

HOW MAY LIPID COMPOSITIONS CHANGE UNDER ENHANCED ATMOSPHERIC CO₂ AND HOW IS LIPID TURNOVER IN GRASSLAND SOILS?

Guido L.B. WIESENBERG^{1,2} (guido.wiesenberg@uni-bayreuth.de), Michael W.I. SCHMIDT³, Jan SCHWARZBAUER⁴ and Lorenz SCHWARK

1. Department for Geology and Mineralogy, University of Cologne, Zulpicher Str.49a, 50674 Cologne, Germany
2. present address: Department of Agroecosystem Research, University of Bayreuth, 95440 Bayreuth, Germany
3. Department of Geography, University of Zurich, Winterthurerstr. 190, 8057 Zurich, Switzerland
4. Institute of Geology and Geochemistry of Petroleum and Coal, RWTH Aachen, Lochner Str.4-20, 52056 Aachen, Germany.

Sequestration of organic matter into soils plays an important role in global CO₂ dynamics. Models describing CO₂ budgets therefore assume different rates of soil organic carbon (SOC) turnover depending on the reactivity of plant-derived components. In contrast to the traditional view, where lipids were assumed to be relatively stable in soils (Kögel-Knabner, 2002), recent studies document that lipids are not part of the stable fraction of soil organic matter (SOM) (Wiesenberg et al., 2004b). Other than macromolecular SOM-fractions these compounds are suitable for detailed structural and compound-specific $\delta^{13}\text{C}$ -isotope characterization. A standard approach for estimating bulk and molecular SOC turnover rates utilizes natural isotopic labeling after monoculture C₃/C₄-crop switching. Free air carbon dioxide enrichment experiments (FACE) employ the artificial incorporation of isotopically labeled CO₂ into photosynthate and subsequently into SOM. An enhanced availability of CO₂ is generally thought to increase biomass production of plants. Recent studies however revealed that no significant biomass increase occurred during 10 years of atmospheric CO₂ enrichment in a FACE experiment at Eschikon, Switzerland. We here present isotopic and biomarker data on the development of lipid distribution in plants and turnover into SOM.

Surface soil (0-10cm depth) and plant (*Lolium perenne* and *Trifolium repens*) samples were collected at the Eschikon FACE experiment site after 10 years of exposure to i) ambient CO₂ conditions ($\delta^{13}\text{C}$ of app. -8.7‰ [V-PDB]), and ii) elevated CO₂ concentrations (600ppm, $\delta^{13}\text{C}$ of added CO₂ was -48‰ [V-PDB]). Total lipids were recovered by accelerated solvent extraction and separated into eight fractions of different polarity by liquid chromatography (Wiesenberg et al., 2004a). Fractions of aliphatic hydrocarbons and carboxylic acids were analysed by GC-MS and GC-irmMS.

Carboxylic acid, alcohol and aliphatic hydrocarbon distribution patterns of plant biomass and soils are discussed. While short chain acids reveal a uniform depletion in unsaturated C₁₈ acids in plants and soils under enhanced CO₂ concentration, the alcohol fraction shows diverse trends for *Lolium perenne* and *Trifolium repens* plants and soils. Long

chain alcohols increase in abundance for lolium and decrease for trifolium samples. The *n*-alkanes in soils, as degradation products of plant derived acids and alcohols, exhibit minor compositional variations. Decreasing amounts of plant-derived acids vs. increasing concentrations of alcohols were noted for trifolium samples.

Carboxylic acid and aliphatic hydrocarbon $\delta^{13}\text{C}$ -values of plant biomass and soils are discussed. In general $\delta^{13}\text{C}$ of plant carboxylic acids and alkanes was uniformly shifted to lighter values by approximately 6-8‰ V-PDB. This was consistent with the shift in bulk isotopic values due to the ^{13}C -depleted atmosphere. In soils, short-chain carboxylic acids ($<C_{20}$) mainly derived from microbial sources result in a lower depletion in isotopic values than plant derived long-chain acids ($\geq C_{20}$). The isotopic differences between individual compounds in soils under ambient vs. elevated CO_2 conditions vary significantly, which argues against turnover determinations for lipid classes based on an individual compound. Contrastingly, averaged isotope values result in reliable calculations of replaced carbon proportions and turnover times for lipid classes. In grassland soils carboxylic acids are turned over fastest, followed by bulk carbon and alkanes with the slowest turnover times (Fig. 1). This stands in contrast to previous determinations for arable soils, but confirms observations in peaty soils indicating that *n*-alkanes contribute to the relatively stable soil carbon fraction.

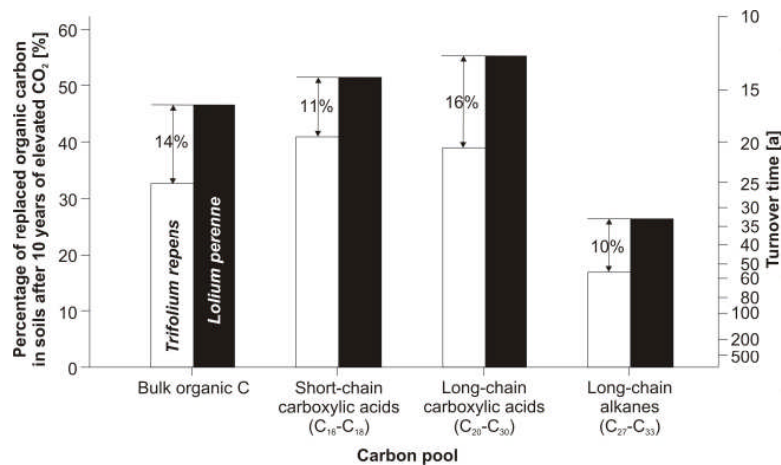


Figure 1. The new carbon proportions of bulk soil organic carbon and the plant-derived long-chain *n*-alkanes and *n*-carboxylic acids of the Eschikon FACE experiment.

REFERENCES

- Kögel-Knabner, I. (2002) The macromolecular organic composition of plant and microbial residues as inputs to soil organic matter. *Soil Biology and Biochemistry*, **34**, 139-162.
- Wiesenberg, G.L.B., Schwark, L. and Schmidt, M.W.I. (2004a) Improved automated extraction and separation procedure for soil lipids. *European Journal of Soil Science*, **55**, 349-356.
- Wiesenberg, G.L.B., Schwarzbauer, J., Schmidt, M.W.I. and Schwark, L. (2004b) Sources and turnover of organic matter in agricultural soils derived from *n*-alkane/*n*-carboxylic acid composition and C-isotope signature. *Organic Geochemistry*, **35**, 1371-1393.