Warmer and wetter climates amplify carbon release

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Thomas Blattmann, co-author on the study, is taking a sample at Gaoping River in Taiwan. Credit: Shing-Lin Wang / T. Eglinton / ETH Zurich

Terrestrial ecosystems help mitigate climate change by absorbing large amounts of carbon from the atmosphere. A new study now confirms that changing climate conditions could reduce this effect because in warmer and wetter areas, carbon stored in the soil is released back into the atmosphere more quickly.

Without land ecosystems, our climate would probably be under even greater threat than it already is. Plants and soil currently consume about a third of anthropogenic carbon emitted to the atmosphere, which makes them a key mitigator of global climate change. Soil plays a prominent role here because it stores a large portion of the organic carbon, delaying the latter's return to the atmosphere when plants die.

Concerns justified

How these important terrestrial carbon reservoirs will fare in the future is the subject of intense debate among experts. Many researchers are concerned that in a warmer climate, terrestrial ecosystems may release more organic carbon than they do today, thus losing the mitigating effect they have on climate change.

An international team of researchers led by Timothy Eglinton, Professor of Biogeoscience at ETH Zurich, has now confirmed that these fears are justified. Their comprehensive study was recently published in the journal *PNAS*. The scientists demonstrated that organic carbon is released from the soils more quickly in warmer areas than in colder ones, leading them to conclude that further warming of the climate may be detrimental to the soil's capacity to sequester carbon.

The full picture

Various in-depth local studies have investigated the exact processes by which soil absorbs and stores organic carbon, but, due to their selectivity, they still don't reflect the full picture. Eglinton: "We wanted to find a way to study the behavior of entire areas. Rivers are ideal for this, as they act like an echo chamber that reflects what's going on in the whole catchment area," he explains.

Smaller rivers such as the Dulnain in Scotland were also included in the study. Due to carbon-rich soils in the catchment, the river water is brown in color. Credit: M. Schwab / T. Eglinton / ETH Zurich

Over a period of several years, the researchers collected sediment samples from the mouths of 36 rivers around the world. Some of the samples were sediment particles that the team filtered directly from the river water, others were material deposits from the riverbanks. On the basis of these samples, the researchers were able to determine the age of the organic carbon that the rivers were exporting to the sea.

Essentially, the idea is that the older the organic carbon in the rivers, the longer it must take in the given catchment for the stored organic carbon to be released and exported after the plants have died. Comparing the age of the organic carbon from the various catchments enables the researchers to determine the key factors that influence the carbon budget and, in turn, how the storage capacity of the soil may change in future.

Focus on specific molecules

However, to really get to the bottom of the matter, the researchers had to use a clever trick. The carbon in river water comes from many different sources, including sedimentary rocks and organisms that live in the water. So they used molecular techniques to separate two plant-derived molecule groups from the samples: lipids from the wax of plant leaves and phenols from lignin in wood fibers. The scientists then applied radiocarbon dating, a method for determining the precise age of carbon compounds using the radiogenic isotope carbon-14.

Interesting prospects for research

Their evaluation of the data showed a clear correlation between the average age of plant-derived carbon in the samples and the climate in the catchment area. In warmer and wetter areas, organic carbon remains in the soil for less time than it does in colder, drier watersheds. "Our results confirm that climate has a strong influence on soil behavior," Eglinton says. The influence of land use, on the other hand, appears to be less significant, despite changes in recent decades to how many watersheds are managed. "At the moment, modern agriculture appears only to have a secondary impact," he explains.

What's especially remarkable about the study is that it enabled Eglinton and his team to make the first broad statements about how organic carbon is stored in terrestrial ecosystems. This opens up some interesting prospects for further research: scientists will be able to apply this method to analyze sediment deposits of different ages and reconstruct how soil behaves under different climatic conditions. Subsequently, they will be able to refine their results by including lower order tributaries in the analysis. And that's precisely what Eglinton now plans to do as part of a larger study in Switzerland.

More information: Timothy I. Eglinton et al. Climate control on terrestrial biospheric carbon turnover, *Proceedings of the National Academy of Sciences* (2021). DOI: 10.1073/pnas.2011585118

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