One-fifth of carbon entering coastal waters of eastern North America is buried

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Mangroves in the Everglades National Park tidal wetlands. Credit: Christian@94 / Flickr

Coastal waters play an important role in the carbon cycle by transferring carbon to the open ocean or burying it in wetland soils and ocean

sediments, a new study shows.

The team, led by Raymond Najjar, professor of oceanography in Penn State's College of Earth and Mineral Sciences, constructed the first known carbon budget of the eastern coast of North America from the southern tip of Nova Scotia, Canada, to the southern tip of Florida. They tracked the flows of organic and inorganic carbon into and out of coastal waters.

Cycling of carbon in the open ocean and on land has been the focus of much research, but coastal waters, which border the two areas, have "fallen through the cracks," Najjar said.

"Coastal waters have a whole set of issues that are difficult to grapple with, such as the tides affecting certain areas twice a day, and this has made it difficult to incorporate this area into quantitative models," he said. "We recognized there was a gap there and thought we should develop a carbon budget so we could see what we know and don't know."

Models are the primary way scientists predict future carbon dioxide levels in the atmosphere, which in turn tell us how much the global surface temperature may rise from the greenhouse effect. This new research helps to establish how coastal waters influence atmospheric carbon dioxide levels and, in turn, climate.

Najjar began this research in 2012 and has since partnered with 29 other scientists who specialize in various aspects of coastal oceanography. The team gathered data from dozens of published studies to quantify how much carbon enters, exits and is transformed within coastal waters of eastern North America. They report in Global Biogeochemical Cycles that, of the carbon entering coastal waters from rivers and the atmosphere, about 20 percent is buried while 80 percent flows out to the open ocean.

The study subdivided coastal waters into tidal wetlands, estuaries and continental shelf waters. Tidal wetlands and estuaries, despite being the smallest ecosystems in the study domain at 2.4 percent and 9 percent of the area, respectively, buried the majority of the region's carbon, the team found. Tidal wetlands buried 42 percent of the carbon in the study and estuaries buried 38 percent, for a total of 80 percent of carbon burial in coastal waters.

Najjar believes this is due to the relatively shallow depth of water in tidal wetlands and estuaries, as well as the fact that rivers bring life-sustaining nitrogen to these ecosystems.

"The way carbon gets buried usually starts with photosynthesis, through which carbon dioxide is converted to organic material in the form of plankton, marsh grass, mangroves, or sea grass," he said. "Eventually that material dies and settles to the bottom. But continental shelf waters are deeper than tidal wetlands and estuaries, so there is more time for bacteria and other animals to consume this dead matter before it can get buried."

Carbon burial is an important metric when it comes to predicting future atmospheric carbon dioxide levels because, once carbon is in the sediments, it has the potential to remain there and not contribute to the greenhouse effect. However, the fragility of the coastal zone, Najjar said, could be cause for concern.

"As sea level continues to rise and disturb the coasts, some of the buried carbon could be respired and released to the atmosphere in the form of carbon dioxide," he said.

The team used the mass balance approach for their calculations, which assumes that the total amount of carbon going into a system equals the amount leaving a system. Carbon cycling within coastal waters is

complex and the team sought to identify how carbon flows into and out of tidal wetlands, shelf waters and estuaries. The team compiled data from many studies and for the first time synthesized observations and numerical model output to develop a cohesive view of the carbon cycle in a large coastal region. The scientists also identified carbon fluxes where further research would be needed to reduce uncertainties, including the exchange of carbon between shelf waters and the open ocean.

Najjar is now working with scientists to create a carbon budget that includes the Gulf of Mexico, as well as a carbon budget of the western North American coast.

More information: R. G. Najjar et al. Carbon Budget of Tidal Wetlands, Estuaries, and Shelf Waters of Eastern North America, *Global Biogeochemical Cycles* (2018). DOI: 10.1002/2017GB005790

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