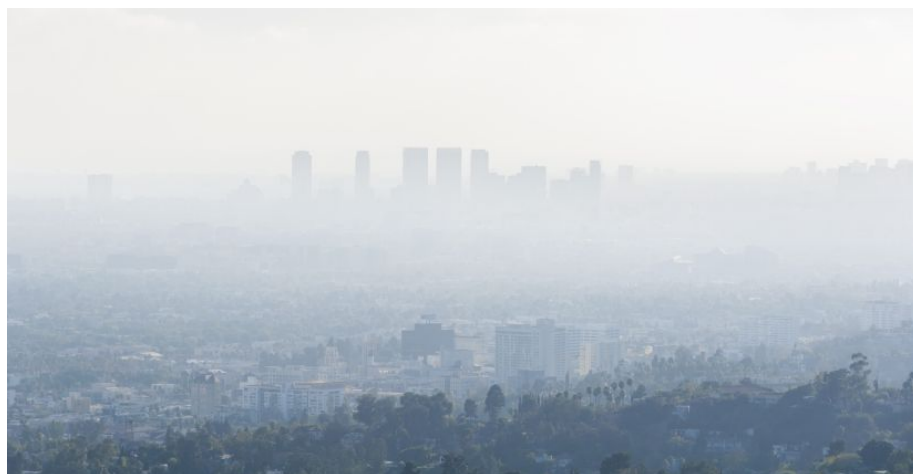


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MIT researchers found a more dramatic decline in organic aerosol across the U.S. than previously reported, which may account for more lives saved than the U.S. Environmental Protection Agency anticipated in a 2011 report on the Clean Air Act and amendments. The study found that the decline is likely due to human behaviors.

Photo: Andrius K / Shutterstock

# Cleaner air, longer lives

## Research shows the Clean Air Act was likely responsible for a dramatic decline in atmospheric organic aerosol.

**Carolyn Schmitt | Department of Civil and Environmental Engineering**  
**December 25, 2017**

Press Inquiries

PRESS MENTIONS

The air we breathe contains particulate matter from a range of natural and human-related sources. Particulate matter is responsible for thousands of premature deaths in the United States each year, but legislation from the U.S. Environmental Protection Agency (EPA) is credited with significantly decreasing this number, as well as the amount of particulate matter in the atmosphere. However, the EPA may not be getting the full credit they deserve: New research from MIT's Department of Civil and Environmental Engineering (CEE) proposes that the EPA's legislation may have saved even more lives than initially reported.

A new study by MIT researchers found that the Clean Air Act has had a larger impact on reducing the mortality rate than originally thought, reports Alan Moses for *U.S. News & World Report*. The researchers found that, "the decline in organic aerosol may account for more lives saved than the EPA had estimated."

"In the United States, the number of premature deaths associated with exposure to outdoor particulate matter exceeds the number of car accident fatalities every year. This highlights the vital role that the EPA plays in reducing the exposure of people living in the United States to harmful pollutants," says Colette Heald, associate professor in CEE and the Department of Earth, Atmospheric and Planetary Sciences.

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The EPA's 1970 Clean Air Act and amendments in 1990 address the health effects of particulate matter, specifically by regulating emissions of air pollutants and promoting research into cleaner alternatives. In 2011 the EPA announced that the legislation was responsible for a considerable decrease in particulate matter in the atmosphere, estimating that over 100,000 lives were saved every year from 2000 to 2010. However, the report did not consider organic aerosol, a major component of atmospheric particulate matter, to be a large contributor to the decline in particulate matter during this period. Organic aerosol is emitted directly from fossil fuel combustion (e.g. vehicles), residential burning, and wildfires but is also chemically produced in the atmosphere from the oxidation of both natural and anthropogenically emitted hydrocarbons.

The CEE research team, including Heald; Jesse Kroll, an associate professor of CEE and of chemical engineering; David Ridley, a research scientist in CEE; and Kelsey Ridley SM '15, looked at surface measurements of organic aerosol from across the United States from 1990 to 2012, creating a comprehensive picture of organic aerosol in the United States.

