



Algebra Application

Why Are Wildfires So Dangerous?

Background

Wildfires can destroy trees, harm wildlife, and are a threat to people living nearby. But what makes wildfires so dangerous even to people who don't live near the fires?

Aside from the damage to the immediate environment and wildlife, the lingering effects of smoke can be just as damaging. Why is smoke so dangerous? Here are some of the effects of prolonged exposure to smoke:

- Impaired breathing and lung function
- Cardiovascular problems

- Smoke-induced asthma or allergies

The very young and the elderly are particularly prone to the harmful effects of smoke.¹

Measuring Pollutants

Wildfire smoke is a pollutant. The smoke is made up of a number of different substances:

- Gas pollutants like carbon monoxide
- Gaseous toxic hydrocarbons
- Particles

The main component of wildfire smoke is the third item, particles, often referred to as particulate matter. These particles are so small that they are the size of a micron.

What is a micron? It's a very small amount.

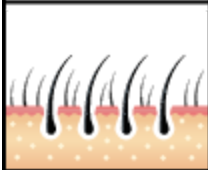
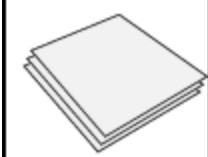
$$1 \text{ micron} = 1 \times 10^{-6} \text{ meters}$$

The unit of measure for a micron is a micrometer:

$$1 \text{ micrometer} = 1 \mu\text{m}$$

Here are some examples of different objects measured in microns.

¹ <https://www.epa.gov/pm-pollution/how-smoke-fires-can-affect-your-health>

	Bacterium	1 – 10 μm
	Width of human hair	17 – 180 μm
	Thickness of a sheet of paper	20 – 200 μm

A smoke particle from a wildfire can be as small as 2.5 microns! Think of the billions of smoke particles that can be released from the burning of one tree. Now think of the impact of a forest of burning trees.



Measuring Particulates

As you have seen, the main culprit in wildfire smoke is the particulate matter (PM). The EPA measures two types of PM²:

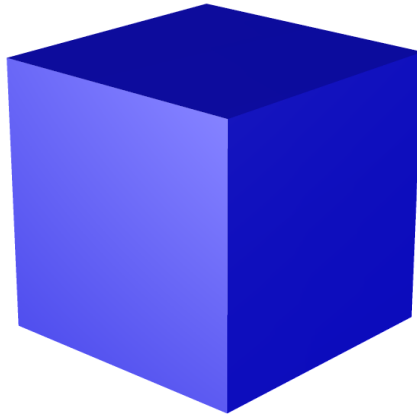
- PM₁₀: Particulate matter that is roughly 10 microns in size.

² <https://www.epa.gov/pm-pollution/particulate-matter-pm-basics>

- PM_{2.5}: Particulate matter that is roughly 2.5 microns in size.

Wildfire smoke includes both types of PM.

We can calculate how many smoke particles would be in a cubic meter of air. Here's how.



Assume that each particle of smoke is a 2.5-micron cube. Find the number of such cubes that would fit in a cubic meter.

$$\begin{aligned}
 \text{Volume of a smoke particle} &= s^3 \\
 &= (2.5 \mu\text{m})^3 \\
 &= (2.5 \times 10^{-6} \text{ m})^3 \\
 &= 15.6 \times 10^{-18} \text{ m}^3 \\
 &= 1.56 \times 10^{-17} \text{ m}^3
 \end{aligned}$$

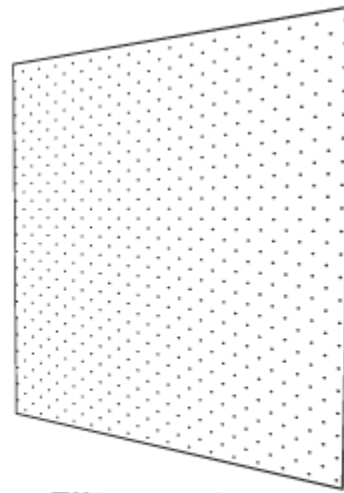
To find the total number of smoke particles in a cubic meter of air:

$$\begin{aligned}
 \text{Number of particles} &= \frac{1 \text{ m}^3}{1.56 \times 10^{-17} \text{ m}^3} \\
 &= 0.06 \times 10^{17} \\
 &= 6.0 \times 10^{15}
 \end{aligned}$$

So, 6 quadrillion (or a thousand trillion) particles would fit in one cubic meter of air.

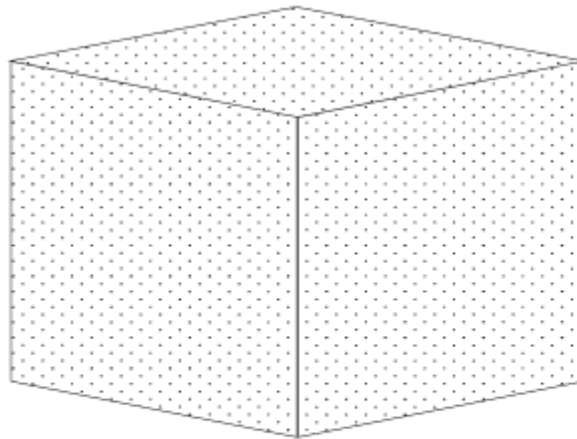
Measuring Air Quality

Rather than counting particles, scientists measure the weight of the smoke particles. One way they do this is to use filters that capture smoke particles.



**Filter captures
smoke particles.**

The smoke particles are captured in the filter. By weighing the filter before and after the particle capture, you can measure the weight of the smoke particles. This way, scientists measure the density of smoke in a cubic meter of air.



