Origin and fate of dissolved organic matter in the subsoil

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Background

Dissolved organic matter (DOM) is the most mobile form of organic matter in soils and represents a major source of carbon (C) in the subsoil. However, the transformation processes of DOM during the migration in soils remain unclear. The preferential removal of more sportive DOM compounds (e.g. phenols) in the topsoil and leaching of more labile once (carbohydrates) cannot explain e.g. the depletion of ^{14}C in DOM in the subsoil nor the higher stability of DOM against microbial decomposition. The cascade model (Fig. 1) proposes that DOM is subjected to continuous sorption on mineral surface combined with microbial processing and remobilization when migrating through the soil[1]. However, there is lack of experimental evidence under field conditions, which supports such a model. By using ^{13}C labeled leaf litter we hypothesize that

- the contribution of fresh litter-derived C in mineral-associated organic matter (MOM) and DOM decreases with increasing soil depth
- the removal of labeled litter introduce a pulse of $DO^{13}C$ mobilized from MOM to larger depth due to exchange processes with fresh non-labeled DOM

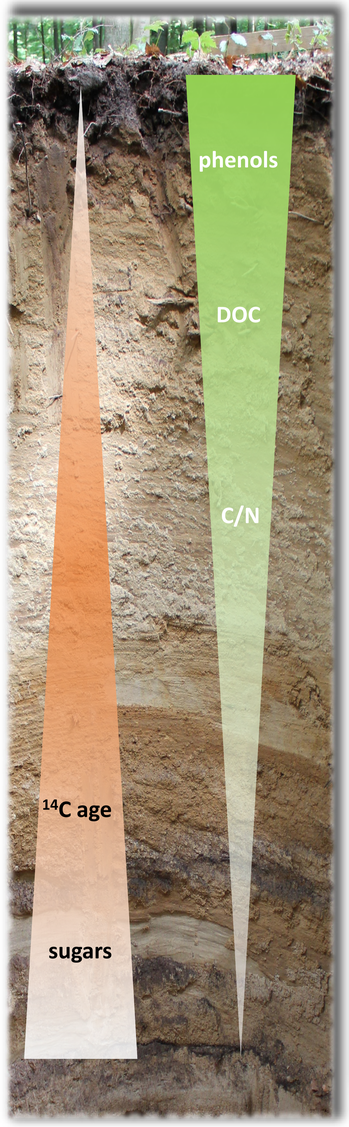
Materials and Methods

Labeling experiment on a Dystric Cambisol in a beech forest
- 1st Addition of ^{13}C enriched beech litter (124 g C m^{-2}, 1880 ‰)
- 2nd After 2 years stop of ^{13}C input of labeled litter and replacement with original litter

Soil sampling 0 and 18 month after replacement (0-180 cm)

Analysis

Water extractable organic C (WEOC)
Density fractionation (fPOM, oPOM and MOM)
TOC and ^{13}C measurements of all fractions
UV and fluorescence spectroscopy of WEOC



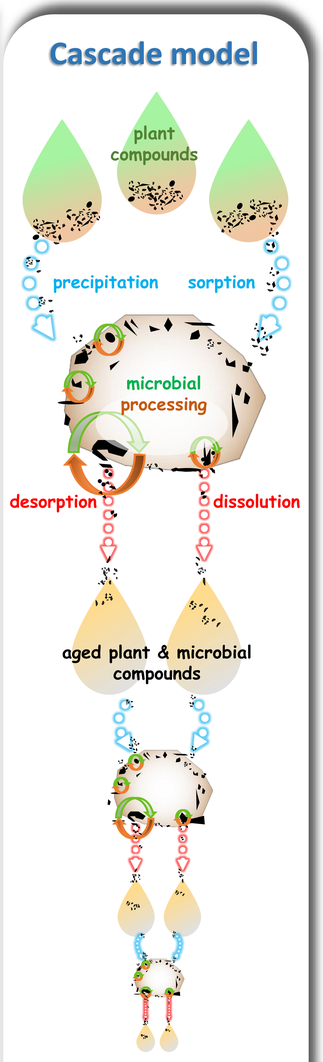


Fig. 1 After Kaiser and Kalbitz 2012.

Conclusion

- **Fresh litter-derived C is only minor source of DOM and MOM in the subsoil**
- **DOM in subsoil originated more from microbial processed OM**
- **Exchange processes of fresh and altered DOM not evident in MOM, but in DOM?**
- **First field indications of the cascade model for DOM migration in the soil**

Litter-derived C in MOM and DOM

- WEOC more sensitive for labeled litter-derived C than MOM
- Contribution of litter-derived C decreases with depth and time
- Small pulse of $DO^{13}C$ in 5-10 cm after 18 month (blue arrow)
- Decline of litter-derived C in between 0-60 cm

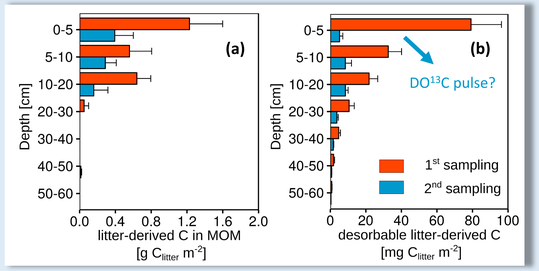


Fig. 2 Labeled litter-derived C in (a) MOM and (b) water extractable organic C for the two samplings. Means and standard error (n = 3).

MOM as DOM source

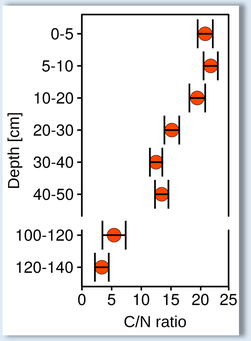


Fig. 3 C/N ratio of MOM

- Decreasing C/N ratio of indicate more processed organic matter (N_{min} ?)
- Shift in DOM composition with depth indicated by change in SUVA and HIX
- Higher proportion of plant-derived compounds between 0-50 cm
- Below increasing proportion of microbial-derived compounds

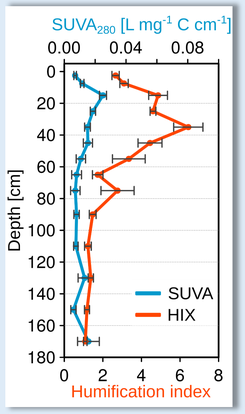


Fig. 4 DOM composition characterized by UV and fluorescence spectroscopy. Means and standard errors (n = 6).

Ideas for further analyses on samples with low DOC concentrations 1 mg L^{-1} and small volume (5 mL)?

Reference: [1] Kaiser, K. and Kalbitz, K.: Cycling downwards – dissolved organic matter in soils, Soil Biol. Biochem., 52, 29–32, doi:10.1016/j.soilbio.2012.04.002, 2012.

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