Geophysical Research Abstracts
Vol. 17, EGU2015-6389, 2015
EGU General Assembly 2015

The effects of extracellular sugar extraction on the 3D-structure of biological soil crusts from different ecosystems

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Biological soil crusts (BSCs) play important roles in the hydrological cycles of many different ecosystems around the world. In arid and semi-arid regions, they alter the availability and redistribution of water. Especially in early successional stage BSCs, this feature can be attributed to the presence and characteristics of extracellular polymeric substances (EPS) that are excreted by the crusts' organisms. In a previous study, the extraction of EPS from BSCs of the SW United States lead to a significant change in their hydrological behavior, namely the sorptivity of water (Rossi et al. 2012). This was concluded to be the effect of a change in the pore structure of these crusts, which is why in this work we investigated the effect of the EPS-extraction on soil structure using 3D-computed micro-tomography (μCT). We studied different types of BSCs from Svalbard, Germany, Israel and South Africa with varying grain sizes and species compositions (from green algae to light and dark cyanobacterial crusts with and without lichens and/or mosses).

Unlike other EPS-extraction methods, the one utilized here is aimed at removing the extracellular matrix from crust samples whilst acting non-destructively (Rossi et al. 2012). For every crust sample, we physically cut out a small piece (1cm) from a larger sample contained in Petri dish, and scanned it in a CT at a high resolution (voxel edge length: 7μm). After putting it back in the dish, approximately in the same former position, it was treated for EPS-extraction and then removed and scanned again in order to check for a possible effect of the EPS-extraction.

Our results show that the utilized EPS-extraction method had varying extraction efficiencies: while in some cases the amount removed was barely significant, in other cases up to 50% of the total content was recovered. Notwithstanding, no difference in soil micro-structure could be detected, neither in total porosity, nor in the distribution of pore sizes, the tortuosity or the relationship of tortuosity vs. length of the pores. Although most of the variables we investigated showed a high variation, some of which likely due to slight changes in orientation of the scanned crust piece between the two scans (or the loss of large grains or micro-aggregates), our method was able to detect differences between the four different crusts, proving that it is suited for the investigation of the structure. Also the visual comparison of the crust before and after the treatment revealed no distinct patterns of change in the structure of the crusts. This leads us to conclude that the change in sorptivity is related more to a change of the physico-chemical properties (namely the hydrophobicity) of the very surface of the crust, rather than a change of the inner structure.

References:

Rossi, F., Potrafka, R.M., Garcia-Pichel, F., Philippis, R. de, 2012. The role of the exopolysaccharides in enhancing hydraulic conductivity of biological soil crusts. Soil Biology and Biochemistry 46, 33–40.