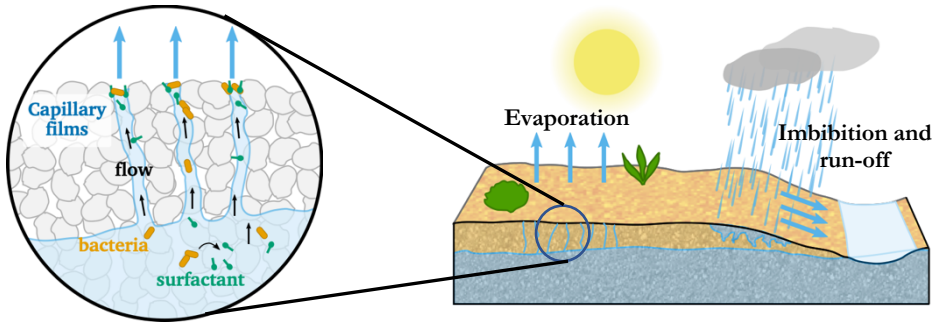
Impact of bacteria on soil drying dynamics

Surface evaporation from bare soils is a key component of the Earth's hydrological cycle, returning 20% of rainfall from land masses to the atmosphere. This "drying" of the soil is controlled at microscopic scales by capillary flows along water films linking water at depth to the surface. Drying dynamics are therefore sensitive to the physicochemical properties of the soil environment, such as the surface tension of water or its contact angle with soil particles. Bacteria are a ubiquitous feature of the soil environment, present in concentrations up to 10 billion per gram of soil. They produce molecules with strong activities at water-air interfaces – surfactants – which can significantly lower surface tension. Despite this, the impact of these bacteria on drying dynamics remains almost completely unexplored. As extreme climatic events such as droughts become more frequent, it becomes even more crucial to understand how soil bacteria modify water dynamics, and to explore their potential for soil bioaugmentation.



Soil drying and imbibition dynamics are environmentally dependent on microscopic capillary flows. For drying, how bacteria modify capillary pumping remains unknown.

This project will study how the model soil bacterium *Bacillus subtilis* and the strong surfactants it produces modify drying dynamics in idealized porous media. Using a combination of microfluidic devices and granular columns, microscopy techniques will be used to characterize water dynamics at the scale of microscale films. The project will also (depending on student interests) investigate the impact of surfactants on drying dynamics using simple mathematical models, characterize interface modifications by bacteria, and describe the microbial dynamics of growth and production of surfactants.

The **skills** to be gained from this project are: basics of bacterial culture, fundamentals of microscopy and image analysis, design and implementation of microfluidic devices, and general background in soft matter and environmental sciences.

Project setting: the project will take place at the Institut de Physique de Rennes (UMR 6251), within the Soft Matter and Divided Media departments. Interactions with the research units Geosciences Rennes (UMR 6118) and Ecobio (UMR 6553) will permit more extensive exploration of the project's environmental aspects according to the student's interests.

This project may continue into a PhD thesis, subject to student and supervisor agreement.

Informal inquiries are welcome. If you are interested, please contact:

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Related readings:

- D. Or, P. Lehmann, E. Shahraeeni, and N. Shokri, "Advances in Soil Evaporation Physics - A Review," Vadose Zone Journal, 12(4) 2013.
- J Q Yang *et al.*, "Evidence for biosurfactant-induced flow in corners and bacterial spreading in unsaturated porous media," PNAS, 118(38), 2021.