LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY | LIST

HYDRO-CSI

CLUSTER 2 – NEW TRACERS AND APPROACHES FOR INVESTIGATING HYDROLOGICAL PROCESSES

Luxembourg Institute of Science and Technology (LIST)
5, avenue des Hauts-Fourneaux | L-4362 Esch/Alzette
Tel: (+352) 275 888 – 1 | LIST.lu

Summary of Hydro-CSI research clusters

INTRODUCTION

The Doctoral Education Unit in Hydrological Sciences (Hydro-CSI) is contributing to the exploration of new and interdisciplinary research avenues to overcome limitations in our current understanding of catchment functioning.

Hydro-CSI is led by LIST in partnership with the University of Luxembourg (LU), Vienna University of Technology (AT), Wageningen UR (NL), Karlsruher Institute of Technology (DE) and is supported by the FNR.

Hydro-CSI is composed of four research clusters:

- Cluster 1 – Innovative field-deployable instruments for high-frequency monitoring
- **Cluster 2 – New tracers and approaches for investigating hydrological processes**
- Cluster 3 – Remote sensing applied to hydrology
- Cluster 4 – Hydrological forecasts and projections under global change

In this document, please find the presentation of Cluster 2.

2.1 PHD PROJECT OF PERRINE FLORENT

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Topic: Environmental virology

<u>Project objectives</u>:
In hydrology and virology, the fate of bacteriophages within the pedosphere remains poorly known. Here we propose to explore their potential for exploring the hydrological systems and to improve our knowledge on bacteriophages communities in soils. The main objective of this PhD project is to characterise the population of bacteriophages in soils and to validate their use as hydrological tracers over short spatial and temporal scales.
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Abstract:

Albeit recent technological developments (e.g. field deployable instruments operating at high temporal frequencies), experimental hydrology is a discipline that remains measurement limited. From this perspective, trans-disciplinary approaches may create valuable opportunities to enlarge the amount of tools available for investigating hydrological processes.

The ubiquitous character of bacteriophages in water has triggered countless applications as environmental tracers for studies in water quality, source tracing or prediction of waterborne pathogen occurrence. They have been also widely used as biological tracer for investigating colloid transport and contamination of ground water systems. However, there are only a few studies focusing on the employability of bacteriophages as surface water tracers (i.e. phage transport, system functioning) at the catchment scale. We hypothesize that such viral particles can be a promising tool in catchment hydrology for tracing runoff flow sources and pathways across a wide range of spatial and temporal scales. More specifically, we intend to focus on the rainfall-runoff events to detect hydrological connectivity between the riparian zone/river bank and the stream. For this purpose, we propose to work with the F-specific RNA phages as virus models. These viruses from faecal origin are widely spread in aquatic environment and have the ability to distinguish animal from anthropogenic faecal sources. Experimental work will be conducted at different scales, from lab to field experiences. Thus, one of the main pillars of this PhD project consists in the combination of hydrological and microbial approaches to estimate the virus transport and water system functioning.

2.2 PHD PROJECT OF JASPER FOETS

Topic: **Eco-hydrology and tracer hydrology** Project objectives: In this PhD, we first focus on an in-depth investigation on the ecology of terrestrial diatoms. More specifically, we try to link the occurrence of diatoms to hydroclimatological and environmental parameters and use the newly acquired knowledge to overcome some of the limitations linked to the use of diatoms as hydrological tracers. Secondly, we will investigate a more effective method for sampling diatoms during rainfall events.	

Abstract:

Diatoms are widespread and present in almost all habitats containing water (e.g. lakes, streams, soils, rocks) and count among the most common algal groups in both freshwater and marine ecosystems. Their diversity and specific ecological preferences have made them indispensable in water quality assessment, palaeoecological reconstruction and stratigraphic correlations. While aquatic diatoms are very well studied, this is not the case for terrestrial diatoms where the majority of the studies have focused on the floristics and not on the ecology. This lack of ecological knowledge hampers further use of terrestrial diatoms as hydrological tracers, or biological indicators of anthropic disturbances and soil quality.

To overcome this problem we will measure the spatial and temporal variability of diatom communities and try to link the occurrence/absence of certain species to an extensive set of environmental variables. The main part of this PhD research will focus on a high-frequent sampling (once a month) campaign in the Attert River basin, where we will measure numerous hydroclimatological and other environmental factors (some of them will be used for the first time) in combination with qualitative and quantitative diatom community assessment. In the second part of the study we aim to further unravel the controlling factors on diatom community assemblages using controlled experiments. Using field and/or lab experiments where we artificially change parameters such as nitrogen and phosphorus content, pH, soil moisture. We aim to better understand what the ecological preferences are of the most important indicative diatom taxa we found in the first part of the study to eventually increase their utility as a hydrological tracer and as a potential indicator of soil quality.

2.3 PHD PROJECT OF ALESSANDRO MONTEMAGNO

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Topic: **Sediment fingerprinting**

<u>Project objectives:</u>

Transport of suspended sediments (SS) within a river is a spatially and temporally dynamic process, which requires high frequency monitoring to capture SS dynamics and quantify SS fluxes. However, current optical methods to quantify SS fluxes are highly influenced by composition, size and concentration of SS. Here, we propose to use *in-situ* sensors to measure the characteristics of SS and ultimately improve flux estimations.

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<u>Abstract</u>:

This is an interdisciplinary research project that will focus on a better understanding of processes controlling water exchanges in the critical zone. One of the main pillars of this PhD project consists in the combination of quantitative (hydrology) and qualitative (geochemistry) approach to estimate the bio-geo-chemical processes that control the temporal dynamics of the water exchanges between the regolith and the plants in forest ecosystems. We hypothesized that the proposed multi-tracer approach (REEs and O-H stable isotopes) combined with physical-based hydrological modelling will allow to better understand the origin and dynamics of water fluxes between specific compartments of the critical zone, from the rhyzosphere toward the different tree compartments. The main objective of this project particularly relies on a rigorous and detailed study of the REE fractionation processes in a slate regolith – beech tree continuum. This will allow to identify the sources of REEs absorbed by the trees and the bio-geo-chemical processes that promote the nutrient/water uptake by trees. The combined experimental (O-H stable isotopes + field monitoring) and modelling hydrological approach will quantify the related water fluxes between the studied critical zone compartments.

According to the proposed objective, the project will be decoupled in progressive steps:

- water/roots interactions with a focus on the REEs uptake;
- REEs transportations through the plants towards aerial parts;
- REEs fate from the plant's leaves by integrating atmospheric dust contribution and linking with stemflow and throughfall;
- Monitoring of O-H stable isotopic composition in groundwater, soil solution, sap, throughfall, rainfall and stemflow;
- Calibration and validation of 1D hydrological model.