A river flipped: Humans trump nature on Texas river

August 16 2010

A new study by geochemists at Rice University finds that damming and other human activity has completely obscured the natural carbon dioxide cycle in Texas' longest river, the Brazos.

"The natural factors that influence carbon dioxide cycling in the Brazos are fairly obvious, and we expected the radiocarbon signature of the river to reflect those influences," said study co-author Caroline Masiello, assistant professor of Earth science at Rice. "But it looks like whatever the natural process was in the Brazos, in terms of sources and sinks of carbon dioxide, it has been completely overprinted by human activities."

The study, which is available online in the journal Biogeochemistry, is the first to document such an overwhelming influence of human activity on carbon dioxide in a major river.

With humans adding some 8.5 gigatons of carbon dixoide to the atmosphere each year through the burning of fossil fuels, scientists are increasingly interested in studying how the atmosphere and biosphere exchange carbon dioxide. Plants take up carbon dioxide from the air via photosynthesis and store it in their leaves and stems. Some of that stored carbon gets buried in the soil and locked away for hundreds or thousands of years. But much is also washed into rivers, where rapid decomposition can quickly return it to the atmosphere. Understanding when and where that plant carbon dioxide is returned to the atmosphere is essential if policymakers are to plan effective carbon-sequestration strategies.

One method scientists use to gauge how effectively ecosystems store carbon is radiocarbon dating. The technique involves precisely measuring the amount of radioactive carbon-14 in samples from an ecosystem. Because about half of the carbon-14 atoms in a material will decay and become nitrogen-14 every 5,730 years, scientists can determine the age of a material based on how much carbon-14 it still contains.

In a 2005 study, Masiello and colleagues used radiocarbon dating and found that the Amazon River, the world's largest, cycles carbon into the atmosphere in less than five years. Previous radiocarbon dating studies in cooler climates, like the U.S. Northeast, had found that rivers could store carbon from plants for thousands of years. The Amazon study indicated that rapid carbon cycling could be the norm for tropical and subtropical rivers where warmer temperatures aid decomposition.

"We wanted to know if Texas is more like New York or more like Brazil," said study first author Fan-Wei Zeng, a graduate student in Masiello's lab. "Because it is hot and humid in Texas, we expected the geochemistry of Texas' rivers to more closely resemble the geochemistry of tropical rivers."

To test the idea, Zeng began collecting and analyzing water samples at seven sites along the Brazos in 2007. The Brazos is the U.S.'s 11th longest river. Zeng gathered samples from as far south as Freeport, Texas, near the river's mouth, to Granbury, Texas, about 300 miles inland. Zeng, Masiello and co-author Bill Hockaday, now an assistant professor of geology at Baylor University in Waco, Texas, used radiocarbon dating to determine the age of the carbon dioxide in the samples.

"The headwaters of the Brazos are in limestone that formed in the Cretaceous, at least 65 million years ago," Masiello said. "If you're running water over that limestone, and dissolving it, then it should contain no measurable radiocarbon. But downstream, south of College Station, there's no limestone and it's a humid, subtropical system. So we expected the lower Brazos to be another fast, five-year system like we'd seen in the Amazon."

The lab results showed the exact opposite. At the head of the river, the carbon is from rapidly cycling organic matter, and at the base of the river, the radiocarbon tests revealed ancient carbon that had been locked away from the atmosphere for several thousand years.

In a 2009 study, Zeng and Masiello had found that human activity -- namely the use of seashells as road base material in the late 19th and early 20th centuries -- skewed the radiocarbon results in Buffalo Bayou, a heavily urbanized watershed that runs through downtown Houston. Based on those results, the team believes the "old" carbon from the southern Brazos is also from dissolved seashells in old roads.

"The carbon dioxide chemistry in the Brazos is flipped," Hockaday said. "Downstream, the carbon dioxide we found was old due to the dissolution of shells. In the upper part of the river, damming has changed the dynamics so much that if there ever was any carbon dioxide coming into the river from the limestone it's been cut off. With the damming, the carbon in the upper reaches appears to be rapidly cycling between the air and the water due largely to algal photosynthesis."

Scientists currently believe Earth's rivers take up about 1 gigaton of carbon each year and give off about the same amount. But the exact dynamics of the process are largely unknown. For example, the residence time of carbon dioxide -- how long it stays in the river -- has been studied in fewer than a half a dozen rivers worldwide. If a significant number of those rivers are like the Brazos, scientists may need to adjust the way they think about rivers inhaling and exhaling carbon dioxide.

"The Brazos may be a special case," Zeng said. "The upstream damming is not usual in the developed world, but the dissolved carbonate from seashells may be somewhat unusual."

Masiello said, "What this shows, as much as anything, is that rivers have unique geochemical stories. We may need to read many more of these stories before we can understand the bigger, global saga of riverine carbon cycling."

Provided by Rice University