Soil structure development of anthropogenic soils used in bioretention cell

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Soils and the food, water, energy nexus

Motivation and goal

- Engineered soils play an important role in urban hydrology e.g. in the functioning of green roofs and stormwater bioretention cells
- For better design and long-term reliable performance of bioretention cells for urban stormwater irrigation detailed knowledge of transport processes in engineered soils is needed

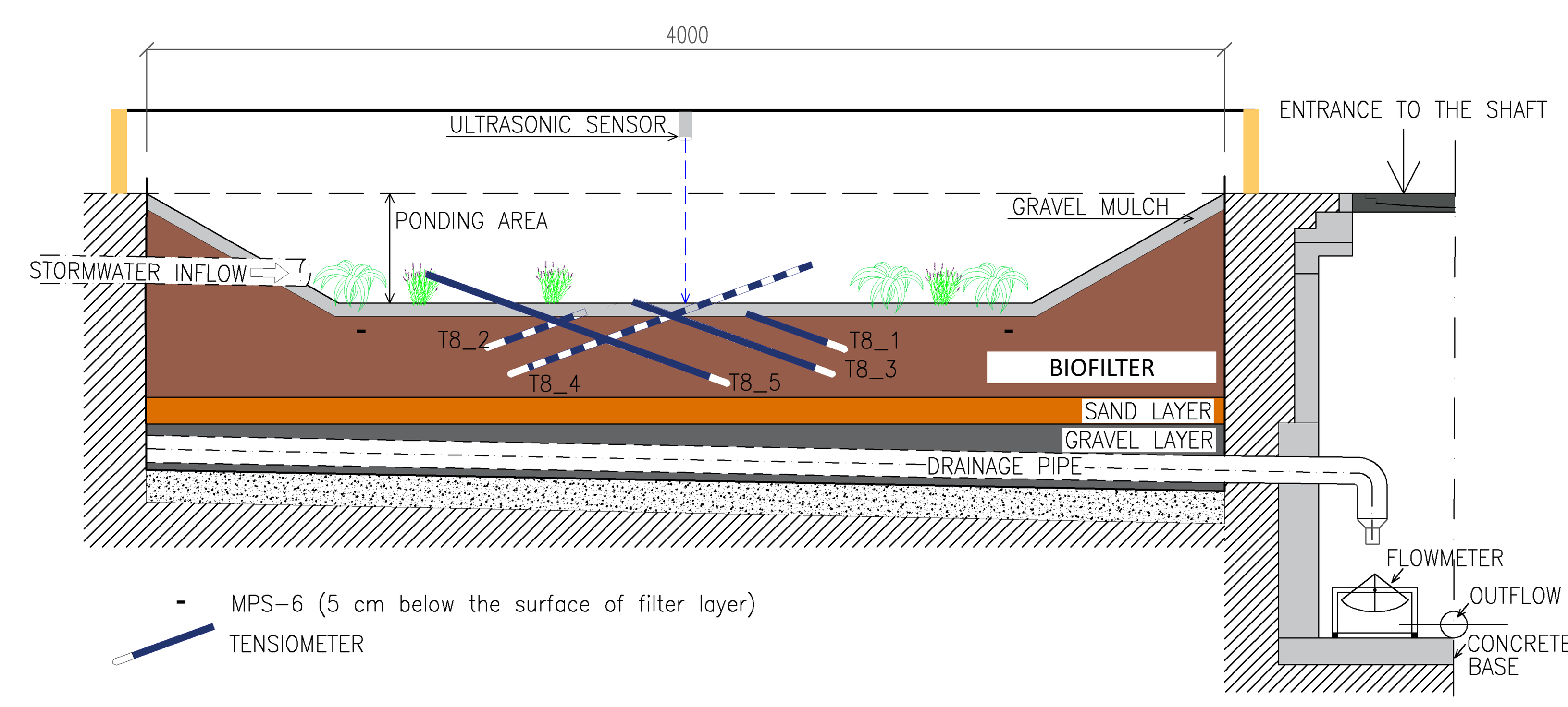
- **The aim** is to elucidate changes in bioretention cells performance by studying the structural changes of constructed soils at the microscale by invasive and noninvasive methods

