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Substrate limitation controls SOC-stability outside of microbial hotspots in deep soil – A zymography approach

Julian Heitkötter (1), Jiem Krüger (2), Henrik Redweik (2), Jörg Bachmann (2), and Bernd Marschner (1)

(1) Ruhr-Universität Bochum, Soil Science and Soil Ecology, Bochum, Germany (julian.heitkoetter@rub.de), (2) Leibniz Universität Hannover, Institute of Soil Science, Hannover, Germany

The spatial heterogeneity of carbon distribution and fluxes is much higher in subsoils than in topsoils due to the greater relevance of preferential flow paths, roots and animal burrows for fresh organic substrate inputs. Substrate inputs, such as dissolved organic carbon or root exudates, will most likely form hotspots of microbial life and C-turnover in subsoils. However, it is unknown, if areas outside of such hotspots are occupied by microorganisms, possibly in a dormant state due to substrate scarcity for maintaining microbial metabolism.

In an ongoing study, we characterize the spatial distribution of three enzymes (b-glucosidase, chitinase and acid phosphatase) and their activities within different depths. This should indicate, if C-turnover is limited to small volumes in subsoils, while the largest part of subsoils is scarcely occupied by active microorganisms. The sampling technique developed by Krueger and Bachmann (2017) was applied to obtain undisturbed soil samples from 0-11, 15-26, 60-71, 80-91 and 150-161 cm depths. After initial enzyme mapping on the soil sample surfaces, they were homogenously sprayed with 14C-glucose as model substrate to remove a possible substrate limitation for microbial activity. Using this approach, it was possible to tackle the question, if microorganisms outside of subsoil hotspots exist and can contribute to SOC mineralization when substrate limitation is overcome.

The results show that hotspots in subsoils represent 1-5% of the total area, where enzyme activities were about 2-6 times higher than in the surrounding areas (i.e. non-hotspots). The effect of glucose on enzyme activities in initial hotspots was not significant, but boosted the enzyme activities outside of these initial hotspots by up to 500%. On average, 90% of initial non-hotspots showed increased enzyme activities, while 3% was unaffected and 7% of the area showed reduced activity. These results clearly indicate that microorganisms exist outside of hotspots in subsoils, which can be activated from dormancy when substrate arrives and are then able to mineralize SOC. Thus, substrate limitation seems to be a key mechanism for SOC persistence outside of microbial hotspots.

Literature

Krueger, J., Bachmann, J., 2017. New Field Sampling Method to Analyze Spatial Distribution of Small-Scale Soil Particle Surface Properties and Processes in Intact Soil. Vadose Zone Journal 16, 0.