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Visualisation of Multi-Scale Desorption Dynamics in Clay-Coated Microfluidic Channels: Optimising Recovery Strategies for Valuable Contaminants

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1. Challenges & Motivations

Recovering valuable water contaminants through sorption-desorption methods offers a simple, cost-effective, and efficient approach to sustainable water management while supporting circular economy principles and minimising harmful by-products.

- ✓ Recovery of valuable substances
- ✓ Promoting circular economy & resource reuse
- ✓ Mitigating environmental impacts
- ✓ Sustainable treatment technologies

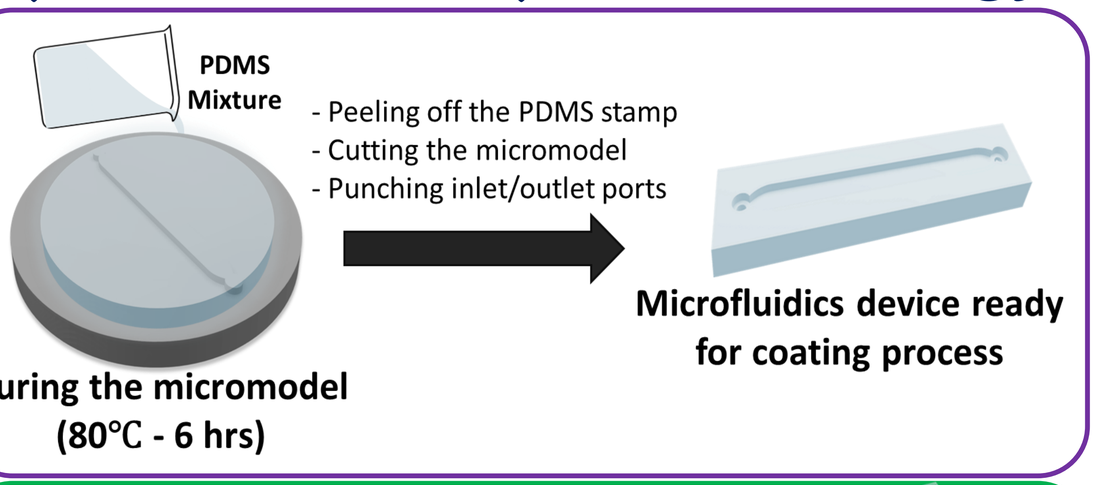
- ? Underexplored desorption dynamics in recovery processes
- ? Limited pore-scale insights from traditional experiments
- ? Opacity of soil environments hinders direct observation

2. Objectives

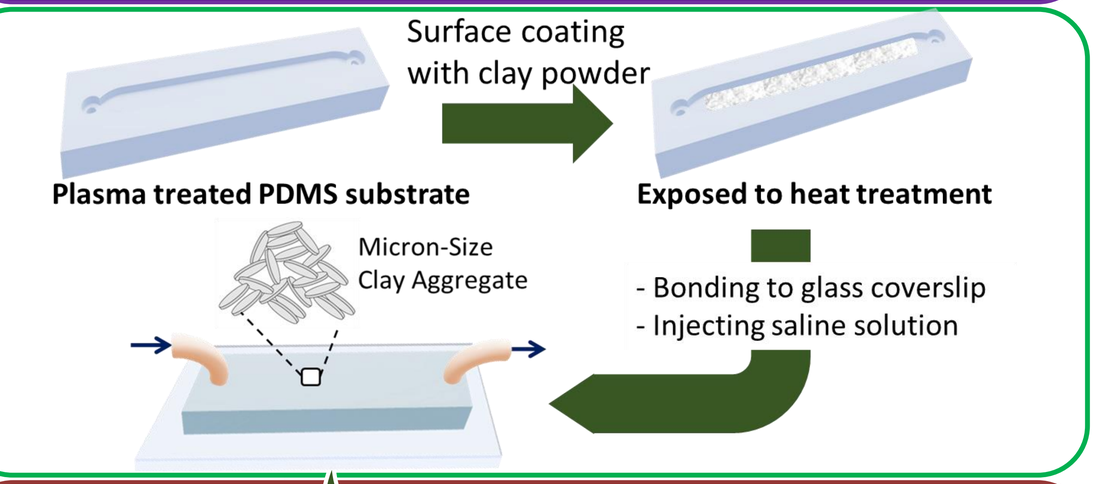
- ✓ *Visualisation of desorption dynamics in clay-rich porous media.*
- ✓ *Assessing flow rate effects on desorption dynamics & recovery efficiency.*
- ✓ *Determination of porous geometry influence on contaminant release.*
- ✓ *Identification of optimal flow conditions for maximum recovery.*
- ✓ *Quantification of relationship between flow dynamics and desorption rates.*

