



## **Stabilization of lignin in soils - lessons from compound specific $^{13}\text{C}$ analysis in long-term field experiments**

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A frequently cited assumption is that lignin in soils should be relatively stable due to its recalcitrant chemical structure. In recent years, this view has been challenged by new analytical techniques that use both lignin-specific biomarker molecules and compound specific isotope analysis.

Applying these techniques to long-term field experiments with natural carbon isotopic labelling (C3-C4 vegetation change), it could be shown that the dynamics of lignin in soils are more complex and cannot be explained by its recalcitrant structure alone. In particular, there seem to be both a stable and a labile lignin pool in soils. As for soil organic carbon in general, interactions with the mineral phase have been suggested to be involved in the stabilization of lignin in soils.

The present study focuses on the stable pool and tries to answer the following questions: (I) Which soil fractions contain most lignin? (II) Is the stable pool related to a particular soil fraction? (III) Can differences in lignin content between soil fractions be explained by properties of the mineral phase (surface area, type of minerals)?

We used a combined density and aggregate size fractionation of an agricultural soil before and after it had been naturally  $^{13}\text{C}$ -labelled by 18 years of maize cropping. We identified old lignin deriving from the time before maize cropping by compound-specific isotope analysis of lignin-derived phenolic biomarkers. In the studied soil, we found a large proportion of lignin in coarse heavy fraction, suggesting inclusion in macroaggregates. However, isotope data indicated that lignin in this fraction was less stable in the long-term than lignin in light fractions. A potential explanation might be that some lignin-containing cell structures (e.g. thick cell walls) are recalcitrant enough to persist for decades even under intensive cropping. Due to intensive cropping before the isotopic labelling started, the light fractions would already be enriched in these structures, whereas in aggregates, also more decomposable structures may have been preserved. Aggregate turnover would then liberate part of these easily decomposable lignin structures resulting in the observed decomposition pattern. Therefore we suggest that inclusion in aggregates is particularly important for stabilization of the more easily decomposable lignin fraction in soil.