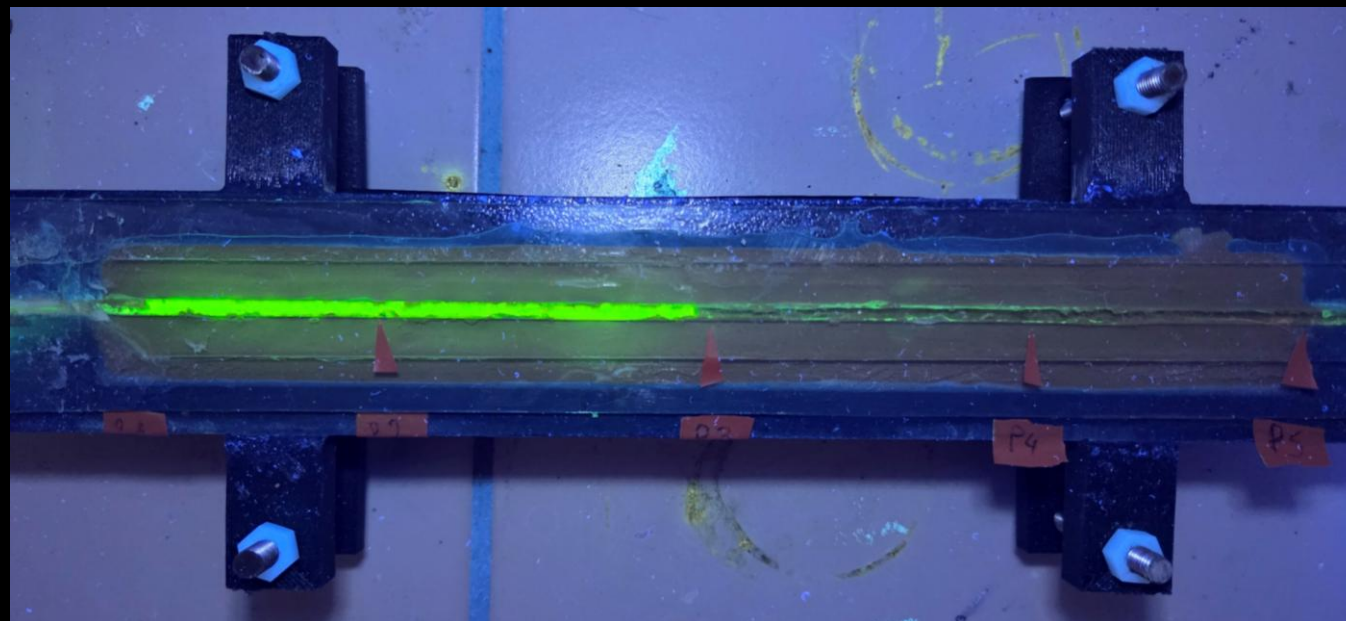


INFLUENCE OF MACROPORES ON PFAS TRANSPORT IN LOW-PERMEABILITY MEDIA: FROM EXPERIMENTAL SETUP TO MODELLING



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Barcelona, 08/10/2026

1. Introduction

➤ PFAS = >12 000 Compounds

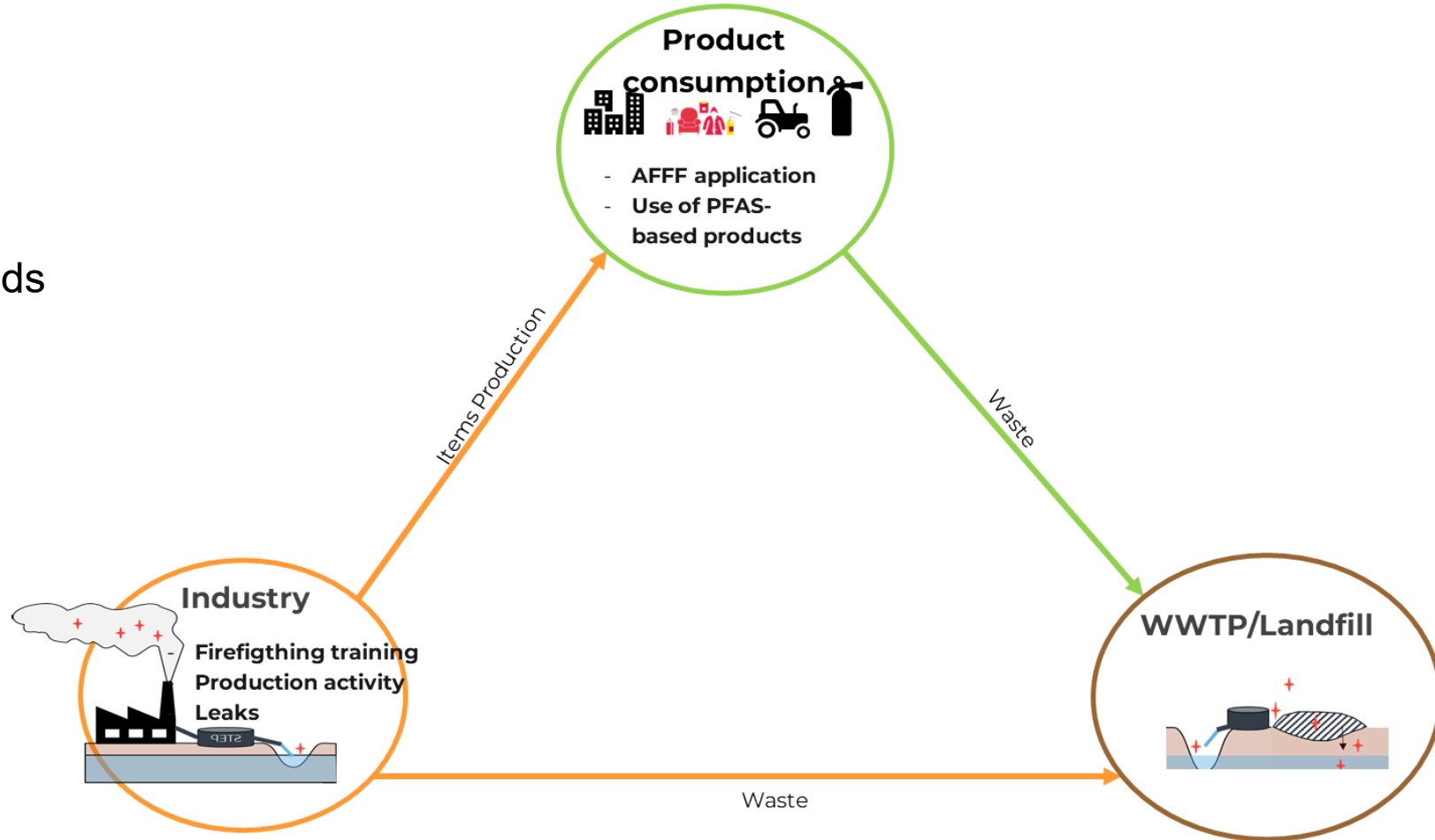
➤ PFAS contamination:

- AFFF contamination
- Industrial contamination
- Landfill
- WWTP/Biosolids



Vadose zone contamination:

- Long term contamination
- Surface contamination (first meters)



1. Introduction

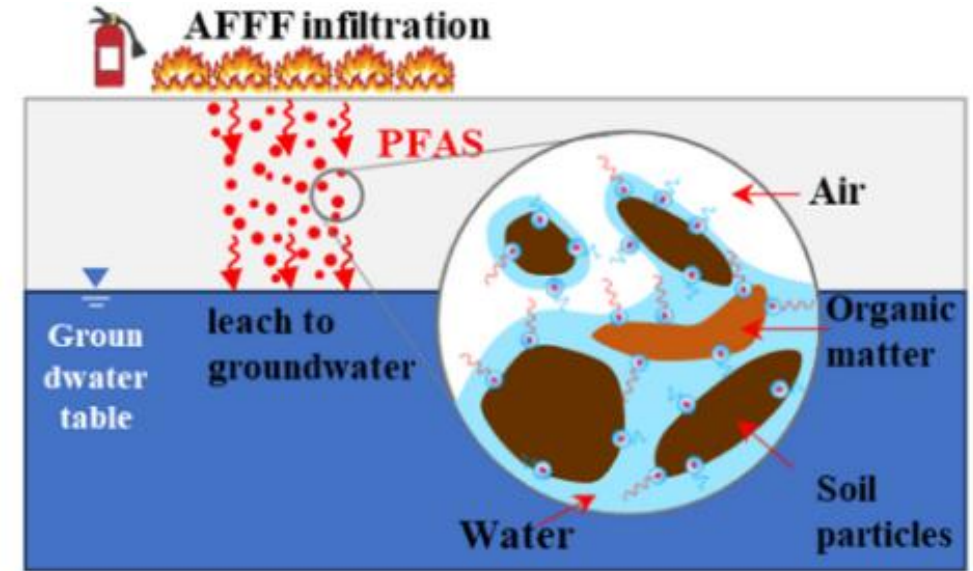
State of art:

- Transport in sandy soils
- Columns and batch tests
- Spiked contamination
- Homogenous soils
- Few studies about contaminated site characterization and intact historical contaminated columns

Goals:

