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Major Storm Events Play Key Role In Biogeochemistry of Watersheds

A new Yale-led study finds that heavy weather events cause an inordinate amount of organic material to bypass headwater systems, pushing them downstream into larger rivers and coastal waters and inland basins — with profound implications for water quality through the watershed.

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A new Yale-led study offers a new conceptual framework for understanding the biogeochemistry of watersheds. The framework combines hydrologic and biogeochemical theory to test well established concepts in watershed ecology.

The paper, published in the journal *Ecology*, suggests that heavy weather events, though infrequent, cause an inordinate amount of organic material to bypass headwater systems, pushing them downstream into larger rivers, coastal waters, and inland basins.

This phenomenon can have profound ecological implications on the quality of water systems worldwide and the chemical processes that occur within them. Dissolved organic matter — a complex mix of compounds that leeches into waterways and gives rivers and streams their color — introduces nutrients and pollutants, influences the escape of carbon dioxide from the water, and can impact the amount of light that penetrates the water. That, in turn, can affect levels of phytoplankton, a major food source for many organisms.

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Researchers have long believed that organic materials are naturally processed by organisms in the “first order” streams — the smaller streams at the headwaters of a river network headstream waters — creating new compounds that are in turn processed by organisms farther downstream, with the process occurring throughout the system. The process is known as the River Continuum Concept.

But the new paper underscores that this process does not account for the importance of heavy weather events, which trigger “pulses” of organic matter into waterways. As the authors explain, these events also push, or “shunt,” this organic matter past the headwaters before there is time for those reactions to occur since they also accelerate the velocity of the water flow.

They term this theory the “pulse-shunt concept.”

“We predict that a lot of this organic matter is actually shunted past the small streams and the reactions occur in the larger rivers or even in the coastal ocean,” said **Peter Raymond**, a professor of ecosystem ecology at the Yale School of Forestry & Environmental Studies (F&ES) and lead author of the study. “We also offer a new conceptual theory for watershed biogeochemistry that demonstrates this through first principles and is transferrable to other watersheds and other nutrients.”

Previous research has estimated that about 60 percent of the transported DOM from terrestrial landscapes to waterways occurs during 15 days, including days of heavy rain or snow melt.

“Because the concentration of material transport increases with the size of the event, the total flux off the landscape is greatest when you have a few large events as opposed to several smaller events,” Raymond said. “However, the ‘shunt’ that occurs during these large events also reduces the amount of material that is removed within the smaller streams and rivers.

“So there is this double additive effect that exports more of these organic materials to coastal waters.”

The researchers say that shifts in the transport of DOM could potentially impact mercury inputs to inland waters and the Sound, dissolved oxygen concentrations, and water clarity.

“Because the concentration of material transport increases with the size of the event, the total flux off the landscape is greatest when you have a few large events.”
— Peter Raymond

The paper was co-authored by **James Saiers**, the Clifton R. Musser Professor of Hydrology at F&ES, and William Sobczak from the College of the Holy Cross.

Part of the work was was funded by the National Science Foundation’s macrosystems biology grant initiative, which supports research exploring the effects of climate and land-use changes on organisms and ecosystems at regional to continental scales.

“Major storms, whether rainstorms or snowstorms, make a big impact on what flows downstream from the land, through rivers and streams, and eventually out to sea,” says **Tim Kratz**, program director in the National Science Foundation (NSF)’s Directorate for Biological Sciences, which funded the research. “These results show that land and sea are connected through streams and rivers in a much more complex way than we thought.”

The authors say their findings provide an important framework for watershed biogeochemical modeling and will help scientists better predict and understand ecological processes in river networks.

– Kevin Dennehy *kevin.dennehy@yale.edu* *203 436-4842*

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