Wildfire residue may contribute to climate change

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Wildfire smoke from the Harris Fire in October 2007 lingered over the Sweetwater Reservoir in San Diego County, California. Credit: Michael S. Majewski/U.S. Geological Survey

Wildfires leave behind large swathes of blackened earth when they raze a landscape. That charred material contains a host of molecules that

could continue to release carbon dioxide into the atmosphere days and weeks after the fire has gone out, according to new research.

A new study presented at AGU's Fall Meeting in San Francisco shows burned leaf litter and other biomaterials can leach these molecules —called pyrogenic carbon—into fresh water where they react with sunlight. That means pyrogenic carbon in our waterways could degrade into carbon dioxide faster than previously suggested, providing an unexpected source of this greenhouse gas to the atmosphere, according to the researchers.

Scientists previously thought pyrogenic carbon didn't react with sunlight, but the new findings push back on the idea that this material is inert, said Jessica Egan, a hydrologist and graduate student at the University of Colorado Boulder who presented the research.

Nearly 80 percent of fresh water in the United States originates in forested environments at risk of wildfires, according to the U.S. Geological Survey. That makes it easy for scorched debris, and the carbon it contains, to infiltrate watersheds throughout the country.

The "typical, old school view" is that temperatures in wildfires burn hot enough to make the carbon-based molecules in this char non-reactive, Egan explained. "I don't know if that's a completely fair assessment," she said. That's primarily because previous research on pyrogenic carbon degradation focused on the charcoal left behind in soil—not water—which can linger for millennia.

In the new study, Egan wanted to know what was happening to pyrogenic carbon from wildfires that washed into the watersheds in the U.S. So she and her team set out to understand if pyrogenic carbon dissolved in water could continue to react.

To do that, Egan went to Great Smoky Mountains National Park in Tennessee where she collected leaf litter and topsoil that she later burned in the lab at temperatures between 200 and 700 degrees Celsius (400 and 1300 degrees Fahrenheit) to replicate the heat of wildfires. That procedure produced a spectrum of pyrogenic carbon molecules for the team to analyze.

Egan extracted water-soluble pyrogenic carbon from the burned materials and dissolved them in water. She left bottles of the dissolved solutions in sunlight and dark conditions for 25 days, to see if the molecules broke down when exposed to light. She took samples at regular time intervals throughout the trial to monitor the signs that the molecules had changed.

The results showed the pyrogenic carbon was decomposing in response to sunlight exposure. The researchers saw an increase in the concentration of hydrogen peroxide in the samples exposed to light, but no such change for the dark samples. Hydrogen peroxide is a byproduct of the process that breaks down carbon-based molecules into components that look more like carbon dioxide.

"What's really cool and unexpected as well is that you can see a change," Egan said. And that change happened in days and weeks, not thousands of years, as scientists previously thought.

When the researchers looked at the presence of all organic material in their samples, they saw that the signal associated with labile, easily decomposed pyrogenic carbon molecules diminished significantly after exposure to sunlight, all but disappearing at the end of the trial. That strongly suggests the pyrogenic carbons are being transformed by sunlight, Egan said.

"So there's some interesting dynamics to check there," said Egan. "If

you're getting these huge releases of carbon from multiple sources [in wildfires], and [pyrogenic carbons] are available and clearly able to be oxidized to carbon dioxide, that becomes a larger problem for the carbon budget."

Other scientists are intrigued by the research. "[Egan] used a quite simple, but I think really a smart design," said Cristina Santin, a wildfire scientist at Swansea University in the United Kingdom who was not involved with the study. In particular, Santin was impressed with the hydrogen peroxide test that Egan employed to detect the decomposition of pyrogenic carbon.

The research team continues to investigate exactly which molecules are being affected by light degradation so that they can better understand how pyrogenic carbons participate in the carbon cycle after wildfires. Eventually, they would like to expand their project to include regions outside the U.S. like the Arctic. Santin also suggested the researchers use samples from managed wildfires that would be more representative of realistic charring conditions than the furnace Egan used in the lab.

Overall, Santin said that the team's results fit in with other advances in the field, all of which suggest scientists need to rethink their concept of pyrogenic carbon as a carbon sink.

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