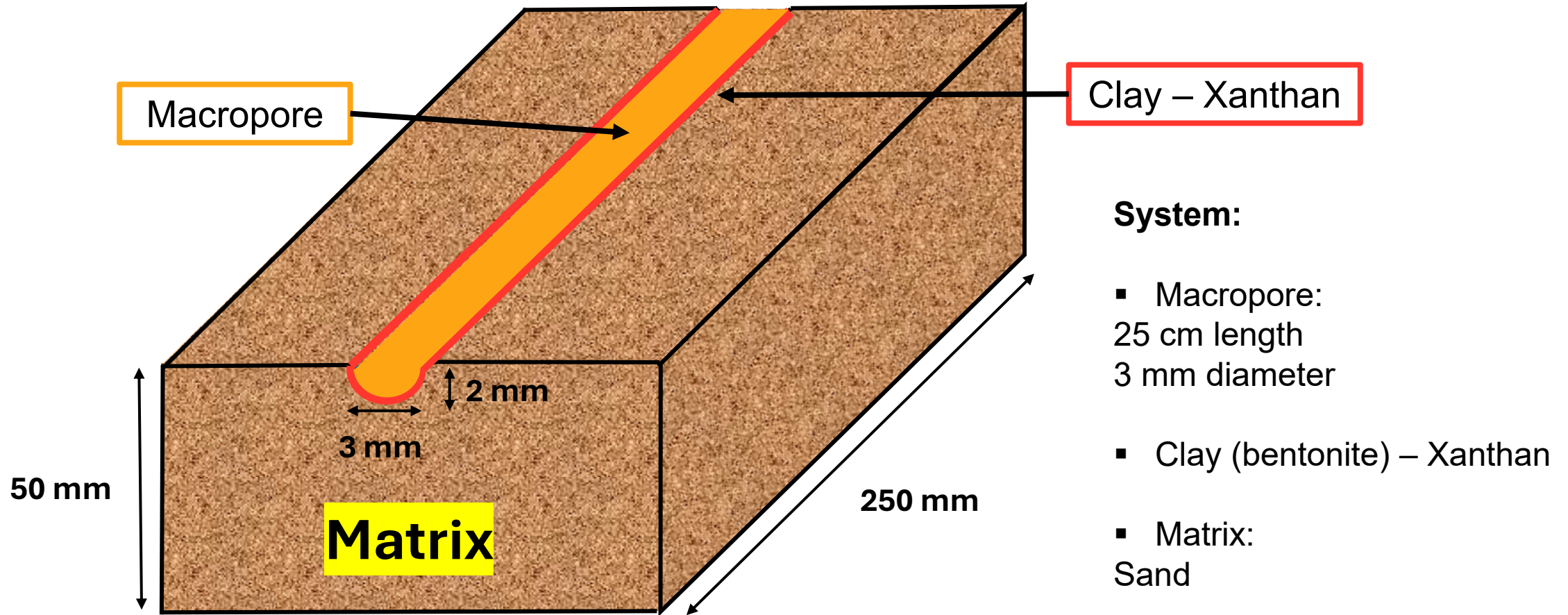
- To study PFAS contamination in unsaturated zone
- To evaluate the effects of heterogeneities in low-permeability unsaturated soils
- Predictive model for PFAS transport in unsaturated zone

