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► **To cite this version:**

Clara Mendoza-Lera, Núria Catalán, Anna Lupon. Editorial: Watershed and Stream: The Inseparable Functional/Biogeochemical Unit. *Frontiers in Water*, 2021, 3, 10.3389/frwa.2021.801389 . hal-03501131

HAL Id: hal-03501131

<https://hal.science/hal-03501131>

Submitted on 23 Dec 2021

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Editorial: Watershed and Stream: The Inseparable Functional/Biogeochemical Unit

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Keywords: biogeochemical cycling, scales, stream processes, riparian zone, hyporheic zone, catchment, reach

Editorial on the Research Topic

Watershed and Stream: The Inseparable Functional/Biogeochemical Unit

As stated by the small catchment concept from Bormann and Likens (1967), the watershed and the stream draining it are functionally an inseparable unit. Terrestrial processes strongly affect the structure and function of aquatic ecosystems by determining the lateral inputs of energy and nutrients to streams. Watershed topography, land cover, and vegetation, are examples of terrestrial processes affecting in-stream organic matter and nutrient processing (Buffam et al., Estévez et al., Pearce et al., Yang et al.). Watershed geology and topography can also indirectly affect biogeochemical processes at reach scale by modulating both the channel morphology and preferential groundwater flow paths (Commer-Warner et al., Khamis et al., Meredith et al., Ploum et al.). Paradoxically, terrestrial and aquatic studies often evaluate processes separately, limited within their ecosystem boundaries. Placing ecosystems in boxes is useful to gain mechanistic understanding, but limits our comprehension of watersheds' functionality. The studies contributing to this Research Topic aim to re-visit the small watershed concept bringing together research that connects ecosystems and processes from a more integrative, catchment-scale approach.

In the last decades, land cover is quickly changing due to anthropogenic processes such as increasing urbanization or the abandonment of agricultural lands (Grimm et al., 2008; Seto et al., 2012). Estévez et al. shed some light on the effect of the later on stream biogeochemistry by showing that dissolved organic matter (DOM) properties in streams mostly reflected present-day gradients of riparian cover rather than historical legacies of land uses. On the other hand, Yang et al. show that the hierarchical scaling of human settlements in watersheds influences the spatial patterns of total phosphorus (P_{tot}) inputs and removal at the network scale. Specifically, they observed that the efficiency of P_{tot} removal relates inversely with stream-order, but that the magnitude of P_{tot} removed is higher in larger streams with higher urbanization.

In addition, there is a link between the effect of land use on stream biogeochemistry and its transfer to the food web (Pearce et al., Buffam et al.). In their work, Pearce et al. demonstrated that urban streams showed increased nutrient concentrations and variations in element stoichiometry compared to forested streams. Additionally, this nutrient enrichment had a bottom-up effect in the stoichiometry of primary consumers, yet this effect muted with increasing trophic positions. The influence of water chemistry can also be top-down, as shown by Buffam et al. Their work shows that mesoscale controls, determined by watershed management and properties, such as surficial sediment coverage, directly influence brown trout distribution. Once carbon and nutrients reach the river, there are two critical controls of stream water chemistry: the lateral exchange of water and materials between the river and riparian zone, and the vertical connectivity between surface and

OPEN ACCESS

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Specialty section:

This article was submitted to
Water and Critical Zone,
a section of the journal
Frontiers in Water

Received: 25 October 2021

Accepted: 08 November 2021

Published: 30 November 2021

Citation:

Mendoza-Lera C, Catalán N and
Lupon A (2021) Editorial: Watershed
and Stream: The Inseparable
Functional/Biogeochemical Unit.
Front. Water 3:801389.
doi: 10.3389/frwa.2021.801389

hyporheic water (Winter et al., 1998). Laterally, riparian-stream connections can affect stream biogeochemistry at different scales. At the reach scale, Ploum et al. demonstrated that preferential groundwater flow paths, namely DRIPs, act as control points for riparian vegetation and stream water chemistry. Specifically, they show that DRIPs areas are wetter than surrounding lands, which support specific vegetation species and supply organic matter-rich water to streams. At larger scale, Estévez et al. showed that streams draining watersheds dominated by riparian forests had a greater abundance of O-rich phenols and polyphenols because these ecosystems regulate DOM photodegradation in streams (by canopy cover) and terrestrial DOM inputs.

Vertically, Commer-Warner et al. and Meredith et al. show that spatial heterogeneity modulates reach-scale biogeochemical patterns by controlling water travel times and the exchange of nutrients between the water column and the streambed. Specifically, longer water residence times are linked to larger particulate organic matter storage and higher rates of respiration and methane production, while shorter residence times are linked to low nitrogen retention and high release. Thus, in addition to spatial patterns, temporal heterogeneity is also a key factor to consider. For example, the influence of lateral riparian-stream connections on stream DOM can vary in time depending on watershed hydrology (Ploum et al.). Further, Khamis et al. showed that the fate of stream DOM varies depending on the time scale considered. At seasonal scale, DOM tends to be removed as it is transported downstream, but at daily scale DOM is consumed during the day and released at night.

Overall, this Research Topic shows that watershed processes constraint biogeochemical patterns at different spatial (i.e.,

from habitat to basins) and temporal (i.e., from daily to seasonal) scales and thus emerging as modulators of stream and riparian biogeochemistry. This Research Topic is timely, as we are witnessing unprecedented land use changes at a very fast speed, which effect in the biogeochemical cycling in freshwaters needs to be fully understood urgently. Thus, the aspects discussed here are of critical importance when setting up strategies for river, catchment, and fluvial network management.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

CM-L received support from German Research Foundation (DFG: ME5498/3-1 and ME5498/2-1). NC received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No.839709. AL was supported by the Government of Catalonia and the European Commission through the program Beatriu de Pinós (BP-2018-00082).

ACKNOWLEDGMENTS

We want to thank all the authors that contributed to this Research Topic, as well as the reviewers that ensured the high quality of the manuscripts.

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