3. Experimental Setup & Methodology

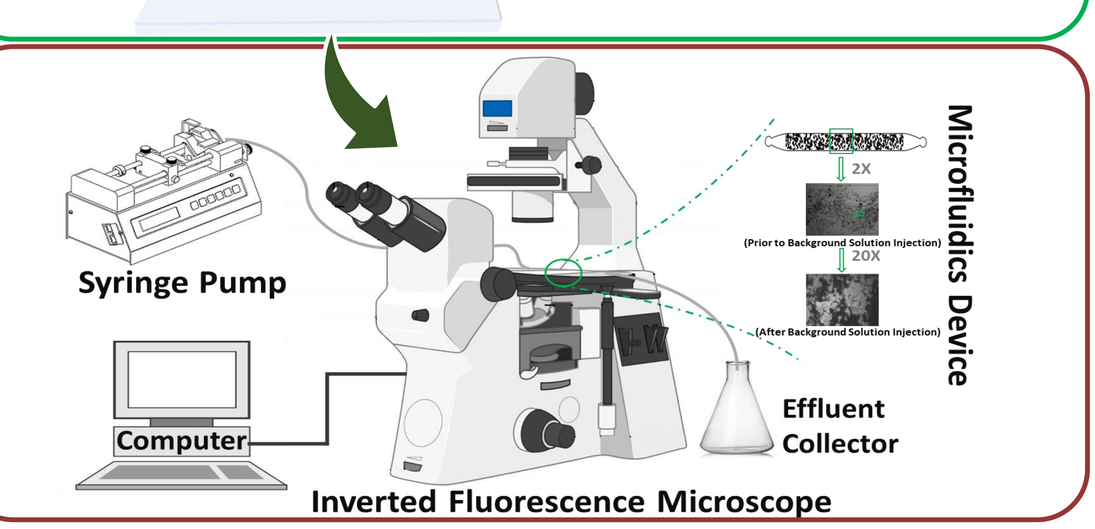
Microchips Fabrication



Surface Modification

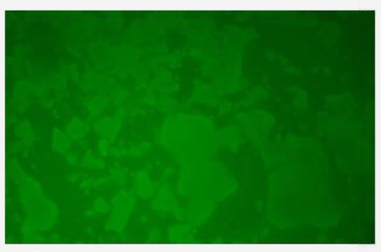


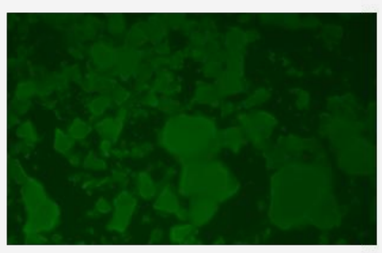
Real-Time Visualisation

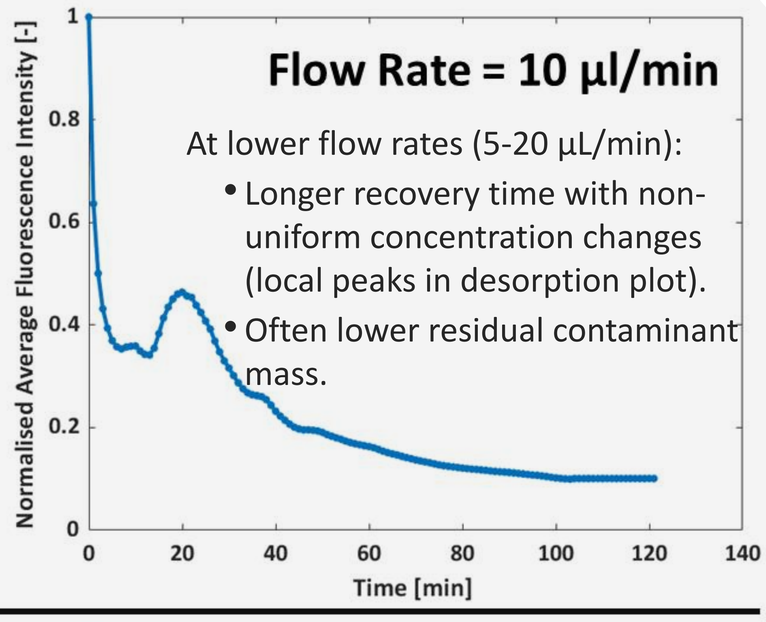


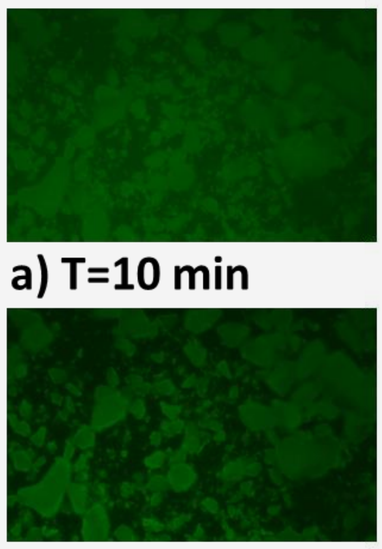
4. Pore-Scale Desorption Dynamics