➡ To understand PFAS transport within a macropore

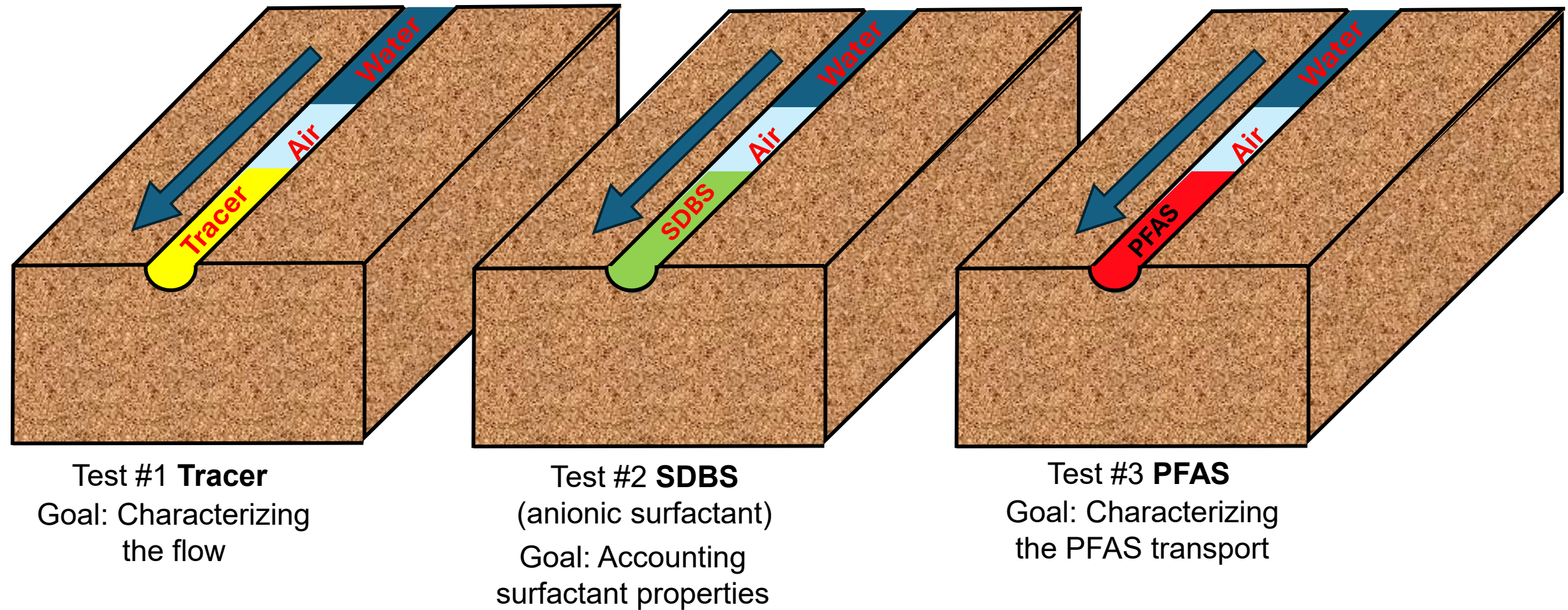


H. Li et al., 2023

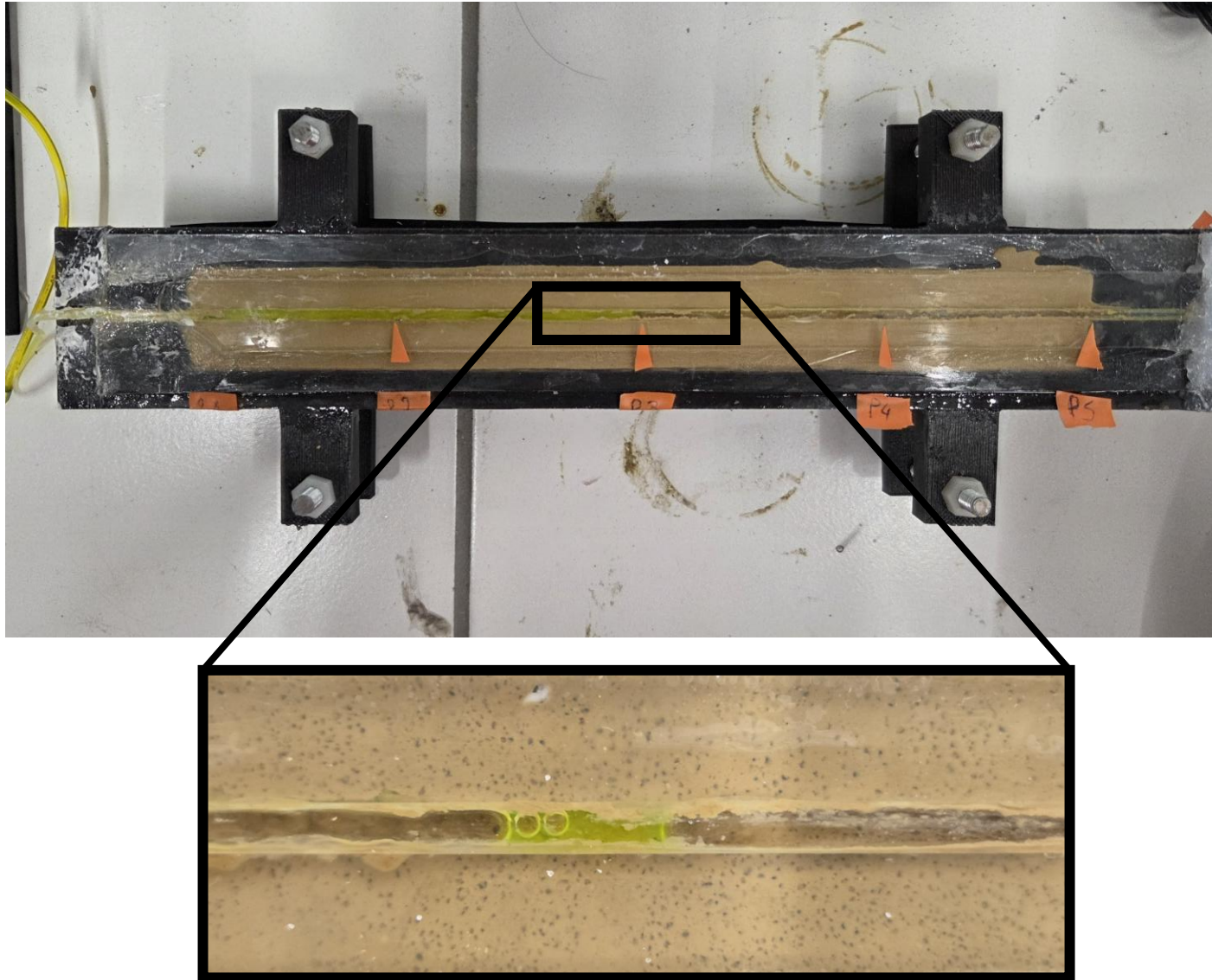
2. Experimental Setup



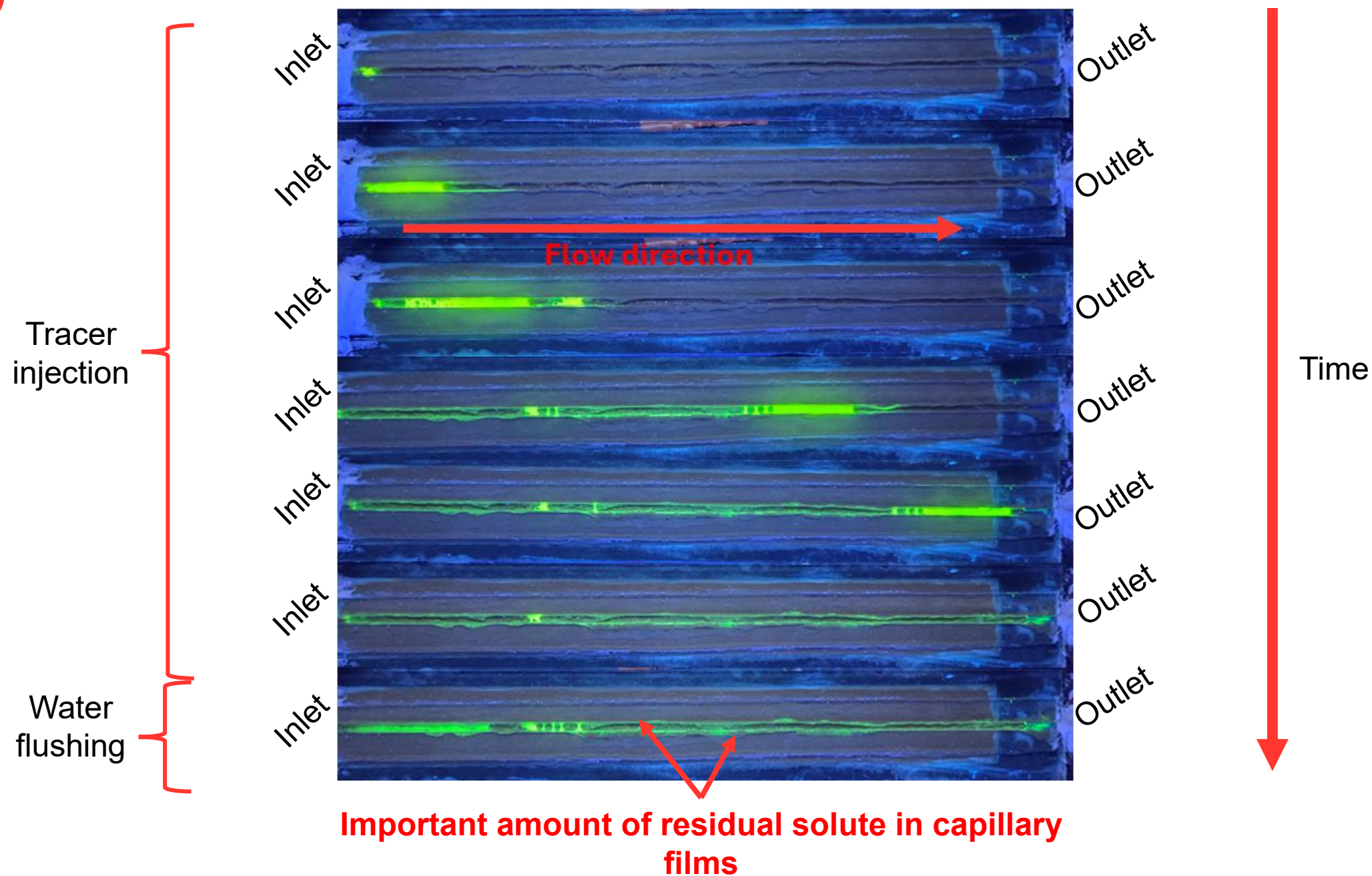
2. Experimental Setup



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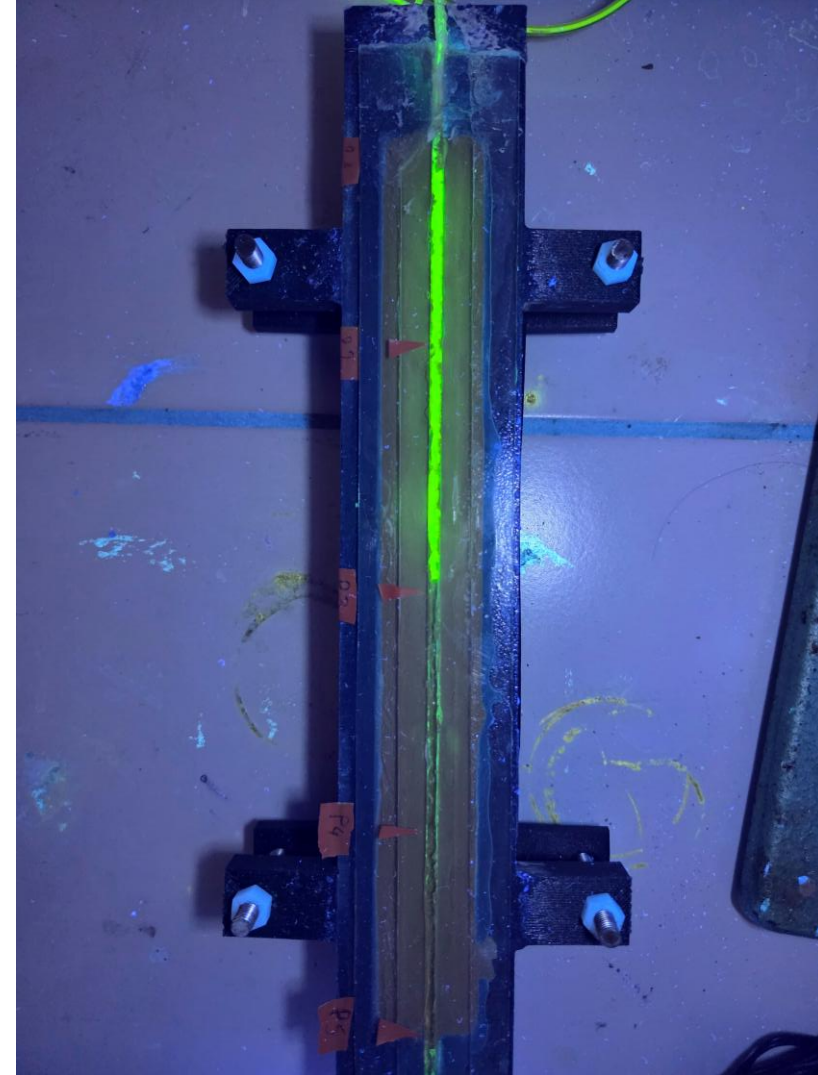
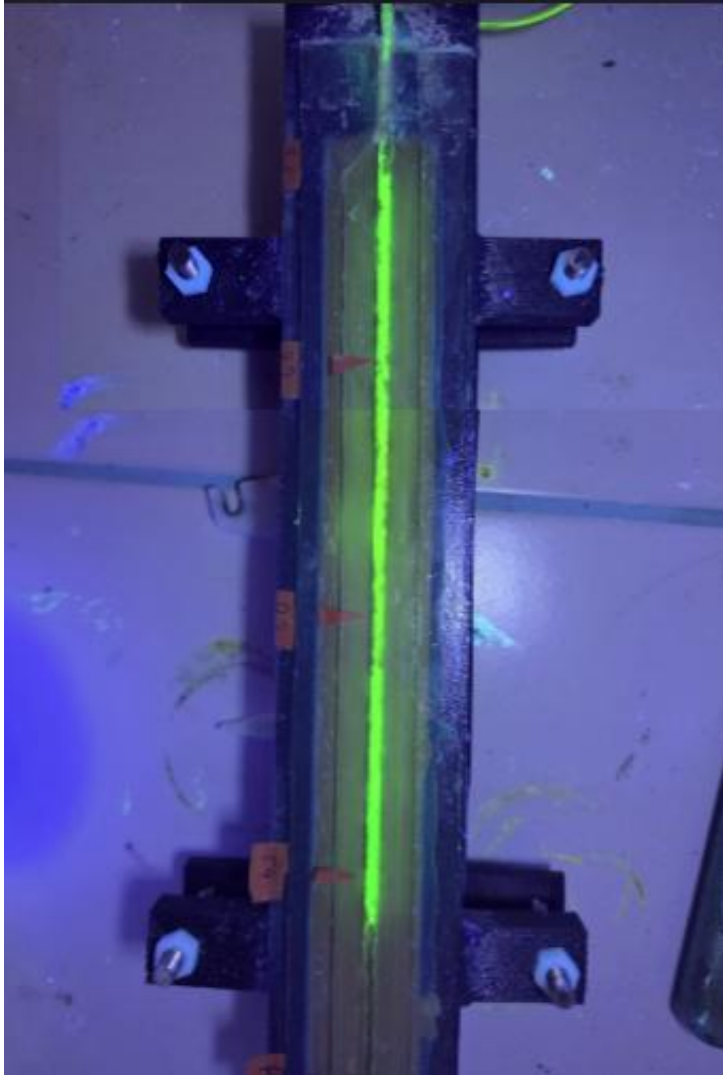


