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Using diatoms, hydrochemical and stable isotope tracers to infer runoff generation processes

N. Martínez-Carreras (1), C.E. Wetzel (1), J. Frentress (1,2), D. Hlúbiková (1), L. Ector (1), J.J. McDonnell (2), L. Hoffmann (1), and L. Pfister (1)

(1) Centre de Recherche Public - Gabriel Lippmann, Département Environnement et Agro-Biotechnologies, Belvaux, Luxembourg (martinez@lippmann.lu), (2) Oregon State University, Department of Forest Engineering, 015 Peavy Hall, Corvallis, OR 97331-5706, USA

Imaginative techniques are needed to improve our understanding of runoff generation processes. In this context, the hydrological community calls to cut across disciplines looking for new and exciting advances in knowledge.

In this study, hydrologists and ecologists have worked together to use not only hydrochemical and stable isotope tracers, but also diatoms to infer runoff generation processes. Diatoms, one of the most common and divers algal group, can be easily transported by flowing water due to their small size ($\sim$10-200 μm). They are present in most terrestrial habitats and their diversified species distributions are largely controlled by physico-geographical factors (e.g. light, temperature, pH and moisture). Thus, hydrological systems largely control diatom species community composition and distribution.

This study was conducted in the schistose Weierbach catchment (0.45 km^2, NW Luxembourg). Its runoff regime is characterised by seasonal variation and a delayed shallow groundwater component originating from a saprolite zone. The catchment was instrumented with piezometers, suction cups, an automatic streamwater sampler, a sequential rainfall sampler, and soil moisture and temperature sensors. Samples collected bi-weekly and during storm runoff events allowed the characterisation of the different end-members. Chemical and isotopic hydrograph separations of stream discharge were used to determine not only the geographic sources of water, but also the fractions of old and new water contributing to streamflow. Diatoms intra-storm variability was also analysed and samples of diatoms from various terrestrial and subaerial substrates (bryophytes, litter and leaves), as well as from aquatic habitats (epilithon, epipelon and drift samples) were regularly collected. Diatoms were then used to constrain assumptions and to confirm or reject the hypothesis of existing surface runoff during rainfall-runoff events and to document the intermittent character of hydrological connectivity between upland, riparian and aquatic zones. As an advantage, diatoms do not seem to be subject to some inherent limitations of the classical tracer-based hydrograph separation techniques, such as unrealistic mixing assumptions, unstable end-member solutions and temporally varying input concentrations.

Results suggested a substantial contribution of soil water during winter events in the Weierbach catchment, whereas groundwater played a more significant role during summer events. Even though overland flow remained insignificant during most of the sampled events, terrestrial diatom abundance increased with precipitation in all sampled events suggesting a rapid connectivity between soil surface and stream water. We hypothesise the mobilization and flushing away of terrestrial diatoms through a subsurface network of macropores in the shallow soils.