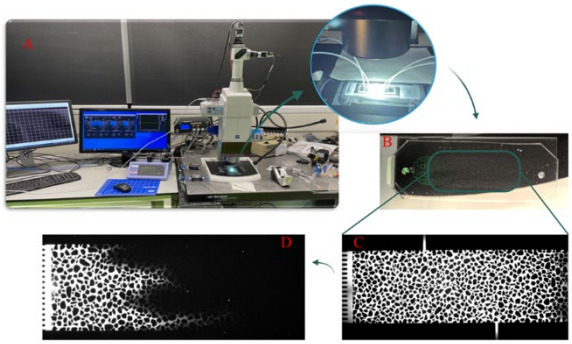
Silicate grout injection on a chip

Investigating grout penetration patterns through soil pores and dilution in groundwater using a microfluidic approach



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Project description

Project overview:

Silicate grouting is a ground improvement technique widely used to reduce the permeability of sandy soils. It involves injecting a grout mixture—typically composed of sodium silicate, water, and a hardener—into the soil, where it fills the pore spaces. After a specific period (the gelation time), the grout solidifies into a gel that blocks groundwater flow. In the Netherlands, this technique is frequently applied beneath construction pits to create impermeable barriers that prevent groundwater inflow. Although silicate grouting has been used for decades, the microscopic flow behavior of grout within soil pores remains poorly understood. This study aims to provide new insight into grout transport and distribution within sandy soils using a microfluidic ("lab-on-a-chip") approach.

Research objectives:

- Visualize grout flow through pore-scale analogues of sandy soil.
- Investigate the influence of grout viscosity on flow and permeability.
- Explore grout–water interactions during injection and gelation.

Methodology:

In this study, the pore structure of sand was replicated on a microfluidic device. X-ray topography of real sand was used to produce a 2D mask, which was then transferred onto a silicon wafer using photolithography. The wafer served as a mold to replicate the pore structure in PDMS, creating the microfluidic chip. Before each experiment, the chip will be saturated with water to simulate subsurface conditions. Grout will then be injected using an Elveflow flow control pump through a designated inlet. Fluorescent nanoparticles will be added to the grout as tracers, allowing real-time visualization of grout movement under a fluorescent microscope. Captured image sequences will be analyzed to study grout flow patterns, evaluate dilution of grout into groundwater, and assess how viscosity affects pore-scale permeability changes.

Student role and expected outcomes:

The student will assist in conducting microfluidic experiments and collecting image data. Through this project, the student will gain hands-on experience in microfluidics, fluid mechanics, and image-based flow analysis. The results will contribute to a deeper understanding of grout injection behaviour.

Job requirements

Interest in experimental research and basic laboratory work (training will be provided).