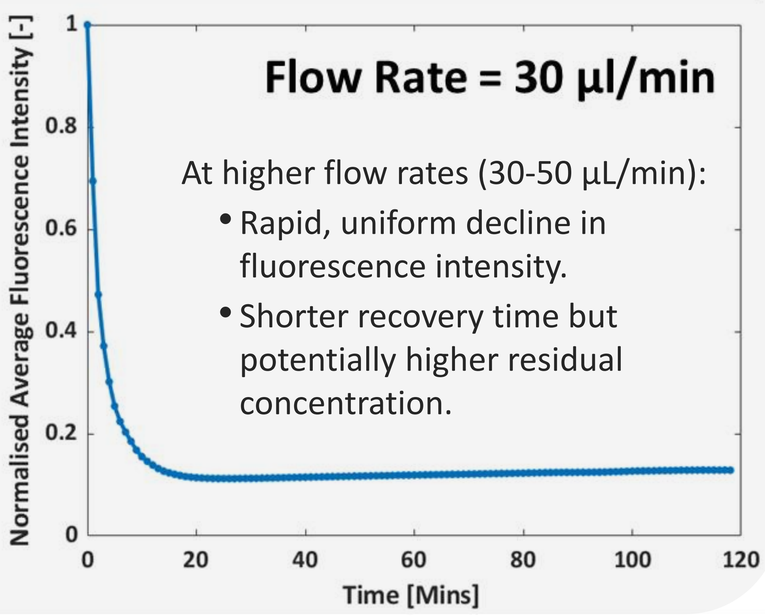
Flow Rate Effects



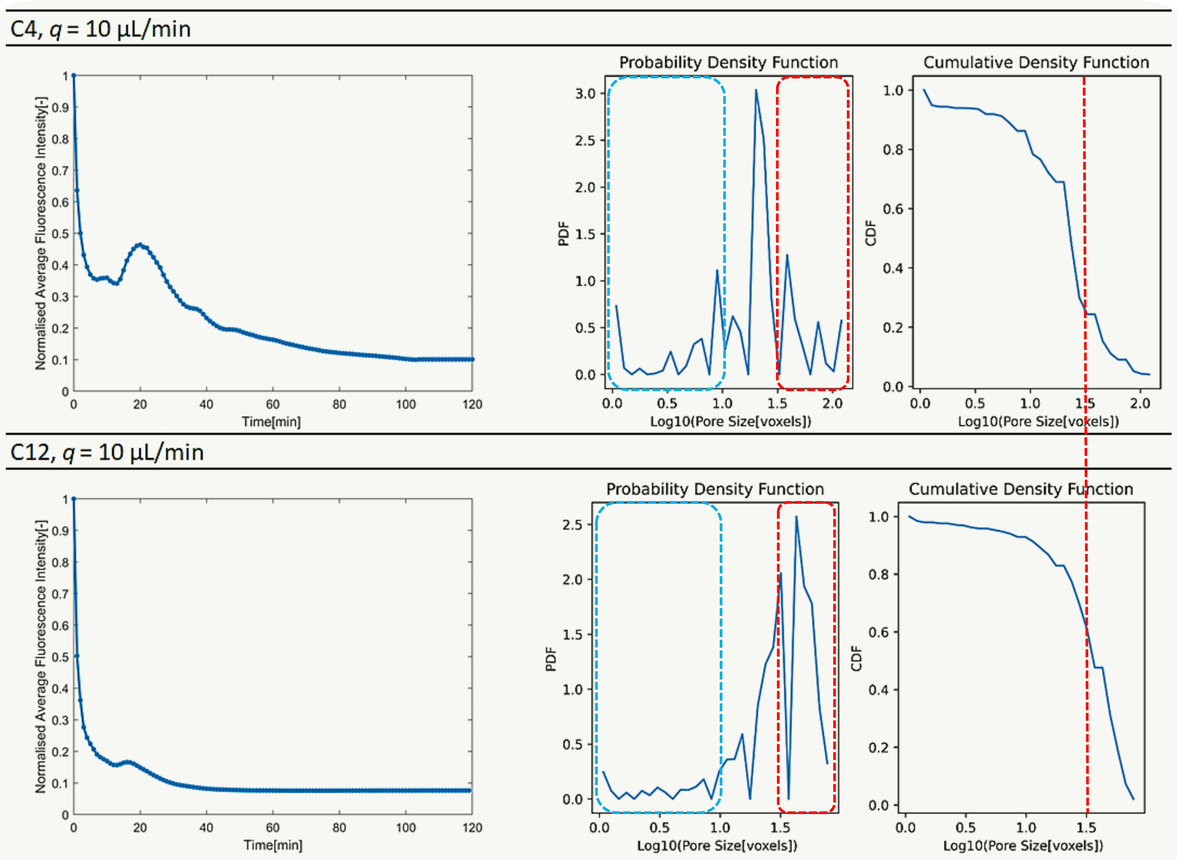






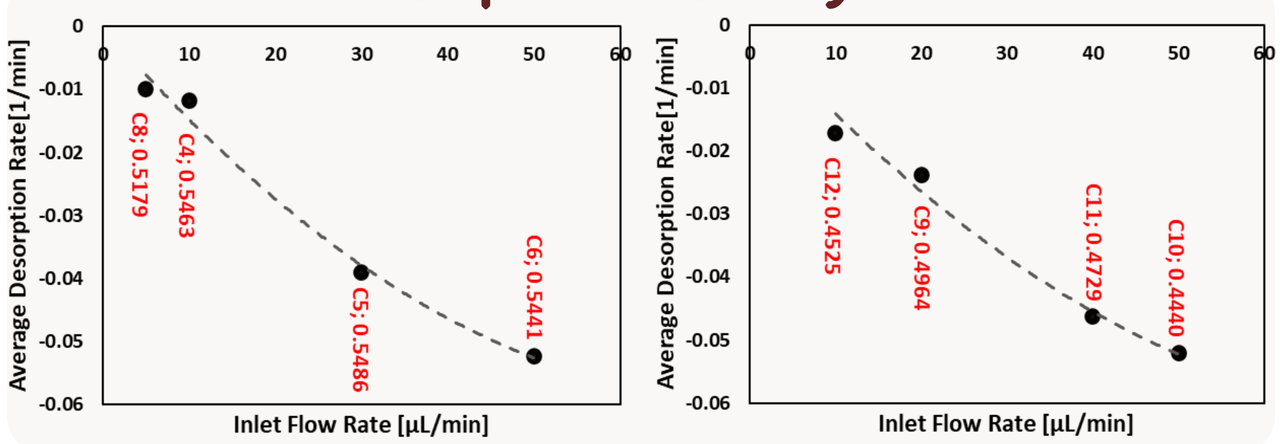


Porous Geometry Effects



- Smaller pores show higher tendency to retain fluorescein compound.
- Pore geometry effects are flow-dependent with geometry influence pronounced at lower flow rates but diminishing at higher flow rates.

Desorption Rate Analysis



- ✓ Desorption behaviour is influenced by interplay between flow dynamics and porous geometry.
- ✓ Critical trade-off between recovery efficiency and processing time: Higher flow rates accelerate recovery but may leave higher residual concentrations.

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