Eco-DAS VIII
Symposium Proceedings

Eco-DAS VIII Chapter 9, 2010, 146-165

Biogeochemical reaction and transport within hydrologic landscapes: crossing disciplinary and ecosystem boundaries

Tamara Harms[1], Brian Reid[2], Daniel Sobota[3], and Amy Burgin[4]*

[1]Institute of Arctic Biology, University of Alaska, Fairbanks, AK 99775

[2]Centro de Investigación en Ecosistemas de la Patagonia (CIEP), Universidad Austral de Chile, Bilbao 449, Coyhaique, Región de Aysén, Chile

[3]National Research Council Research Associateship Program, in residence at the Western Ecology Division, US EPA, Corvallis, OR 97333

[4]Department of Earth and Environmental Sciences, Wright State University, Dayton, OH 45435

Abstract

Delivery of materials from catchments to coasts constitutes a significant flux within many global elemental cycles. However, large uncertainties bracket estimates of land-sea fluxes, due to limited understanding of interactions among material retention, transport, and transformation within hydrologic landscapes. Freshwater ecosystems facilitate biogeochemical reaction by bringing reactants together in complex physico-chemical environments. Further, they comprise the transport network by which materials move from catchments to coasts. Whereas there have been significant gains in understanding and quantifying hydrologic transport (HT) and biogeochemical reaction (BR) within specific types of freshwater ecosystems (e.g., nutrient spiraling in streams), disparate methodologies and approaches among ecosystems hinder synthesis efforts across the hydrologic landscape. Our goal is to increase the potential for synthesis of HT and BR across traditional ecosystem boundaries. We review the methods and metrics for quantifying HT and BR for the major ecosystems within hydrologic landscapes: lakes, rivers, wetlands, and groundwater. We then identify the research challenges that currently limit integration of HTBR across hydrologic landscapes and discuss the potential for a common set of metrics and approaches to represent HT and BR across multiple freshwater ecosystems. We advocate an approach that ties distribution functions of water residence time explicitly with retention efficiency of materials and nutrients. Such an approach reduces the impact of ecosystem-specific complexities that confound scaling exercises, avoids the assumption of steady-state, and provides a means for direct comparison of material dynamics across the hydrologic landscape.

Quantifying the flux of nutrients and materials from land to sea remains an important research challenge in global biogeochemistry. Recent estimates of global land-sea fluxes indicate that 367 Tg organic C, 65.9 Tg N, and 10.8 Tg P enter oceans from land each year (Seitzinger et al. 2005). However large uncertainties bracket such estimates, stemming from limited understanding of interactions among material retention, transport, and effects of anthropogenic activities in freshwater ecosystems (Dumont et al. 2005; Harrison et al. 2005; Jenerette and Lal 2005; Cole et al. 2007). Improved estimates of hydrologic transport and biogeochemical reaction in freshwater ecosystems would contribute to mechanistic understanding and reduce uncertainties associated with material fluxes from land to sea.

Freshwater ecosystems, including streams, wetlands, lakes, and groundwaters, comprise the transport network by which materials and nutrients move from continents to the coasts. In addition to material transport, biogeochemical reactions within these diverse ecosystems change the abundance and form of materials delivered to downstream ecosystems. Ecosystems characterized by surface waters and saturated sediments may be conceptualized together as *hydrologic landscapes*. Many authors have advocated for application of a landscape ecological approach to stream ecosystems (Poole 2002; Ward et al. 2002; Wiens 2002; Fisher et al. 2007; Johnson and

*Corresponding author: E-mail: tamara.harms@alaska.edu

Acknowledgments

We thank Paul Kemp and participants in the 2008 Eco-DAS symposium for their leadership, ideas, and collaboration. We would like to recognize the efforts of Kate Achilles and comments from three anonymous reviewers in the preparation of the manuscript.

Publication was supported by NSF award OCE0812838 to P.F. Kemp

ISBN: 978-0-9845591-1-4, DOI: 10.4319/ecodas.2010.978-0-9845591-1-4.146