From geophysics to ecological systems: Impact of flow variability on habitats, consequences on micro-organism communities and ecosystem functioning

Scientific context: Sir Arthur Tansley (1878 - 1955) defined ecosystems as the indivisible part linking life and its environment. Water plays a critical role, as both a fundamental component of life and as a key component carrying both nutrients and energy. Interfaces (zones of convergences of waters) have a key role in the emergence of "hotpots" with high biological activities: they create gradients that favor specific habitats and biodiversity. However, these interfaces are still poorly understood, particularly because of the difficulty to describe water transfer in heterogeneous environments, the induced spatio-temporal variability and its impact on ecosystems. For example, small lakes are generally considered spatially homogeneous because of the frequent mixing of water masses by wind. However, recent results suggest a strong spatial heterogeneity, inherited from the mixing of different water sources (surface, subsurface) and from biological processes

Scientific questions: The different sources of water converging towards an open water can be diffuse or punctual. This results in a spatial heterogeneity of the physico-chemical properties of water masses that evolve at daily, seasonal and long-term time scales. Several questions arise:

1. How can we measure and highlight the different water sources and the spatio-temporal gradients induced by the mixtures? What are their persistence and their relative contribution to the global functioning of the lake?
2. What are the links between these gradients and the structure, activities and dynamics of micro-organism communities?
3. What are the feedbacks of microbial communities on the biogeochemical gradients?

Approaches: The dual hydrology/ecology approach requires reliance on well-characterized systems. Accordingly, the thesis will focus on the coastal wetland of Lannenec, a Natura 2000 zone located downstream of the Ploemeur Critical Zone Observatory (http://hplus.ore.fr/en/ploemeur, https://twitter.com/Obs_Ploemeur). Water in the pond originate both from surface and groundwater resurgences forming a plume of anoxic water. The use of modern “High Frequency” tools developed within the CRITEX “challenging equipment project” (https://www.critex.fr/) will allow to map with a very high spatial resolution the heterogeneity of the water body which results from both hydrological flows and biological activity. The consequences of this heterogeneity on the microbial food web will also be monitored. High throughput sequencing of 16S and 18S rRNA amplicons will be used to determine planktonic microbial community structure. The diversity of rotifer communities (bacterioplankton grazers) will be characterized by optical microscopy (counting and taxonomic determination). Finally, activity measurements (photosynthesis, respiration, etc ...) will be performed. Statistical analyses and model development will highlight the link between the community structure and activity and physico-chemical gradients in the pond.

Context: The PhD will be set in the University of Rennes, within the "Earth Sciences observatory" OSUR (https://osur.univ-rennes1.fr/page/osur-eng). This research federation links both the hydrogeology and ecology groups. The work will also benefit from data from the national H + observation network (http://hplus.ore.fr/ploemeur), and the CRITEX equipment project (https://www.critex.fr/).

Profile: Highly motivated candidate with a training in modelling, hydrology or ecology, attracted by ecosystem functioning and interdisciplinary approaches.

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Application procedure :

Please contact the persons above for any question on the PhD project. Application should be mad on the UBL website: https://theses.u-bretagneloire.fr/egaal/theses-2018, choose "Ecologie", and "Geosciences Rennes" tab. Follow the link "send a candidature file for this thesis".

References

Ballaud F, Dufresne, A, Francez A-J, Colombet J, Sime-Ngando T, Quaiser A. (2016). Dynamics of Viral Abundance and Diversity in a Sphagnum-Dominated Peatland: Temporal Fluctuations Prevail Over Habitat. Front. Microbiol. 6:1494

Ben Maamar S, Aquilina L, Quaiser A, Pauwels H, Michon-Coudouel S, Vergnaud-Ayraud V, Labasque T, Roques C, Abbott BW, Dufresne A. (2015). Groundwater Isolation Governs Chemistry and Microbial Community Structure along Hydrologic Flowpaths. Front. Microbiol. 6:1457

Jimenez-Martinez, J., Longuevergne, L., Le Borgne, T., Davy, P., Russian, A., Bour, O. (2013): Temporal and spatial scaling of hydraulic response to recharge in fractured aquifers: insights from a frequency domain analysis, Water Res. Res, doi: 10.1002/wrcr.20260

Nunes FLD, Aquilina L, de Ridder J, Francez A-J, Quaiser A, Caudal J-P, Vandenkoornhuyse P, Dufresne A. (2015) Time-scales of hydrological forcing on the geochemistry and bacterial community structure of temperate peat soils. Scientific Reports 5:14132

Pannard, A., Planas, D., & Beisner, B. E. (2015). Macrozooplankton and the persistence of the deep chlorophyll maximum in a stratified lake. Freshwater biology, 60(8), 1717-1733.

Pannard A., A. Guislain, M. Chorin, S. Mahé, G. Bouger, A. Crave, B. Le Rouzic & M. Bormans (2018) Phosphorus more than temperature controls the phytoplankton community in a deep quarry lake: a combined field and laboratory approach, Inland Waters, 8:1, 22-35, DOI: 10.1080/20442041.2018.1424097

Schuite, J., Longuevergne, L., Bour, O., Boudin F., Durand, S., Lavenant, N. (2015) : Inferring field-scale properties of a fractured aquifer from ground surface deformation during a well test, Geophys.Res. Letters, doi: 10.1002/2015GL066387

Taylor, R.G., Scanlon, B.R., Döll, P., Rodell, M., van Beek, R., Wada, Y., Longuevergne, L., et al. (2013) :Groundwater and climate change, Nature Climate Change, doi : doi:10.1038/nclimate1744