VIMS Study Poses New Questions on River Carbon

The ability of scientists to accurately predict future climate change requires a realistic understanding of Earth's carbon cycle. Research by VIMS scientists Dr. James Bauer and Ph.D. student Peter Raymond now suggests that the carbon in river water may be much older—and vary more in age—than previously thought. Their findings, presented in a recent issue of the journal *Nature*, may help resolve a fundamental paradox facing those trying to assess Earth's carbon budget.

By studying water from the Amazon and several North American rivers, including the York, Raymond and Bauer determined that some of the carbon in these waters was thousands of years old. Previous thinking held that river carbon was at most a few decades old.

Researchers have long assumed that rivers play an important role in Earth's carbon cycle by carrying to the sea the carbon that land plants remove from the atmosphere via photosynthesis. When land plants die and decay, the carbon in their tissues enters the soil. As rivers erode the soil, they carry this carbon to the ocean. Once in the ocean, this carbon may sink to deep waters. There, it can become trapped for thousands of years, effectively removing it from the atmosphere and thus helping to lessen the greenhouse effect.

Based on this assumption, oceanographers expect to find large amounts of river-derived carbon in the ocean. "We know that continents supply a lot of carbon to the oceans," says Bauer, "but current techniques tell us it's not there."

The paradox of this missing carbon has long vexed oceanographers. But Raymond and Bauer's results suggest that much of the river-derived carbon may not be "missing"— once in the ocean, it simply may not look like what it started out as on land. Traditional thinking holds that the carbon that rivers carry to the ocean was only recently extracted from the atmosphere by land plants. This "young" carbon can be detected in a water sample by measuring the proportion of stable and radioactive carbon atoms it contains. Oceanographers have thus looked for large amounts of young carbon in their seawater samples as a fingerprint of land-derived carbon—but in vain.

Raymond and Bauer took a different approach, using the carbon-dating technique on water samples from rivers rather than the ocean. Their results show that the carbon in the rivers they studied is on average 670 years old, much older than previously suspected. They also found that the age of the various types of carbon in the samples varied much more than once thought.

"Our research," says Bauer "shows that young carbon in rivers is the exception rather than the rule."

R/V Bay Eagle on the York River, one of the sites Bauer and Raymond studied.

River-borne carbon may thus be more abundant in the ocean than previously thought, but scientists will need to look at something other than its age in order to identify just how abundant it really is.

About 40 percent of the carbon in river water occurs as tiny suspended particles. The rest of river carbon is dissolved in the water. Raymond and Bauer found that particulate river carbon is especially old—the average age of such samples from the rivers studied ranges from around 700 to almost 5,000 years old. This suggests that much of the particulate carbon in these rivers derives not from land plants but from ancient carbon stored in rocks and deep soil layers beneath the rivers' drainage basins.

The dissolved carbon is younger—but still much older than expected. Raymond and Bauer attribute their samples' unexpected age in part to the action of bacteria. Laboratory experiments by the pair show that bacteria in river water preferentially feast on younger carbon, thus enriching the remaining river water in older carbon that plants extracted from the atmosphere long ago.

The pair's research poses as many questions as it answers. One is whether the unexpected age of their samples may, like fossil-fuel burning, reflect a human disturbance to the natural carbon cycle. "Human activities such as agriculture may have modified the rivers' input of carbon to the ocean," says Bauer. In this scenario, tilling of soil in areas surrounding the Chesapeake Bay and other heavily farmed areas may bring older soil carbon to the surface, where rivers can then carry it to the sea.

Raymond and Bauer qualify their findings by noting that they have so far looked at samples from only a handful of rivers. However, they note that the rivers they studied likely provide a good model for the river systems that contribute almost 60 percent of the freshwater delivered to the North Atlantic each year.

Bauer next plans to study water samples from other river systems in North America and New Guinea to determine if the current findings apply elsewhere around the globe.

VIMS Welcomes Faculty Members

Dr. Deborah A. Bronk, Associate Professor, Physical Sciences. B.S., University of Miami; Ph.D., University of Maryland, Horn Point Environmental Laboratory.

Dr. Bronk's research focuses on the cycling of nitrogen in marine and estuarine environments. Specific research includes the role of dissolved organic nitrogen (DON) in microbial food webs, and the utilization of marsh-derived and phytoplankton-derived DON as a nitrogen source for phytoplankton and bacteria.

Dr. Jesse E. McNinch, Assistant Professor, Physical Sciences. B.S. University of Southwestern Louisiana; M.S. University of North Carolina at Chapel Hill; Ph.D. University of North Carolina at Chapel Hill.

Dr. McNinch's research interests are the observation and prediction of shoreface and shoreline changes in response to underlying geology, physical and sedimentary processes on cape-associated shoals, and other inner-shelf sedimentary features.

Dr. Ratana Chuenpagdee, Assistant Professor, Coastal & Ocean Policy. M.Sc. University of Wales, Bangor; Michigan State University; Ph.D., University of British Columbia.

Dr. Chuenpagdee's primary interest is in developing public decision-making processes for resource management and policies.

Dr. Robert L. Hicks, Assistant Professor, Coastal & Ocean Policy. B.A. North Carolina State University; Ph.D. University of Maryland.

Dr. Hicks' major research interests are environmental and resource economics, non-market valuation, natural resource damage assessment, and the economics of commercial and recreational fisheries. Hicks was with the National Marine Fisheries Service for the past three years.

Dr. Rochelle D. Seitz, Research Assistant Professor, Biological Sciences. B.A., Colgate University; M.S., The College of William and Mary; Ph.D., The College of William and Mary.

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