Water and air distribution in 3D computed tomography images to use *in silico* studies of fungal resilience and biodiversity in soils

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Introduction
The water and air filled fractions of the pore space can be obtained using appropriate models.
Lattice-Boltzmann modelling has shown to produce physically accurate water/air distributions in soil.
3D CT Scans + Water/air distributions can be used by microbial pore scale models to untangle the effect of soil architecture on microorganisms.
Different water contents will impact unevenly the soil microbial communities

Bacteria need water

Fungi prefer air filled pores

Eickhorst & Tippkötter, 2008
Aim of the work
To obtain a new set of 3D images of air-water interfaces at two water saturation levels in a material constituted of soil aggregates repacked at different densities.
Material and methods
Lattice-Boltzmann simulations

• **Soil:** Sandy loam at bulk densities 1.2, 1.3, 1.4, 1.5, and 1.6 g cm\(^{-3}\).

• **Model:** Two-phase Two Relaxation Times (Genty and Pot, 2013).

• **Two water contents** with the following hypothesis:
  - ✓ Sw=20% - Connected air and disconnected water space.
  - ✓ Sw=80% - Connected water and disconnected air space.
Results
First, total pore space

Porosity declines with soil density

Pore space remains well connected for all densities
Let’s move on to the water/air distributions!

Image BD12 S1:

- Sw=20%
- Sw=80%

固体

水

空气
Let’s move on to the water/air distributions!

**Liquid phase connectivity**

Water is connected at Sw=80±0.5% and disconnected at Sw=20±0.5%

**Gas phase connectivity**

Air is connected at Sw=20±0.5% and disconnected at Sw=80±0.5%
Application example *

Effect of the spatial distribution of organic matter on the bacterial growth

* Submitted to Frontiers in Microbiology.
Organic matter placement

High heterogeneity

Intermediate heterogeneity

Low heterogeneity

1 x $0.02^3$ cm$^3$

4 x $0.01^3$ cm$^3$

C as DOC

10 repetitions changing POM position
Bacterial placement and water level

690 (230x3) bacteria in 690 spots

Three bacterial strains: competitive, generalist, poor competing
Faster growth when the C is available as DOC at the beginning of the simulation.
Similar kinetics when the OM is particulate
The high competing strain dominates clearly when all C is available at the beginning of the simulation.
The low competing strain 9R is able to growth noticeably in the high heterogeneity scheme.
Final remarks
Focusing on the LBM simulations…

Database of CT images:

✓ Five bulk densities (1.2, 1.3, 1.4, 1.5, 1.6 g/cm³)
✓ Three replicates
✓ Four water contents (0, 20, 80, 100)

Images details:

✓ **Size.** 512x512x512 Voxels (1.3x1.3x1.3 cm³)
✓ **Resolution.** 24 µm

* A total of 60 images that differ in connectivity and geometry and that are available for microbial simulations.
Focusing on the bacterial simulations…

The soil architecture along with the heterogeneity on the resource placement can promote bacterial biodiversity in soils
Thank you very much for your attention!!!

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In depth enough?

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