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“Widespread monitoring of air pollutant concentrations across the United States enables us to verify changes in air quality over time in response to regulations. Previous work has focused on the decline in particulate matter associated with efforts to reduce acid rain in the United States. But to date, no one had really explored the long-term trend in organic aerosol,” Heald says.

ARCHIVES

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There's something in the air

The MIT researchers found a more dramatic decline in organic aerosol across the U.S. than previously reported, which may account for more lives saved than the EPA anticipated. Their work showed that these changes are likely due to anthropogenic, or human, behaviors. The paper is published this week in *Proceedings of the National Academy of Sciences*.

“The EPA report showed a very large impact from the decline in particulate matter, but we were surprised to see a very little change in the organic aerosol concentration in their estimates,” explains Ridley. “The observations suggest that the decrease in organic aerosol had been six times larger than estimated between 2000 and 2010 in the EPA report.”

Using data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network the researchers found that organic aerosol decreased across the entire country in the winter and summer seasons. This decline in organic aerosol is surprising, especially when considering the increase in wildfires. But the researchers found that despite the wildfires, organic aerosols continue to decline.

The researchers also used information from the NASA Modern-Era Retrospective analysis for Research and Applications to analyze the impact of other natural influences on organic aerosol, such as precipitation and temperature, finding that the decline would be occurring despite cloud cover, rain, and temperature changes.

The absence of a clear natural cause for the decline in organic aerosol suggests the decline was the result of anthropogenic causes. Further, the decline in organic aerosol was similar to the decrease in other measured atmospheric pollutants, such as nitrogen dioxide and carbon monoxide, which are likewise thought to be due to EPA regulations. Also, similarities in trends across both urban and rural areas suggest that the declines may also be the result of behavioral changes stemming from EPA regulations.

By leveraging the emissions data of organic aerosol and its precursors, from both natural and anthropogenic sources, the researchers simulated organic aerosol concentrations from 1990 to 2012 in a model. They found that more than half of the decline in organic aerosol is accounted for by changes in human emissions behaviors, including vehicle emissions and residential and commercial fuel burning.

“We see that the model captures much of the observed trend of organic aerosol across the U.S., and we can explain a lot of that purely through changes in anthropogenic emissions. The changes in organic aerosol emissions are likely to be indirectly driven by controls by the EPA on different species, like black carbon from fuel burning and nitrogen dioxide from vehicles,” says Ridley. “This wasn't really something that the EPA was anticipating, so it's an added benefit of the Clean Air Act.”

In considering mortality rates and the impact of organic aerosol over time, the researchers used a previously established method that relates exposure to particulate matter to increased risk of mortality through different diseases such as cardiovascular disease or respiratory disease. The researchers could thus figure out the change in mortality rate based on the change in particulate matter. Since the researchers knew how much organic aerosol is in the

particulate matter samples, they were able to determine how much changes in organic aerosol levels decreased mortality.

“There are costs and benefits to implementing regulations such as those in the Clean Air Act, but it seems that we are reaping even greater benefits from the reduced mortality associated with particulate matter because of the change in organic aerosol,” Ridley says. “There are health benefits to reducing organic aerosol further, especially in urban locations. As we do, natural sources will contribute a larger fraction, so we need to understand how they will vary into the future too.”

This research was funded, in part, by the National Science Foundation, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration.

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## MIT NEWS

September 30, 2018

### Ripple effect

Beach sand ripples can be fingerprints for ancient weather conditions, study shows.

#### Feel the churn

David Thesmar studies what happens when the finance sector shakes up the whole economy.

#### Mathletes at MIT

MIT hosts hundreds of middle and high school students at 10th annual Math Prize for Girls.

#### Sticking a Mars landing

Program users can tinker with landing and path planning scenarios to identify optimal landing sites for Mars rovers.