Methods and Material

Experimental bioretention cell

- Two identical experimental bioretention cells were established in premises of the University Centre for Energy Efficient Buildings of Czech Technical University, Prague in December 2017
- The first bioretention cell BC1 collects stormwater from a 39 m2 roof
- Bioretention cell BC2 is supplied from 2000 liter tank and is used for performing ponding experiments using simulated rainfall episodes
- Specification of anthropogenic soil used in filter layer (**biofilter**) composed from:

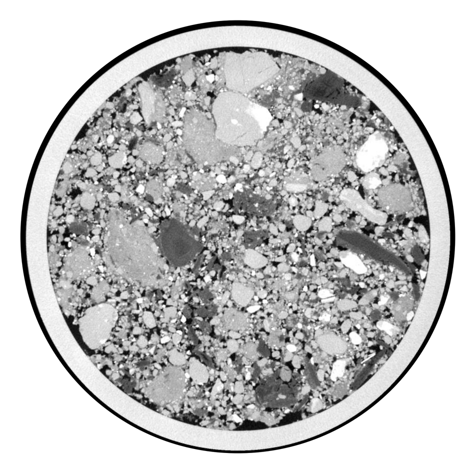
50% sand, 30% compost and 20% topsoil

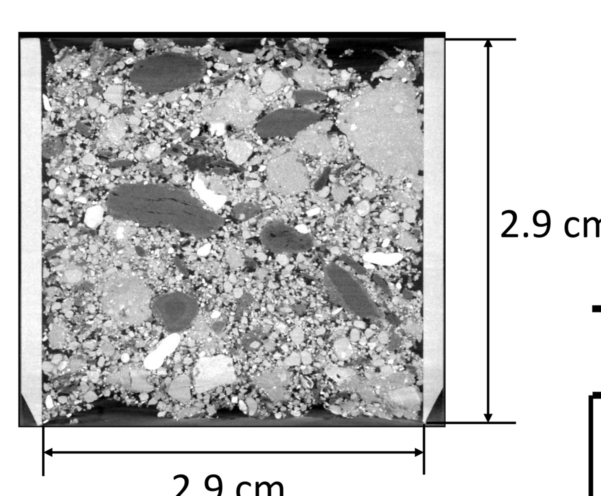


Longitudinal section of the bioretention cells BC1

Soil Samples

- The regular soil sampling program was initiated in 2018 in order to visualize and quantify the soil structure and internal pore geometry of samples
- Undistributed samples were collected from the surface of the biofilter twice a year from each BC (before vegetation season and after vegetation season)
- Three batches of samples were taken during three years (2018, 2019, 2020)
- 48 samples per year were taken per year (12 samples from each BC)
- The aluminum sampling cylinders had an internal diameter and height of 29 mm