**Density of smoke in
a cubic meter of air**

$$\frac{\text{micrograms}}{\text{cubic meter}} = \frac{\mu\text{g}}{\text{m}^3}$$

Density is a rate and is a measure of mass over volume. The density of smoke is the number of micrograms of smoke particles in a cubic meter of air. As the density of smoke increases, it will be reflected in the density measure.

The EPA has set air quality standards for $PM_{2.5}$ and PM_{10} particulate matter. To maintain healthy air quality, in a given year, the $PM_{2.5}$ value cannot exceed 15 micrograms per cubic meter. The PM_{10} value cannot exceed 50 micrograms per cubic meter.³

Air Quality Index

Another common measure for measuring the air quality is the Air Quality Index (AQI). You will often see this value used in weather reports, especially when tracking the air quality due to wildfires.

The AQI ranges from 0 to 300. The lower the AQI value, the better the air quality. The higher the AQI value the worse the air quality.

This table shows the relationship between AQI and the air density measures discussed previously.⁴

AQI	$PM_{2.5}$ ($\mu\text{g}/\text{m}^3$)	PM_{10} ($\mu\text{g}/\text{m}^3$)	Air Quality
0–50	0.0–15.4	0.0–54	Good
51–100	15.5–40.4	55–154	Moderate
101–150	40.5–65.4	155–254	Unhealthy for Sensitive Groups
151–200	65.5–150.4	255–354	Unhealthy
201–300	150.5–250.	355–424	Very Unhealthy

³ <https://www3.epa.gov/region1/airquality/pm-aq-standards.html>

⁴ <https://spacemath.gsfc.nasa.gov/earth/10Page105.pdf>

Take a look at the green band, the one that has the air quality description of “Good.” See how the AQI range is 0 to 50? You can also see that in this range, the PM_{2.5} range is in the range recommended by the EPA. The same goes for the PM₁₀ range.

As the AQI range increases, you can see that the density of smoke particles increases for both the PM_{2.5} and the PM₁₀. As the smoke density increases, so does the public health hazard. Wildfires will produce an AQI value in the unhealthy ranges.

Case Study: Wildfires in the Lake Tahoe Area

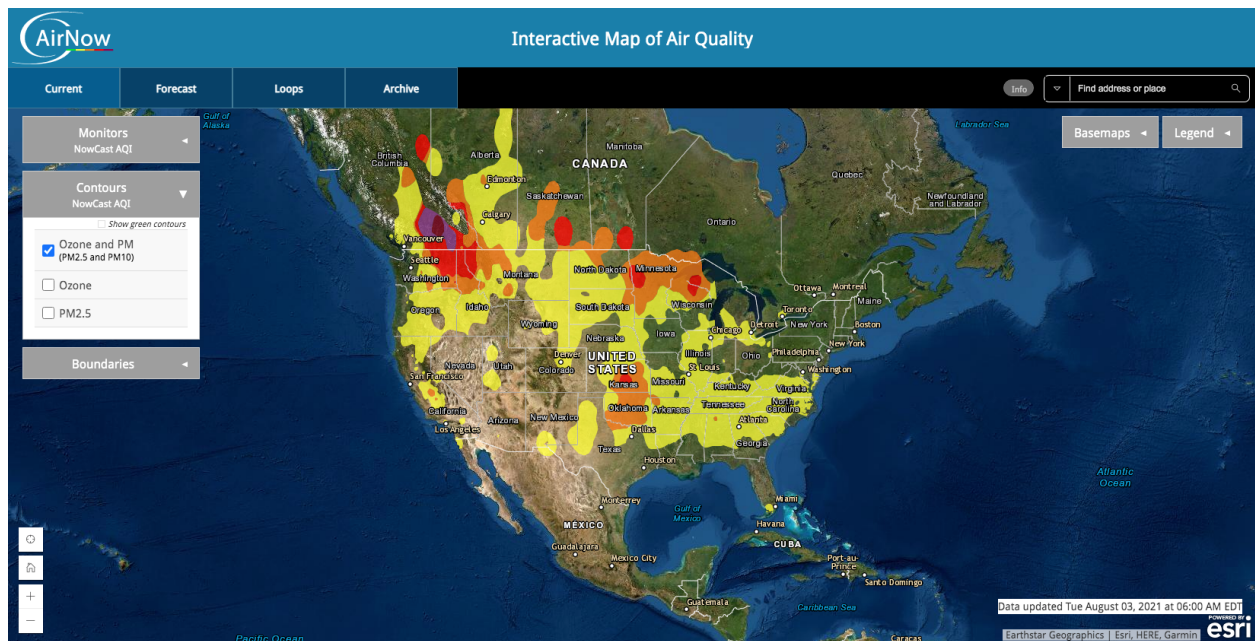
In the summer of 2021, there were a number of wildfires in the Lake Tahoe area that released a great deal of smoke. Watch the video to learn more about these wildfires.



This EPA website tracks current and historical AQI data:

<https://gispub.epa.gov/airnow/>.

The home page of this AQI tracker will look something like this:



You can change the settings to look at a specific region of the country. You can also find specific measures for $PM_{2.5}$ and PM_{10} , as well as historical data.

Assignment

Now that you have learned about wildfires, air quality, and the AQI, analyze the data in the AQI web site to create a report on the conditions in the Lake Tahoe Area. Here are the specifics:

- Select a 7-day period in the July 2021 timeframe.
- Track the $PM_{2.5}$ readings during this period.
- Based on the air quality, make a recommendation to the people that live in the community about the air quality.
- Do the same for people visiting the site on vacation.

Write a brief report that describes the following:

- How you accessed the data. You can include screen captures.
- A description of the data you found.
- How that data was used to make a recommendation about the conditions in the Lake Tahoe area.
- A description of your recommendation.