3. Tracer test

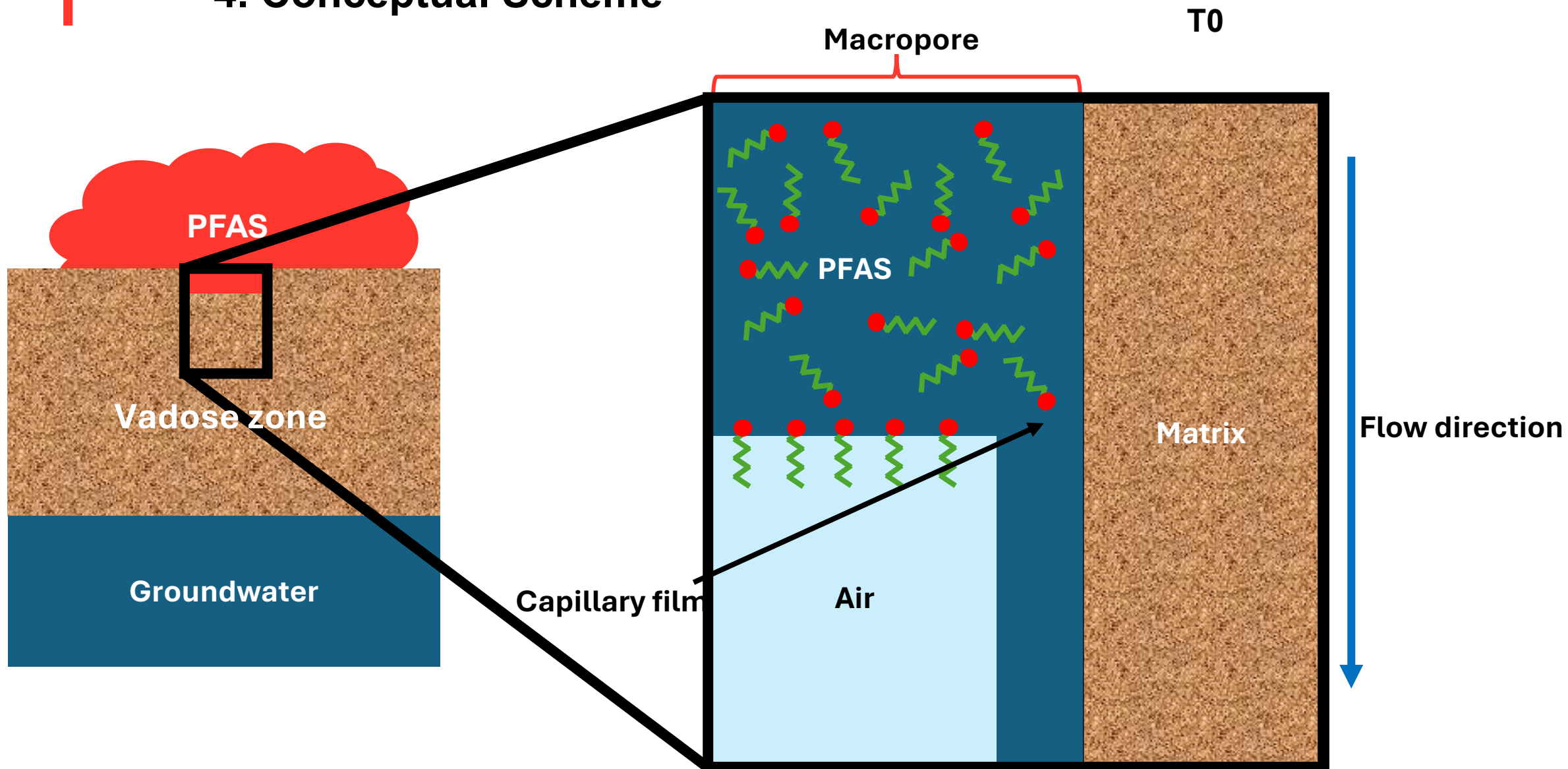


3. Tracer test

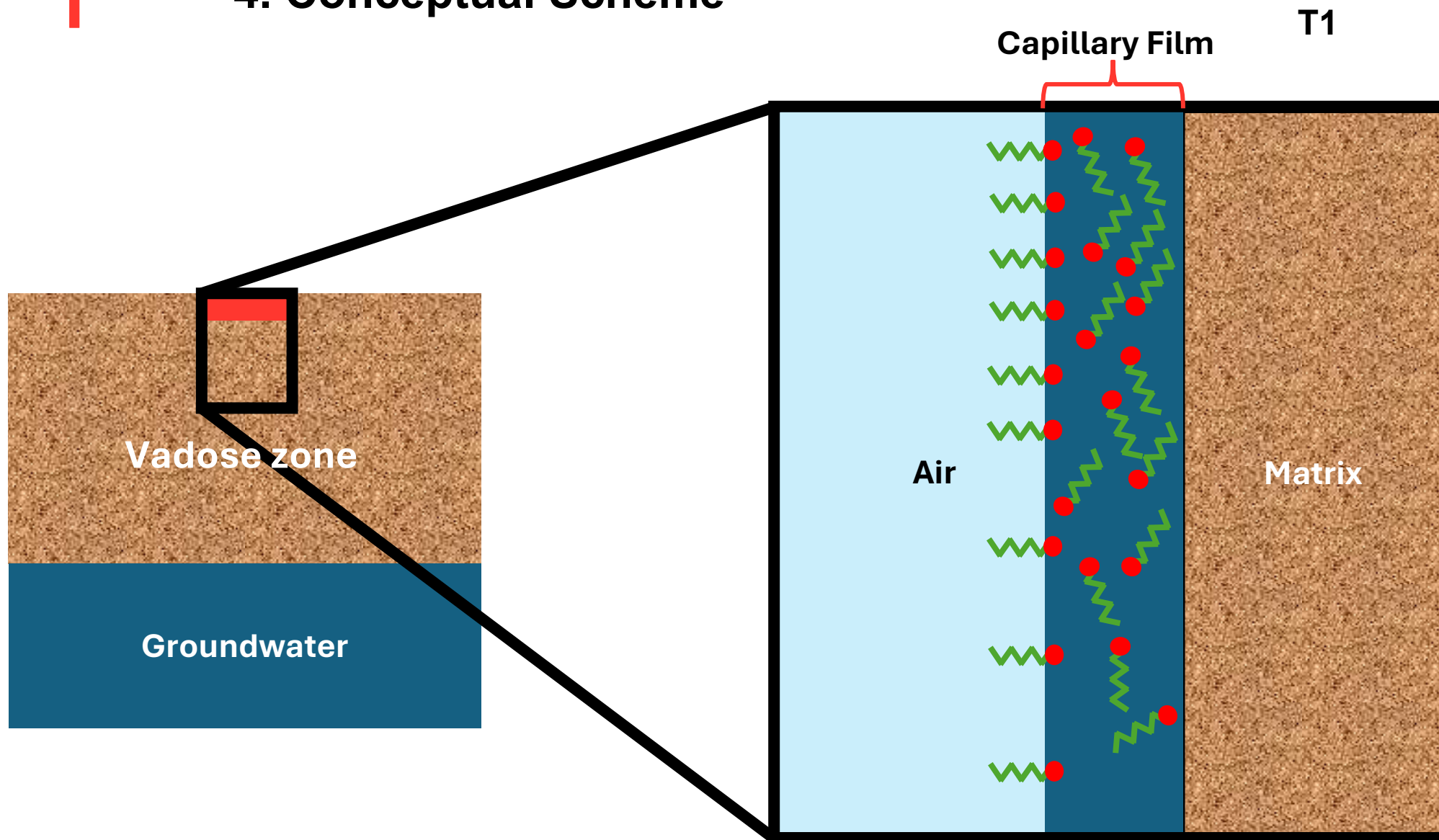
Infiltration from macropore into
unsaturated matrix