CT image

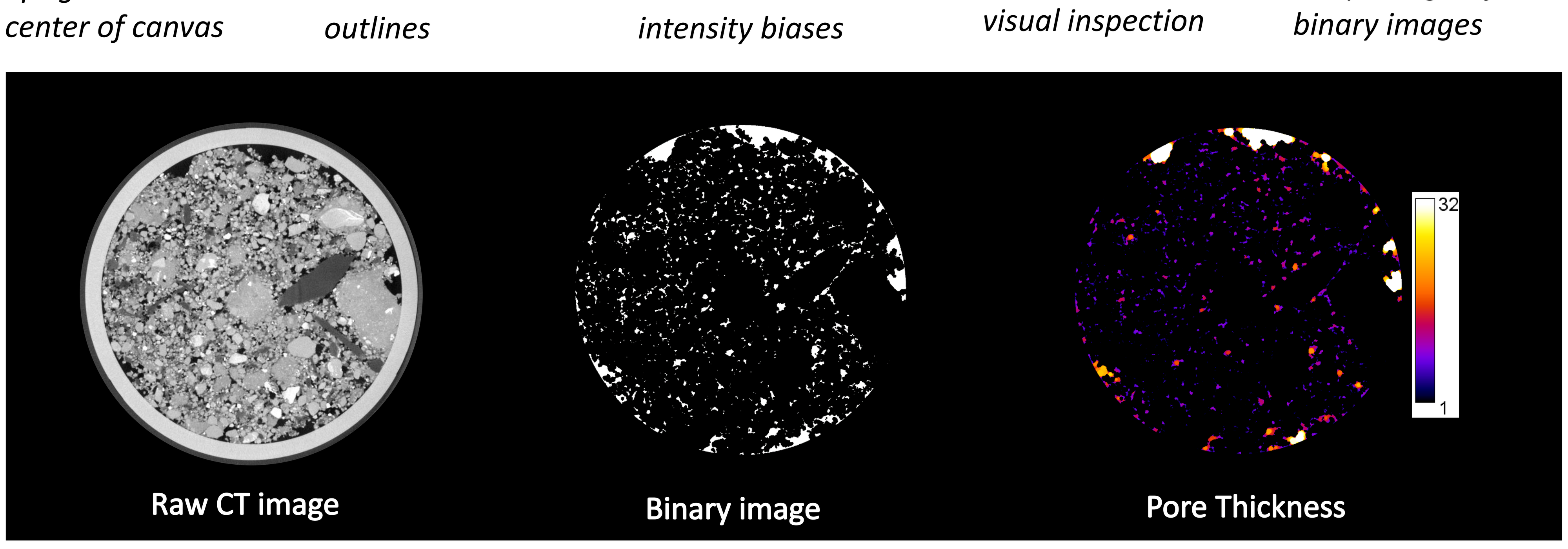
CT imaging

- CT image resolution: 20 µm
- Image matrix: 2014 x 2014 px
- 16-bit images
- The analysis performed using SoilJ package (Koestel, 2018)
- Conducted at SLU (Swedish University of Agricultural Science) and Czech University of Life Sciences Prague

Image processing using SoilJ

Straighten and center → Find column outlines → Calibrate grey values → Segmentation → Pore space analyzer

Straighten and center	Find column outlines	Calibrate grey values	Segmentation	Pore space analyzer
Puts column upright and in the center of canvas	*Detect and stores column wall outlines*	*Standardizes grey-scale removes intensity biases*	*Thresholds determined by visual inspection*	*Allows analyses morphologic of binary images*