Akshat Rathi of *Quartz* reports that Breakthrough Energy Ventures will invest in Commonwealth Fusion Systems, a startup collaborating with MIT to make fusion energy a viable source of renewable energy. The closely-watched fund's investment "signals to others that a breakthrough in fusion may be closer than most think," writes Rathi.

#### LATEST MIT NEWS

Remarks from the installation ceremony for MIT Chaplain Kirstin Boswell-Ford

John M. Deutch endows new MIT Institute Professorship

#### AROUND CAMPUS

From security to systems: J-WAFS name change reflects its breadth and impact

#### IN THE MEDIA

MIT spinout Affectiva Inc. has developed a new system that can study a driver's face to help assess their mental state, reports Hiawatha Bray for *The Boston*

Gift honors emeritus Institute Professor's respect for MIT and its community.

#### Report outlines keys to election security

MIT experts are among co-authors calling for ballot paper trails and other resilient practices to avoid election hacking.

#### How Earth sheds heat into space

New insights into the role of water vapor may help researchers predict how the planet will respond to warming.

#### A big new home for the ultrasmall

MIT.nano building, the largest of its kind, will usher in a new age of nanoscale advancements.

#### New battery gobbles up carbon dioxide

Lithium-based battery could make use of greenhouse gas before it ever gets into the atmosphere.

#### Study: Emissions from most diesel cars in Europe greatly exceed laboratory testing levels

Real-world driving produces up to 16 times more emissions, causing 2,700 premature deaths across the EU, researchers estimate.

#### Celebrating the life of Colt Richter '16

#### MIT Solve selects new class of innovators for 2018

#### The Committee on Animal Care solicits feedback

#### For collecting weather data, tiny satellites measure up to billion-dollar cousins

#### MIT Press, Media Lab launch Knowledge Futures Group

#### 3Q: David Simchi-Levi on advancing global retail operations through analytics and machine learning

*Globe*. Bray explains that the system “analyzes facial expressions to determine if a driver is distracted, angry, scared, sleepy, or drunk.”

Writing for *The New York Times*, Prof. Yasheng Huang examines what Jack Ma stepping down as executive chairman of Alibaba Group Holding Ltd. signals about the future of China's economy. Huang writes that Ma's departure “adds to a gathering sense that China's private sector, the engine of the economy, is losing steam — and faith.”

*Forbes* reporter Amy Feldman highlights Desktop Metal, a company started by MIT graduate Ric Fulop and a number of MIT researchers, that has developed 3-D metal printers that are intended to “print fast enough and at a low enough cost to replace casting and CNC machining for numerous metal parts.”

A study by MIT and Yale researchers finds that the number of undocumented immigrants living in the U.S. may be two times greater than current estimates, reports Andres Picon for *The Boston Globe*. “Our goal was not to do anything political or policy-oriented; it was just to provide a better number, so that policy makers can debate over policies using it,” explains Senior Lecturer Mohammad Fazel-Zarandi.

The Clubhouse Network, which the MIT Media Lab helped launch 25 years ago, has opened its flagship headquarters in Dudley Square, reports Allison Hagan for *The Boston Globe*. Now in 100 cities in the U.S. and other countries, the program helps “young people to use technology for creative self-expression and collaborate with their peers and mentors,” explains Hagan.

Prof. Ibrahim Cissé has been named one of *Science News'* 2018 SN 10 Scientists to Watch for his work investigating how genes are turned on, explains *Science News* reporter Tina

Hesman Saey. Cissé is “everything you could want in a young scientist,” says Prof. Anthony Hyman of the Max Planck Institute of Molecular Cell Biology and Genetics.

Bloomberg reporter Faye Flam writes about a study by Prof. Pierre Azoulay that examines how the death of a superstar scientist impacts intellectual progress. Azoulay and his colleagues found that, “a star's death is followed by an influx of new people into the field, coming from related fields, with different ideas,” Flam explains.

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