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Impact of the molecular structure and microbial community features on the stability of organic components in soil

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The persistence of soil organic carbon (SOC) depends on various bio-physico-geochemical factors, such as physico-chemical soil properties, the complexation by mineral compounds, microbial diversity and the complexity of organic matter. However, the relative impact of these factors on SOC stability is insufficiently understood, not least because determining the organic matter stability remains a major challenge. In the present study, we therefore evaluated the intrinsic stability of various organic compounds in different soils harboring distinct microbial communities using biological and thermal approaches.
Two forest soils and one grassland soil were incubated with organic molecules representative of microbial and plant biomass found in soils, such as cellulose, aromatic nitrogen-containing compounds, fatty acids and lignin. The kinetics of aerobic microbial degradation were monitored in parallel to the thermal stability of the respective compounds using a Rock-Eval® ramped thermal analysis. In addition, the evolution of the composition and the abundance of bacterial and fungal communities were assessed by metabarcoding and qPCR.
Results show that the extent of biological mineralization was generally inversely correlated to the final organic matter and stable organic carbon contents as determined by Rock-Eval® parameters. Furthermore, soil structure and microbial community composition led to a differential response as a function of soil type for some of the substrates tested, in particular cellulose, cutin/suberin-derived compounds and aromatic nitrogen-containing compounds. Forest soils show a more similar response to substrate addition, in terms of degradation capacity, fungal and bacterial diversity. On the contrary, grassland soil displayed distinct diversity profiles which might be related to its lower capacity of nitrogen-containing aromatic compound degradation and its higher capacity to degrade some aliphatic compounds compared to forest soils. In summary, we could show that the composition of organic matter contributes to its biological stability in soil and that it is linked to thermal stability, but that other factors such as microbial community composition can modulate this feature.