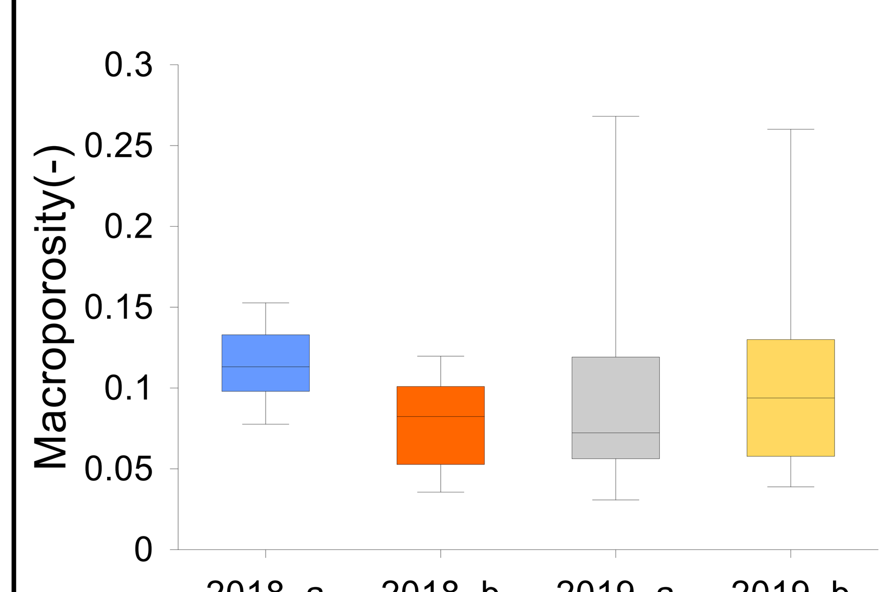
Results

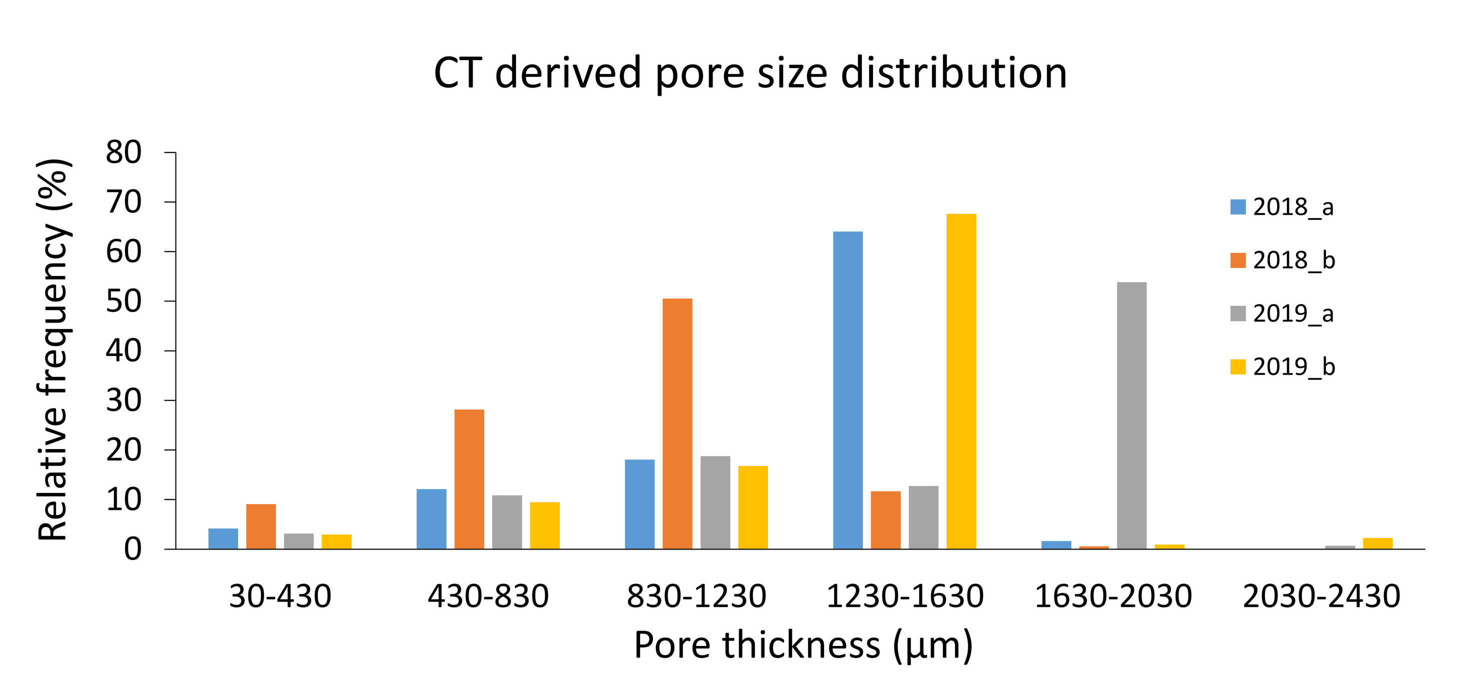
- The first preliminary results shows the development of macroporosity and pore size distribution during the year 2018 and 2019
- One set of samples show the results from both BC (24 samples)
- The box plot shows the median, lower and upper quartiles, maximum and minimum values
- In total 96 samples were analyzed

2018_a – samples taken before vegetation season in 2018
2018_b – samples taken after vegetation season in 2018
2019_a – samples taken before vegetation season in 2019
2019_b – samples taken after vegetation season in 2019

Average macroporosity (-)			
2018_a	2018_b	2019_a	2019_b
0.11	0.08	0.09	0.10

Average pore thickness (µm)			
2018_a	2018_b	2019_a	2019_b
0.044	0.040	0.041	0.055





Conclusions

- The preliminary analysis of X-ray CT imaging demonstrates the decrease of macroporosity during the two years from 11 to
- The highest percentage of pore space was found in the 1230 to 1630 µm pore size range
- Macroporosity was highest after BC establishment before vegetation season 2018
- The pore size variability is higher in 2019 compared to the previous year
- The analysis of CT images will continue and the next year 2020 will be evaluated

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