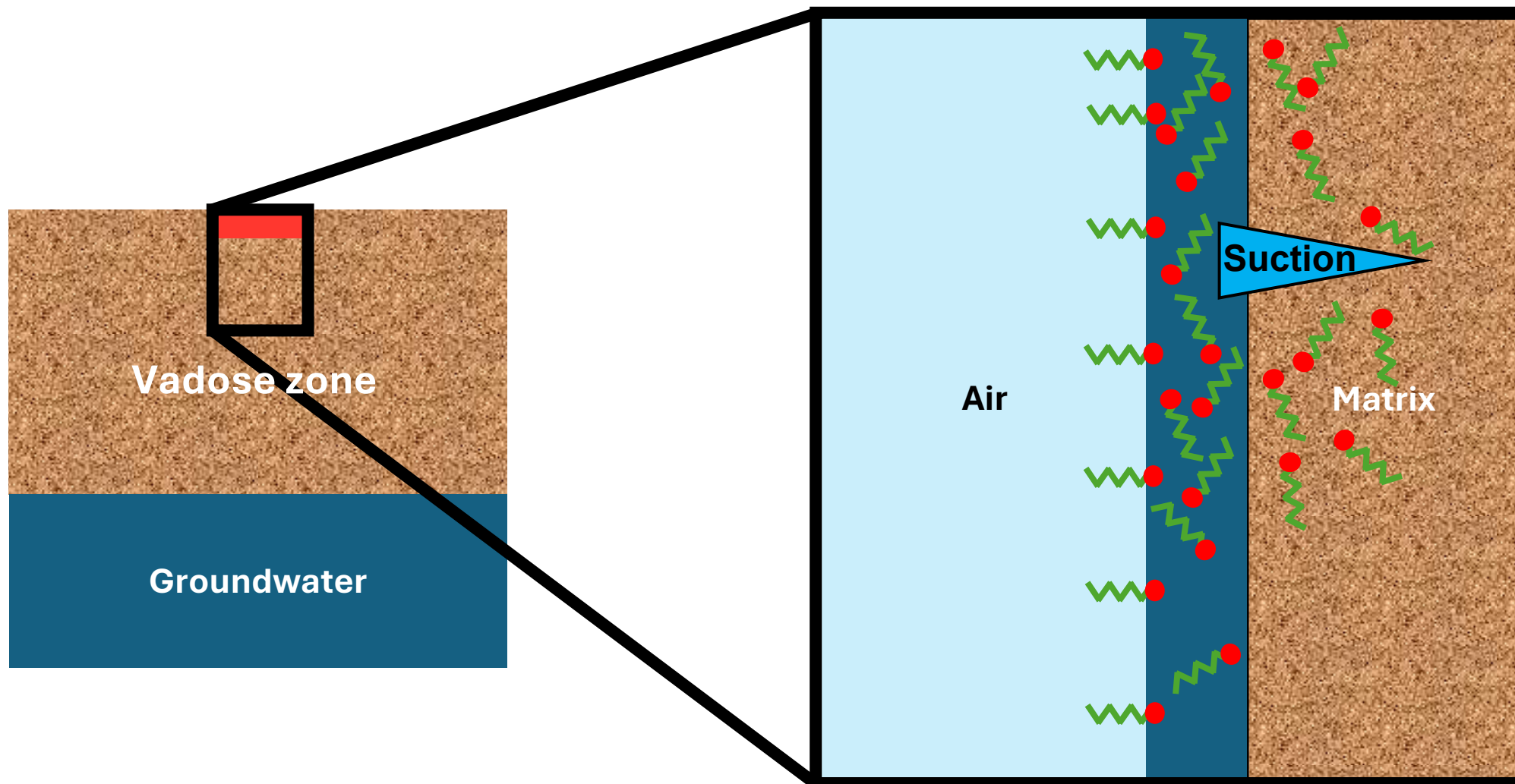
4. Conceptual Scheme



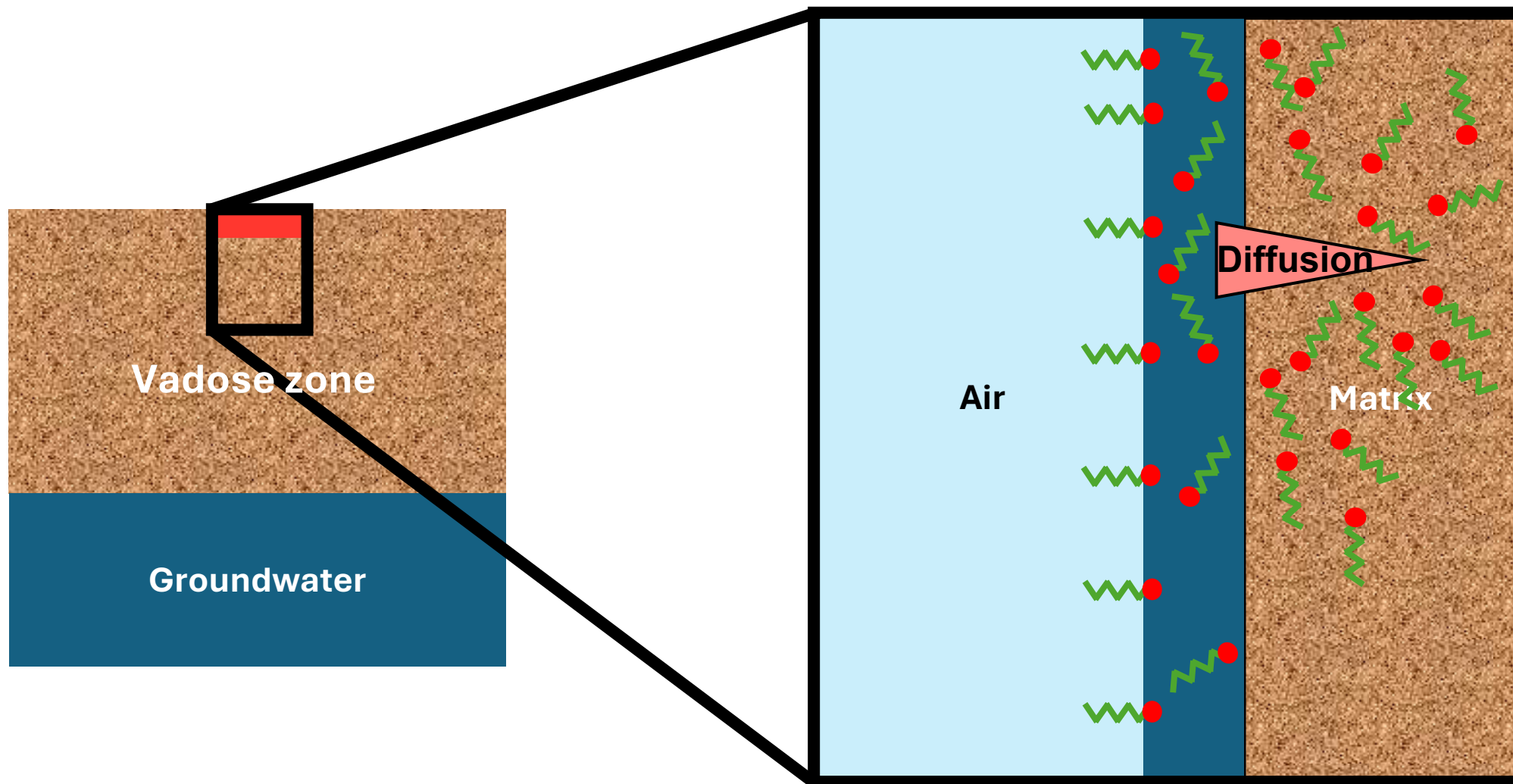
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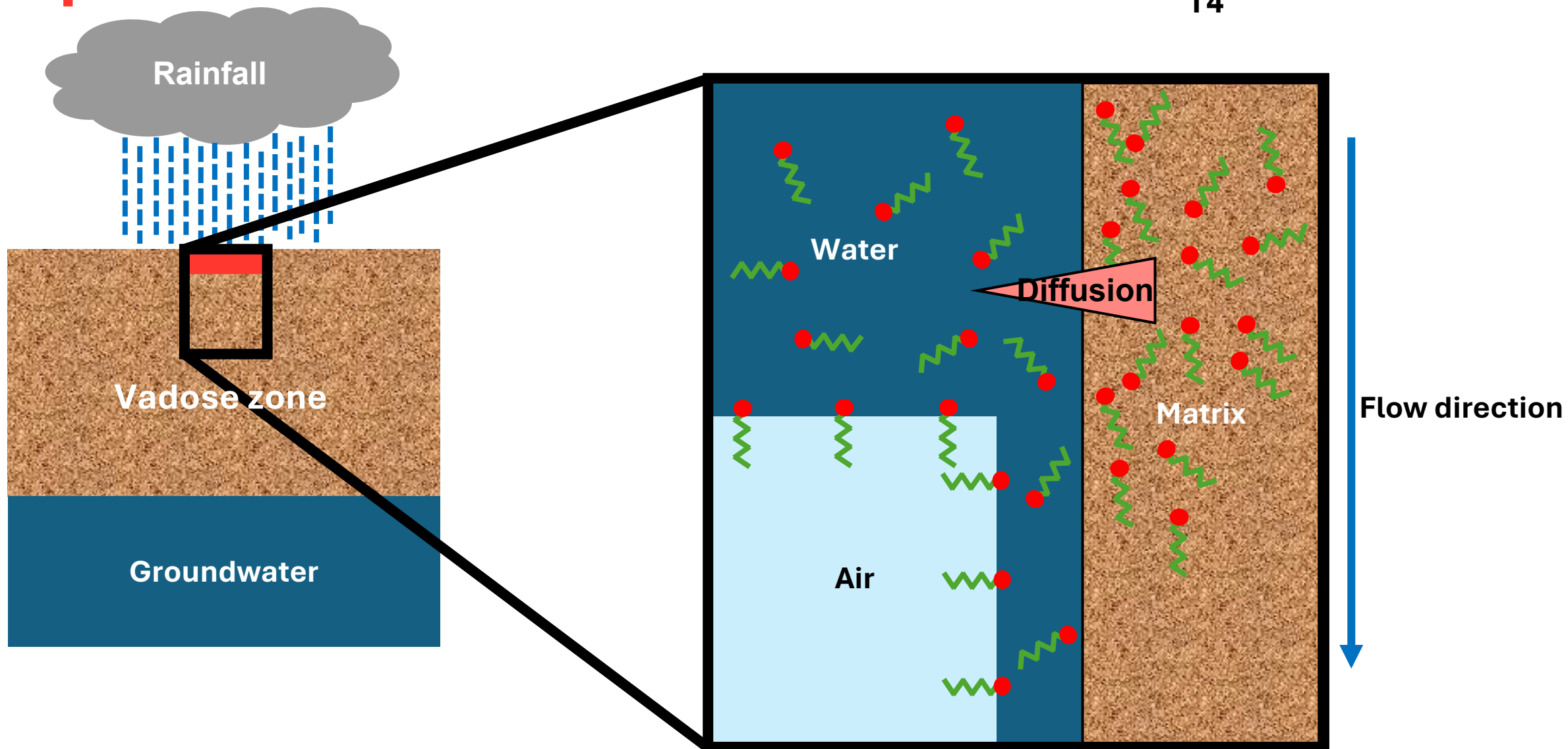
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