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Biomarker patterns in present-day vegetation: consistency and variation – A study on plaggen soils

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Biomarker patterns in present-day vegetation are commonly used as proxies to reconstruct paleo-vegetation composition, land use history and to elucidate carbon cycling. Plaggen soils are formed by diverse vegetational inputs during century-long plaggen (i.e. sod) application associated with plaggen-agriculture on poor soils in north-western Europe. This resulted in remarkably stable organic matter. Plant source identification by biomarkers could provide insight in yet unknown stabilization mechanisms and the fate of organic matter upon ongoing land use change.

The current rationale behind biomarker-based source identification is that patterns observed in present-day vegetation are generally representative with little random variation. However, our knowledge on variability and consistency of biomarker patterns is yet scarce. Therefore, to assess the applicability of biomarkers for source identification in plaggen soils, we analyzed published n-alkane and n-alcohol patterns of species and their various parts which contribute(d) input to plaggen soils. We considered shrubs, trees and grass species and evaluated rescaled patterns (i.e. relative abundances in chain-length range C17-36), odd-over-even predominance (OEP) and predominant n-alkanes. In addition, we explicitly looked into potential sources of systematic variation, e.g. spatial variation (climate, site conditions), temporal variation (seasonality, ontogeny) and laboratory methodology (extraction technique: washing/shaking, Soxhlet/ASE, saponification).

We found meaningful clustering of n-alkanes C27, C29, C31 and C33, allowing for clear distinction of input by shrubs, trees and grasses to plaggen soils. Combination of these homologues with complete n-alkane patterns (C17-36) and OEP enabled further differentiation, while n-alcohols patterns were less distinct. Current limitation is the lack of extended and diverse quantitative records on biomarker patterns, especially for n-alcohols, non-leaf and belowground tissues, which hindered full statistical analysis. On species level we also recognized outliers and spreading. Systematic variation was indicated among tree species according to spatial conditions and by ontogeny. Yet, observed effects were ambiguous for other variation sources.

This study highlights clear opportunities for application of biomarker patterns for source identification and elucidation of stabilization processes in (plaggen) soils. At the same time, application is challenged by systematic variation. Further research is key to quantify controls, magnitude and potential correction factors for such systematic variation. This would validate the use of n-alkane and n-alcohol patterns across broad spatial and temporal scales or identify boundaries wherein their consistency is ensured. Likely, these challenges apply to vegetation in a broad perspective, transcending plaggen vegetation, as assessment and application of present-day vegetation patterns is emerging.