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Plant lipid composition changes as a function of burning conditions and can be used as molecular proxy for the assessment of burning environments in soils

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Plant-derived biomass entering soil commonly leads to a typical chemical composition of soil organic matter (SOM), whereas alteration of biomass during microbial degradation results in different chemical changes of plant-derived SOM. On a molecular level plant-derived SOM is characterized by a predominance of long-chain alkanes, fatty acids and alcohols within the lipid fraction with a strong relative predominance of odd or even carbon-numbered homologues depending on the lipid fraction. E.g. plant-derived alkanes as typical degradation products of functionalized lipids are dominated by odd long-chain alkanes. Contrastingly, a progressive increase in short-chain even-numbered alkanes was found in charred biomass with increasing temperature associated by a decrease in chain-length and a decrease in the predominance of odd n-alkanes [1]. Thermal degradation of plant biomass during a fire results in a modification of lipid distribution patterns that differs from microbial degradation. Not only the composition, but the total amount of lipidic components changes as well. Thus, during charring at low temperatures (<300°C) a relative increase in aliphatic and aromatic hydrocarbons occurs whereas the total amount of extractable lipids is reduced, which is in accordance to NMR spectra [2]. At indermediate temperatures (300-400°C) lipid contents increase relative to thermal degradation at lower temperatures due to an absolute increase in alkanes and PAHs deriving from degradation of other organic components like wax esters. At higher temperatures a decrease in abundance of the all lipidic fractions occurs including even aromatic hydrocarbons with a stronger depletion in aliphatic than in aromatic components. This is in agreement with NMR [2] and Black Carbon investigations using benzene polycarboxylic acids (BPCA) [3], where a higher aromaticity was correlated to higher charring temperatures. All these observations indicate that incomplete burning results in large amounts of complex organic remains in soil, where with increasing temperature burning gets more complete leaving less burning residues.
Recent investigations indicate a structural re-arrangement of lipidic components in burned plant biomass not only as a function of temperature, duration of thermal degradation, and oxygen availability, but also as a function of the initial plant biomass composition. Molecular marker might be useful to trace not only fire in recent and ancient soils, but also the burning conditions and the initial biomass. In this study it will be demonstrated how total lipid contents and distribution patterns are modified during thermal degradation and how molecular markers can be used to trace burning conditions in recent and ancient soils and sediments.

Cited references

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