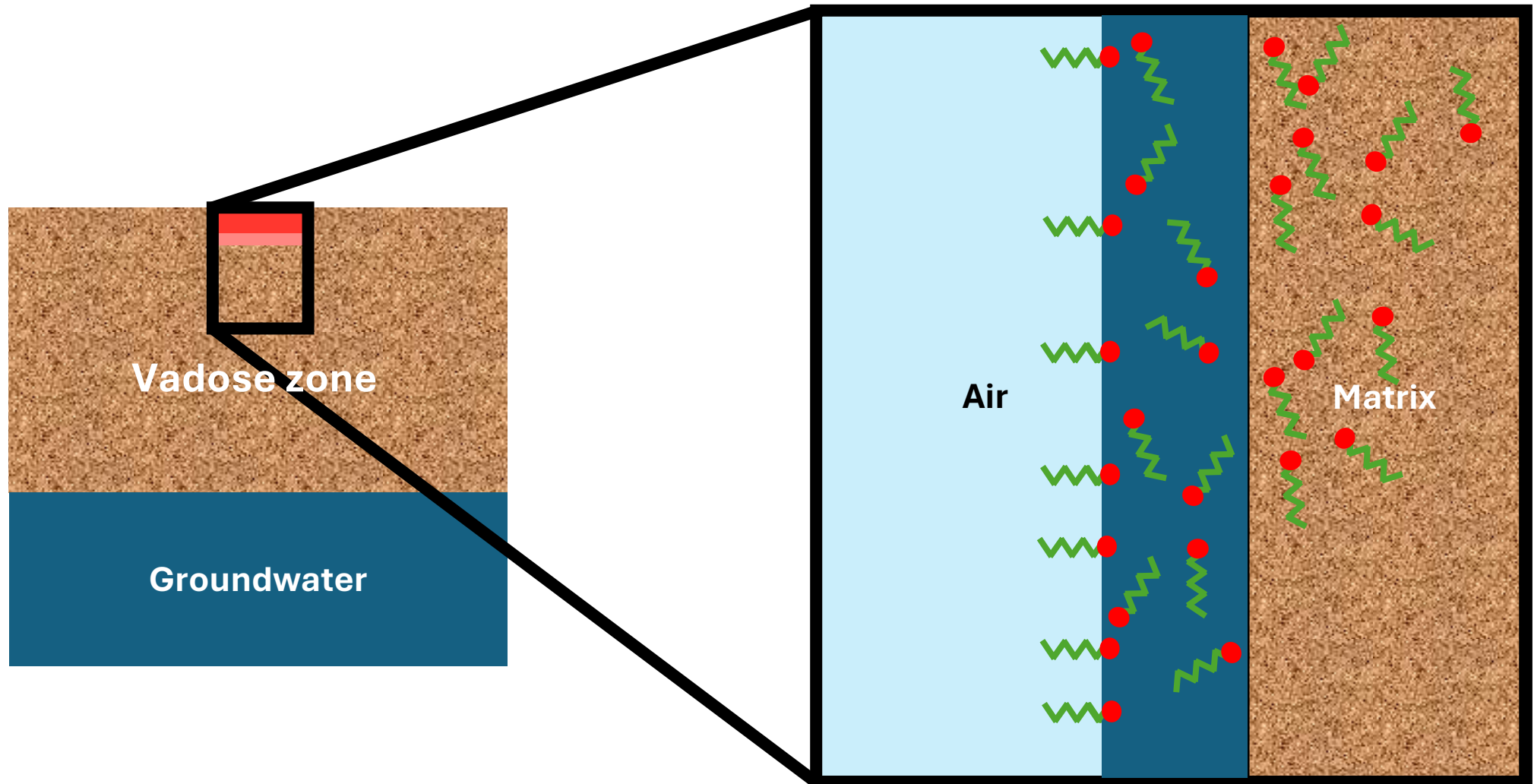
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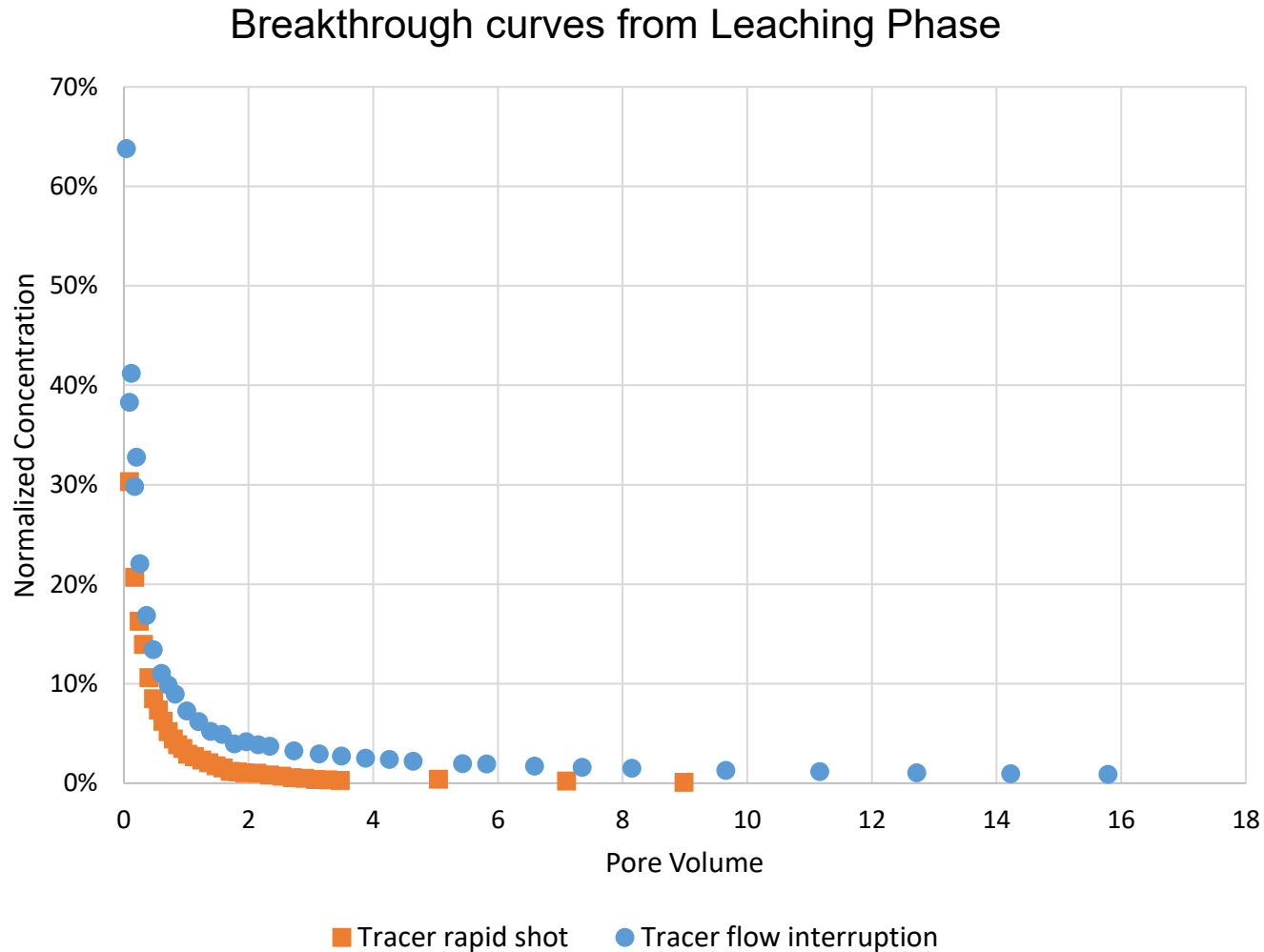


4. Conceptual Scheme



T5
Back to T1

5. Breakthrough curve Tracer



Tracer rapid shot:

