Biotechnologie et signalisation cellulaire

Institut Terre & Environnement de Strasbourg | ITES | UMR 7063 de l'Université de Strasbourg & CNRS & ENGEES

Master's course topic

Role of bacterial biofilm in access to soil nutrients

Laboratories involved:

This multidisciplinary internship is at the interface between microbiology and geochemistry. The student will work at the BSC laboratory for the microbiology part of the study (Illkirch campus) and at the ITES (esplanade campus) for the chemical analyses.

Supervision:

Pr. V. Geoffroy (BSC) and Pr. A-D. Schmitt (ITES) - Dr. S. Gangloff (ITES)

Context of the study

Sustainable management of forest ecosystems requires a better understanding of nutrient dynamics in forest soils. Unlike other macronutrients, such as nitrogen (N) or phosphorus (P), studies on soil dynamics and plant availability of calcium (Ca) are not well developed, despite the fact that it is an essential nutrient with key physiological and structural functions in plant metabolism (Marschner, 1995). Field studies conducted in nutrient-depleted soils (e.g. acidic substrate and/or subjected to acid rain) highlight the essential role of soil nutrient reservoirs in Ca uptake by vegetation (e.g. soil solutions, Ca adsorbed on soil organo-mineral phases, secondary minerals) (Schmitt et al., 2017). Consequently, it appears essential to identify and characterise these reservoirs precisely in order to improve our understanding of the dynamics operating in the different soil reservoirs and of Ca bioavailability to trees.

The omnipresence, in significant quantities, of micro-organisms, whether bacterial or fungal, in natural environments leads to the presence of highly diversified metabolites whose properties influence the availability of nutrients (Barnes and Nierzwicki-Bauer, 1997). However, the implications of these biotic processes are still poorly documented, particularly in the global biogeochemical cycles of elements such as Ca. In particular, it is essential to consider not only the processes occurring at the cell wall/media interface, but also the role of highly reactive extracellular polymeric substances (EPS) and the mechanisms of metabolisation (efflux, internalisation). In fact, the respective roles of the various biological agents and their metabolites in establishing biogeochemical alteration balances, including the removal of nutrients by living organisms, are still poorly understood.

Over the last decade, studies of the biogeochemical cycle of Ca in the critical zone using the different stable isotopes of Ca have revealed isotopic fractionations associated with biotic processes (uptake by roots and translocation within trees, recycling by vegetation) or abiotic processes (precipitation of secondary minerals, adsorption/desorption) (e.g., Cenki- Tok et al., 2009; Cobert et al., 2011; Schmitt et al., 2012; Bagard et al., 2013; Schmitt et al., 2013; 2017;

2018; Gangloff et al., 2014; Schmitt, 2016; Brazier et al., 2019; 2020; Griffith et al., 2020). Two recent studies have shown that adsorption of Ca from a solution onto different ubiquitous soil mineral fractions (such as phyllosilicates like kaolinite, montmorillonite, muscovite, or phyllomanganate like δ-MnO2) showed an enrichment of the solution in ^{44}Ca (up to +1.19‰ for δ-MnO2) (Brazier et al., 2019; Schmitt et al., 2023). An experimental study testing the effects of Ca adsorption on Gram-positive telluric bacteria such as Bacillus subtilis and Gram-negative bacteria such as fluorescent Pseudomonas, both dead and alive, showed an isotopic fractionation during this biotic interaction (Nuvoli et al., submitted).

In natural environments, it is estimated that more than 99% of bacteria reside in the biofilm matrix (Costerton et al., 1987; Flemming and Wuertz, 2019). For this reason, the aim of the present study is to experimentally test the role of biofilms in soil nutrient (Ca) access using an interdisciplinary approach combining microbiology and geochemistry.

The aim of this study is

- to set up an experimental protocol for testing Ca adsorption on a bacterial biofilm and on a bacterial biofilm-mineral mixture
- to test whether or not Ca isotopic fractionation occurs in the presence of a bacterial biofilm
- if fractionation does occur, to identify the mechanisms responsible for this isotopic fractionation
- to determine the role of the bacterial biofilm in the acquisition of nutrients (Ca) by plants.

Skills acquired :

- *Microbiology:* mastery of procedures under aseptic conditions, bacterial culture in planktonic mode and biofilm, biochemical assays.
- *Geochemistry:* ICP and isotopic elemental assays, determination of CEC (cation exchange capacity), mineral synthesis.

Application to be sent to : CV + covering letter

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