. This makes $PM_{2.5}$ measurement and mitigation a crucial component of any radon risk reduction strategy.

The chart below by the Center for Applied Radon Research shows how the concentration of radon decay products - *the red line* - had a steady-state concentration of ~ 50 mWL before $PM_{2.5}$ particulates - *the green line* - were added at ~ 15:45 time. As the $PM_{2.5}$ concentration increased, so did the concentration of the RDP because the RDP were attaching to the $PM_{2.5}$. Once the HEPA air cleaner was turned on at 18:43, the $PM_{2.5}$ concentration dropped almost immediately. The key takeaway is noting how quickly the RDP concentration dropped too because the RDP no

longer had particulate matter to attach to. The RDP levels dropped to below the EPA guidance for RDP exposure – *the light blue line* – because $PM_{2.5}$ was filtered out of the air. Link



In summary, measuring PM2.5 is vital for protecting human health, maintaining indoor air quality, and ensuring safe, habitable environments. Like dew point, PM2.5 offers a direct, actionable metric for environmental control—supporting decisions that affect health, comfort, regulatory compliance, and long-term building performance.