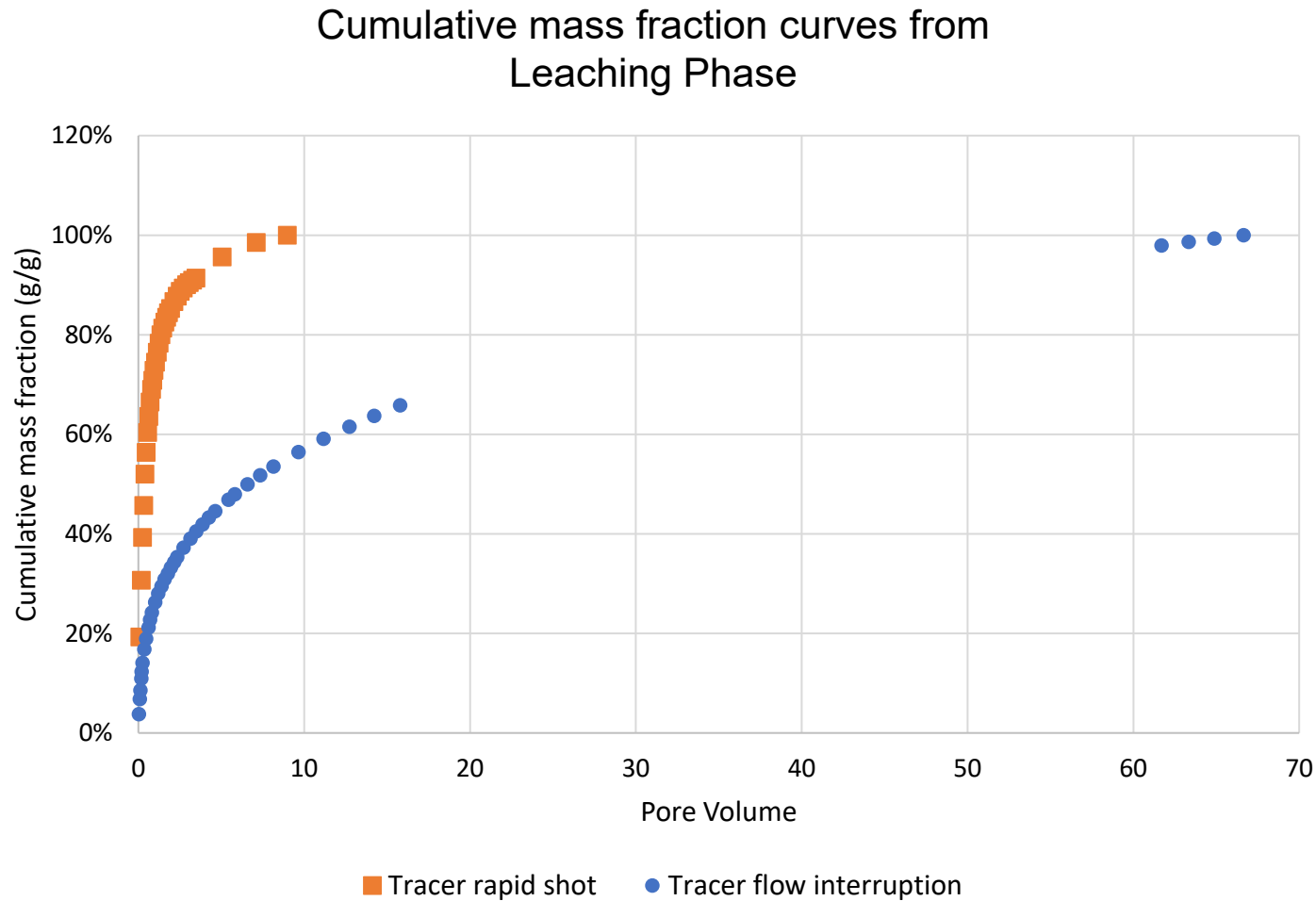
- Tracer injection
- Air injection
- Water injection=Leaching Phase

Tracer flow interruption:

- Tracer injection
- Interruption: 16 hours
- Air injection
- Water injection=Leaching Phase

➤ Diffusion into matrix

5. Cumulative mass curve Tracer



Tracer rapid shot:

- Tracer injection
- Air injection
- Water injection=Leaching Phase

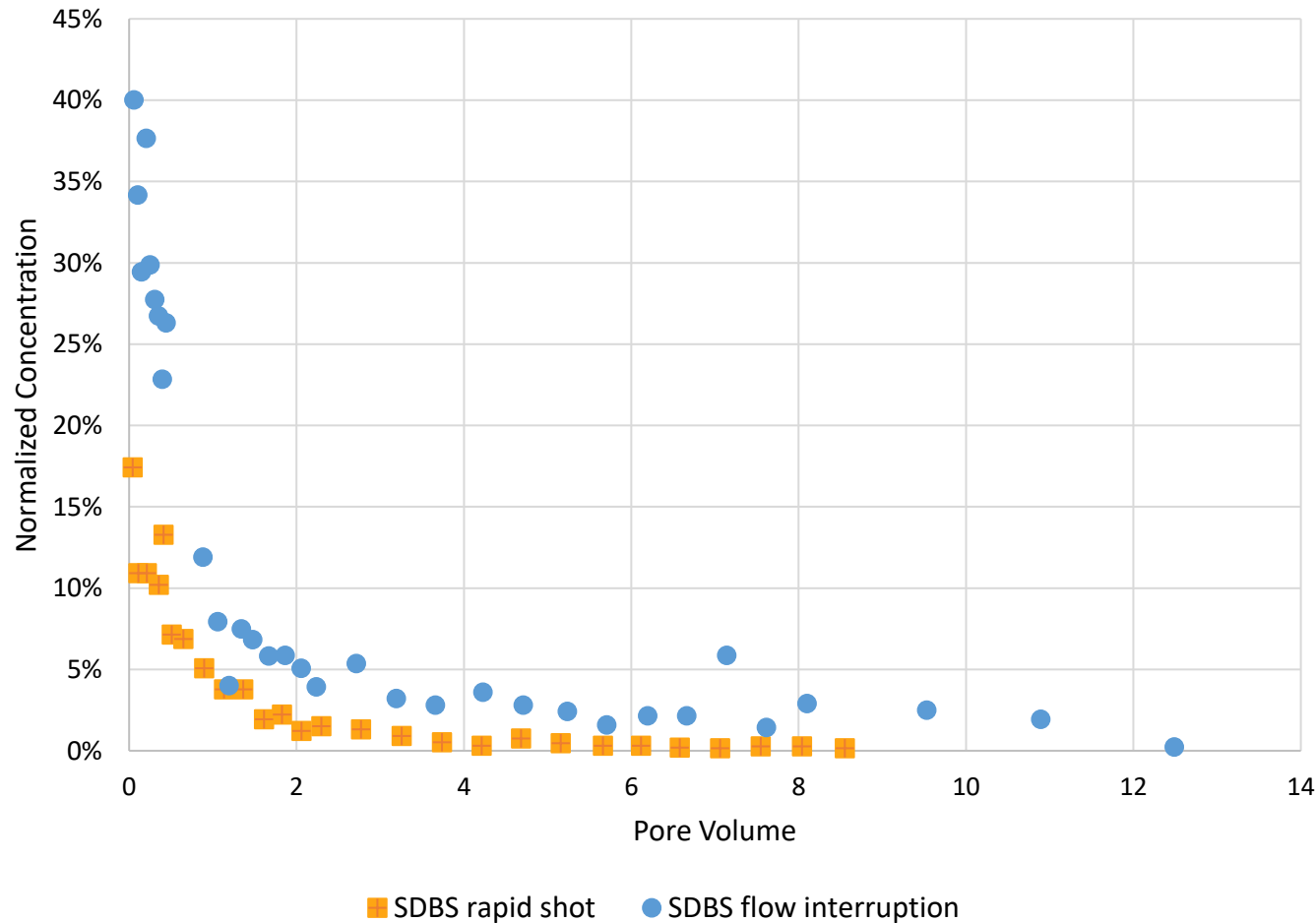
Tracer flow interruption:

- Tracer injection
- Interruption: 16 hours
- Air injection
- Water injection=Leaching Phase

➤ Diffusion into matrix
Recovery time increases

6. Breakthrough curve SDBS

Breakthrough curves from Leaching Phase



SDBS rapid shot:

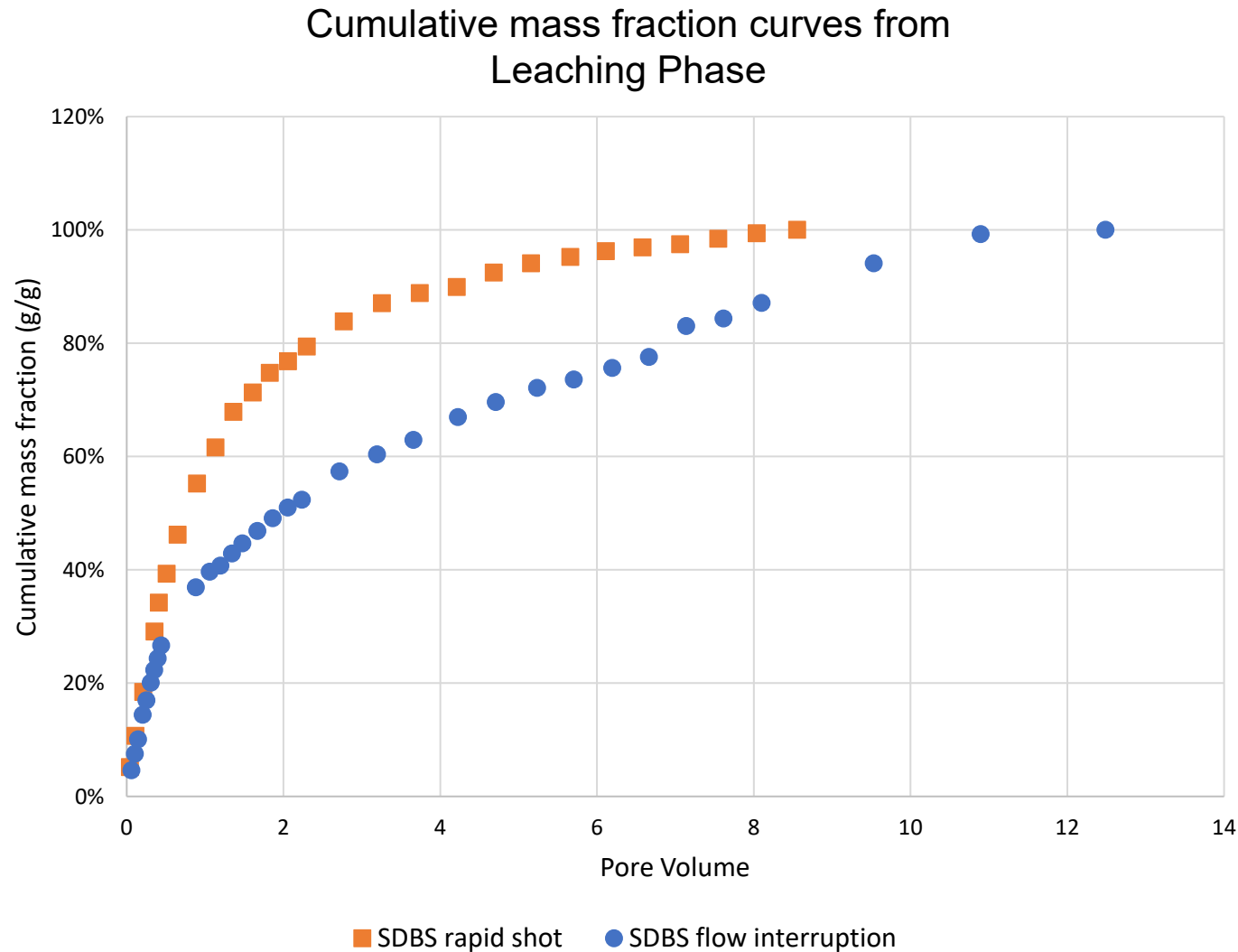
- SDBS injection
- Air injection
- Water injection=Leaching Phase

