Improved air quality could enhance natural carbon sequestration by plants

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Reducing pollution from aerosol particles would improve air quality. It could also increase the amount of sunlight accessible to plants—enhancing their ability to remove carbon dioxide from the

atmosphere and mitigate climate change.

New work from a Carnegie-led team including Liyin He, Lorenzo Rosa, and Joe Berry used satellites to measure both photosynthetic activity and aerosol pollution in Europe, demonstrating that plants capture more carbon on the weekends when industrial production is decreased, and fewer people commute.

Their findings are published by the *Proceedings of the National Academy of Sciences*.

Plants have a special ability, called photosynthesis, by which they convert the sun's energy into chemical energy. To accomplish this, they take in carbon dioxide from the air and fix it into carbohydrates and fats.

This everyday process is a huge help in the fight against climate change caused by human activity. Plants pull some of our carbon pollution out of the atmosphere and retain it as a biological matter, preventing it from contributing to global warming.

"However, this can be diminished by poor air quality caused by aerosols, tiny particles that are spewed into the atmosphere when we commute and burn fossil fuels or wood," He explained. "They have negative effects on air quality, which impacts human health. They can also scatter or absorb sunlight, which would affect a plant similarly to being stuck in the shade."

Previous work has shown that aerosol pollution can suppress agricultural crop yields by as much as 20%.

The research team, which included David Lobell and Yuan Wang of Stanford University; Yi Yin, Yitong Yao, and Christian Frankenberg of Caltech; and Russell Doughty of the University of Oklahoma, used the

TROPOspheric Monitoring Instrument (TROPOMI) on board the Copernicus Sentinel-5 Precursor satellite to make measurements of photosynthetic activity in Europe.

Because one step of the photosynthetic process releases fluorescence, it can be seen from space and measured by satellites—a game-changing research method that Berry and Frankenberg played a central role in developing about a decade ago, along with collaborators from Caltech.

The researchers correlated their photosynthesis findings with aerosol measurements taken by the Visible Infrared Imaging Radiometer Suite and used modeling to understand the relationship.

"We focused on Europe due to an established pattern of human activity throughout the week as compared to other regions," Rosa said. "Additionally, many European ecosystems are already experiencing negative effects from climate change and European countries have set ambitious goals for cutting carbon pollution."

Their work showed a weekly cycle of photosynthetic activity, which peaked on the weekend and diminished during the week, the exact inverse of the patterns of aerosol pollution. They also found a similar pattern during COVID-19 lockdowns when people were sheltering at home instead of commuting.

If particulate pollution could be curtailed throughout the week, maintaining weekend levels of photosynthetic activity all the time, it would remove between 40 and 60 megatons of carbon dioxide from the atmosphere, trapping it in biological matter. It would also increase agricultural productivity without increasing the amount of land used for growing crops.

"These findings have major policy implications for European

governments who are working on a variety of systems to capture about 500 megatons per year of carbon dioxide out of the atmosphere and store it," Rosa concluded. "Our work shows that improving air quality could also help meet climate goals."

This work is part of Rosa's overall research program, which aims to understand the agricultural challenges posed by climate change and assess various ways to improve agricultural sustainability. Rosa joined Carnegie in 2022 as a Staff Associate—a prestigious program designed to give early career scientists the freedom and independence to pursue bold and unconventional research.

Since then, his efforts have included analyses of irrigation strategies, soil moisture-retention techniques, and water storage needs, as well as evaluating solutions to reduce the carbon footprint of fertilizer production and achieve net-zero emissions in agriculture.

More information: Liyin He et al, The weekly cycle of photosynthesis in Europe reveals the negative impact of particulate pollution on ecosystem productivity, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2306507120

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