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Origin and fate of dissolved organic matter in the subsoil

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Dissolved organic matter (DOM) is the most mobile form of organic matter in soils and substantially contributes to the translocation of carbon (C) in the soil profile. DOM represents a major source of C in subsoils but the transformation processes of DOM during migration are poorly understood. The view of soils as a chromatographic system causing more sorptive compounds being preferentially retained in the topsoil and more labile ones being leached into the subsoil is more and more challenged. Kaiser and Kalbitz (2012) proposed the cascade model, stating DOM to become subjected to continuous sorption on mineral surfaces combined with microbial processing and remobilization when passing through the soil. These exchange and remobilization of DOM from the mineral surfaces are influenced by several factors such as availability of sorption sites and composition of DOM. In consequence, the contribution of fresh litter-derived carbon to DOM and soil organic matter (SOM) should decrease with increasing depth. However, there is a lack of experimental evidence under field conditions, which supports such a cascade model.

In this study we used soil samples from a two pulse field labeling experiment in order to assess the contribution of fresh litter-derived carbon to DOM and SOM in relation to soil depth. On three plots in a 100-year old beech forest on a Dystric Cambisol, the natural leaf litter was replaced by an equal amount of ^{13}C-enriched leaf litter. After two years under field conditions, the leaf litter was again replaced by natural leaf litter to stop the input of the ^{13}C label. Soil samples were taken at the time of natural litter replacement and 18 months later. The contribution of litter-derived carbon to DOM was determined by isotope analysis in water-extractable organic matter as a surrogate of DOM migrating through the soil. DOM composition was characterized by UV and fluorescence spectroscopy. Additionally, a density fractionation was used to determine the amount of mineral-bound organic matter.

Two years after the labeling the amount of litter-derived carbon in DOM decreased from 1.6 % in 0-5 cm depth to 0.1 % in 40-50 cm depth. In total, only 2.5 % of the initial litter carbon was retained in the mineral soil fraction in 0 to 50 cm, and below 50 cm we could not measure any ^{13}C enrichment in the mineral soil. This means that recent organic matter from the litter does neither contribute to SOM nor DOM in the subsoil of our study site. In addition, spectroscopic analysis indicates a shift in DOM source in the soil profile: DOM in the first 50 cm exhibits a higher proportion of aged plant-derived compounds whereas below 50 cm DOM was enriched in more microbial-derived compounds. These results provide first evidence of the cascade model under field conditions and confirm that only a minor carbon fraction of recent litter inputs is transferred into the subsoil within an annual timescale.

Reference:

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.