SDBS flow interruption:

- SDBS injection
- Air injection
- Interruption: 18 hours
- Water injection=Leaching Phase

- Diffusion into matrix
- Accumulation into capillary film

6. Cumulative mass curve SDBS



SDBS rapid shot:

- SDBS injection
- Air injection
- Water injection=Leaching Phase

SDBS flow interruption:

- SDBS injection
- Air injection
- Interruption: 18 hours
- Water injection=Leaching Phase

- Diffusion into matrix
- Accumulation into capillary film

Dual Domain model applied to Tracer test:

- Advection
- Diffusion

➤ Rahman et al. analytical solutions:

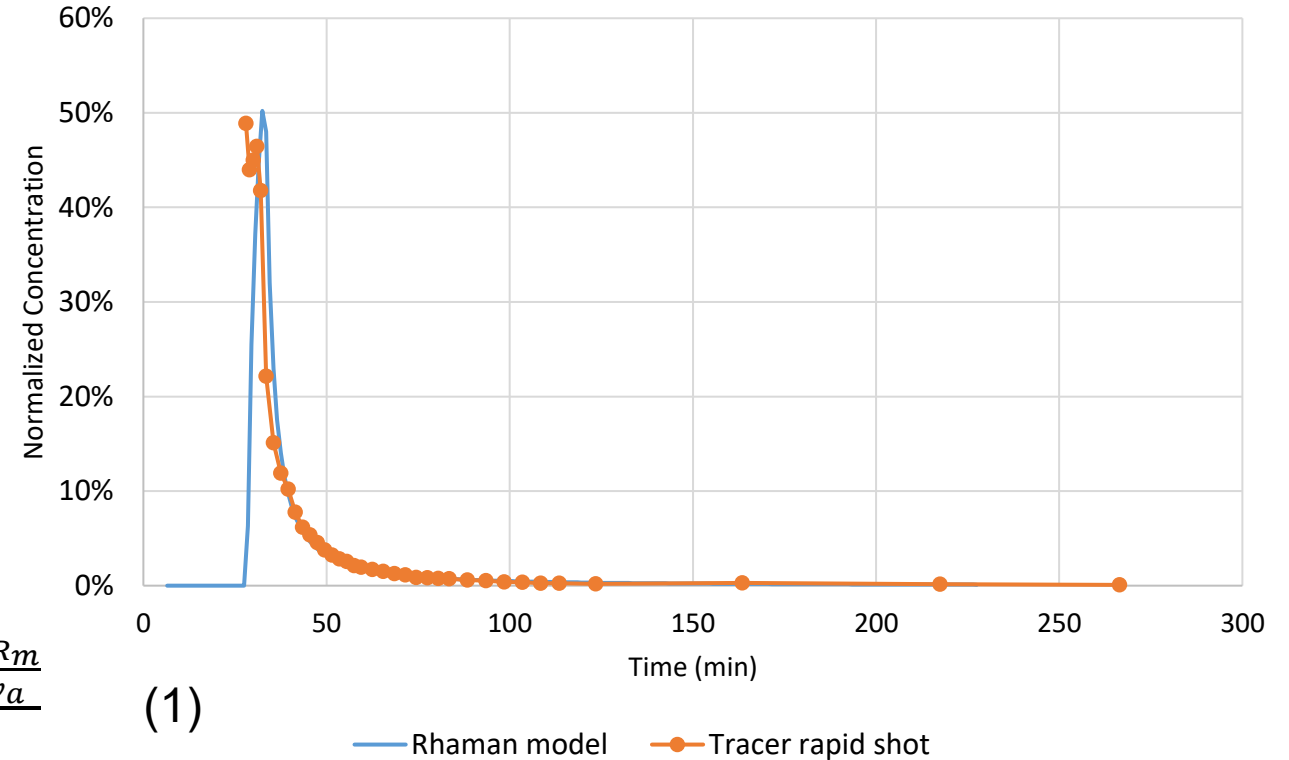
*Concentration
within macropore*

$$C_m(z, t) = C_0 \operatorname{erfc} \frac{\frac{2}{a} \frac{n_{im} R_{im}}{n_m R_m} \sqrt{D_a} \frac{z R_m}{v_a}}{\sqrt{4(t - \frac{z R_m}{v_a})}} \quad (1)$$

*Concentration
within matrix*

$$C_{im}(z, x, t) = C_0 \operatorname{erfc} \frac{\frac{x-a}{\sqrt{D_a}} + \frac{2}{a} \frac{n_{im} R_{im}}{n_m R_m} \sqrt{D_a} \frac{z R_m}{v_a}}{\sqrt{4(t - \frac{z R_m}{v_a})}} \quad (2)$$

Tracer breakthrough curves





8. Conclusion

Experimental setup:

- Close to reality
- Customizable: matrix, water saturation, macropore size

Experiments:

- Tracer tests show effect of diffusion
- SDBS tests show accumulation into the capillary films and diffusion from films into matrix

Model:

- Dual Domain Model with diffusion fits Tracer test

Next steps: Stay tuned for more results

Experiments:

- More data on SDBS transport
- Tests with PFAS
- Test with unsaturated matrix

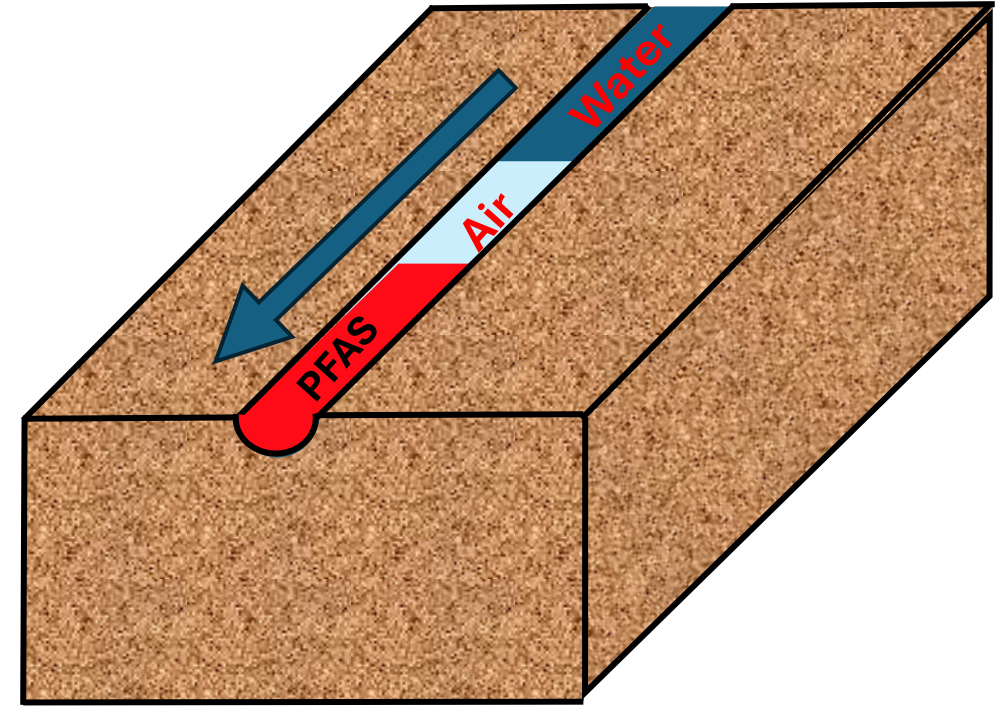
Dual Domain Model:

- Diffusion: to define the diffusive parameters
- Infiltration: to incorporate into the flow
- Capillary film: to incorporate the surfactant properties

Simple Dual Domain
model



Dual Domain Model
accounting Capillary
Film





**THANK YOU
-
QUESTIONS ?**

