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Fluorescent diatoms as hydrological tracers: a proof of concept percolation experiment

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Tracers are widely used in catchment hydrology to understand natural phenomena, such as runoff generation processes and water flowpaths, due to their versatility and generally good detectability. Although tracing methodologies are key observational tools in complex settings such as ungauged basins, their implementation can be hindered by cumbersome detection procedures, unrealistic mixing assumptions, and temporally and spatially varying concentrations. In this framework, recent efforts are being devoted to the development of novel tracing techniques with the twofold objective of reducing tracer identification uncertainty while minimizing detection equipment. Specifically, living organisms such as diatoms have proven successful to investigate rainfall-runoff events, thus positing their feasibility as hydrologic tracers.

In previous and ongoing research from our group, sampling and analysis of terrestrial diatoms in the Weierbach catchment (NW Luxembourg) highlight substantial contribution of soil and groundwater to stream water during winter and summer events, respectively. Nonetheless, terrestrial diatom concentration is observed to increase with precipitation in stream water samples even if overland flow relative contribution is meager. Possible motivations for such behavior can be sought in the transfer and flushing of diatoms through subsurface macropore networks.

In this work, we study the hypothesis of terrestrial diatom flushing through shallow soil macropores by conducting proof of concept percolation experiments with fluorescent diatoms in laboratory settings. Specifically, labeled diatoms are synthesized by either functionalizing their frustules through Rhodamine 123 adsorption or by growing *Conticribra weissflogii* (Grunow) Stachura-Suchoples & D.M. Williams cultures in the presence of the biogenic silica tracer 2-(4-pyridyl)-5-((4-(2-dimethylaminoethylaminocarbamoyl)methoxy)-phenyl)oxazole (PDMPO). Labeled diatoms demonstrate good resilience under weathering agents and enhanced detectability through expeditive and noninvasive spectrofluorometry techniques. Selected quantities of fluorescent diatoms are deployed on the surface of undisturbed and saturated soil cores from the Weierbach ($0.45\,\mathrm{km}^2$, schistous, loamy to sandy soils) and Huewelerbach ($2.7\,\mathrm{km}^2$, sandstone, sandy soils) catchments to experiment with varying soil matrices. Water is added in constant volumes to induce percolation and samples recovered at the bottom of the columns are analyzed through microscopy and spectrofluorometry.

Experimental findings suggest that diatom flushing through the soil cores does not occur after the addition of significant water volumes and for time scales on the order of ten hours. Not taking into account inherent complexities found in the environment, these results are a first step towards a comprehensive understanding of diatom transport in natural watersheds. Further work will be devoted to study the effects of rain drop energy on macropore formation and consequent diatom transfer as well as the impact of series of precipitation events on cell mobility.