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Changes in biogeochemistry of pyrogenic carbon in soil after one year

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Pyrogenic carbon (PyC), incomplete combustion product of biomass and fossil fuel, is ubiquitous in the environment and widely assumed to remain stable in soil (1). The stability of PyC has been challenged by a series of recent laboratory and field experiments (2-4), which show that it is mineralized slowly to CO_2 in soil. We are carrying out a long-term PyC degradation study within an experimental field setup located at Laegeren forest (Wettingen, Switzerland). We have installed cylindrical mesocosms (20 cm long and 10 cm diameter) in a randomized block design with 3 plots, 3 treatments (wood, PyC, and control) and 2 levels of nitrogen (N) input (+N = +60 kg ha-1 y-1 and -N = ambient N deposition). Wood (Pinus ponderosa) and PyC were highly labelled (13C 800‰ and 15N 4.2 atom%) and were added at a rate of 1.5 g-C kg-1 soil and 2.8 g-C kg-1 soil, respectively. We observed that PyC decomposed at a rate of 0.64 % year-1.

We extracted the mesocosms after ca. 10 months in situ and sampled soil at different column depths (0–5, 5–10, 10–15 cm). We carried out δ13C and δ15N analysis to estimate the total recovery of the added substrate and its transport within the soil profile inside the mesocosms. The benzenepolycarboxylic acid (BPCA) molecular marker method was employed to quantify and characterize the PyC before and after its addition into the soil. Density fractionation was applied to identify organo-mineral interactions and understand the dynamics of PyC degradation in soil. We analysed soil sub-samples for microbial biomass using fumigation –extraction. We further study the effect of PyC on soil enzyme to determine if PyC could modify soil biological properties.

We observed that after 10 months in the soil, 1) the quality of PyC, estimated by relative contribution of individual BPCA molecular markers, remained unchanged; 2) PyC showed negligible vertical movement within the soil profile; 3) most PyC was in free and occluded particulate fractions (22% PyC in occluded fraction); 4) Enzyme activity increased significantly ($p < 0.05$) with increased nitrogen input and showed no significant difference in activity due to different substrate. We conclude that some degree of physical stabilization, for example in aggregates, might occur in the initial stages of PyC decomposition.

References

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