



Influence of lignite on soil organic carbon turnover estimated by natural ^{13}C labelling: a dual carbon isotopic tracer study

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Fossil fuel-derived carbon, which often is a major fraction of black carbon, may contribute significantly to the organic matter in soils, particularly in highly industrialised areas (Schmidt et al., 2000). Due to the presumed low degradability of products derived from incomplete combustion (Goldberg, 1985), this carbon source has an important influence on the dynamics of soil organic carbon (SOC) and, moreover, can result in erroneous estimates of 'natural' SOC turnover based on carbon isotopic analyses. It may also hinder the identification of physical or chemical stabilisation mechanisms when functionally-defined soil fractions are analysed (Rethemeyer et al., 2005).

The initial objective of this study was to investigate physical stabilisation mechanisms of SOC in an agricultural soil in Halle/Saale (Germany) by determining turnover times of organic carbon in particle-size fractions with the help of natural ^{13}C labelling. This approach is based on a change from a C_3 to a C_4 vegetation, in the case of Halle from rye to maize cultivation, which enables one to trace the isotopic label of the C_4 vegetation, e.g. to quantify the addition of maize-derived carbon to SOC. This was hindered by a high contribution of fossil fuel-derived carbon, amounting to about 50 % in the surface soil at Halle, which was quantified by ^{14}C analysis of the soil organic matter and mass balance calculation. The fossil material was assumed to originate mainly from lignite, since the study site is located in a highly industrialised region of Germany with open cast lignite mining and industries using and processing lig-

nite. Black particles, selected from the upper 30 cm of the soil by hand-picking, were examined by scanning electron microscopy coupled to energy-dispersive X-ray spectroscopy. The results of these analyses suggest non-combusted lignite fragments as well as their combusted residues as main sources of the black material in the Halle soil. Comparable $\delta^{13}\text{C}$ values of the black particles and lignite samples from a nearby mine (Wiesenberg et al., 2005) confirm this hypothesis. However, the presence and continuous addition of lignite-derived carbon, with a C_3 $\delta^{13}\text{C}$ isotopic signature, led to a drastic underestimation of the contribution of the new C_4 vegetation to natural SOM. In consequence, unrealistically long turnover times of carbon in particle-size fractions were calculated, based on the natural ^{13}C abundance method. These ranged from 138 years (coarse sand) to 718 years (fine sand). The turnover of organic carbon was slowest in the fine sand and coarse silt fraction agreeing with low ^{14}C values of 24 pMC and 32 pMC, respectively, which both indicate an enrichment of fossil, lignite carbon in these size classes.

As a consequence, we estimated the proportion of the fossil, ^{14}C -free carbon by ^{14}C values of the particle-size fractions. These data were used to correct the underestimated accumulation of carbon derived from maize in each size fraction by mass balance calculation. Thus corrected percentages of maize-derived carbon yielded more realistic turnover times, which ranged from 43 to 170 years, increasing from coarse sand to clay. The dual isotopic approach, used to calculate carbon turnover times in a lignite contaminated soil, was checked by the comparison of soils, separated by density fractionation, from Halle and from a field trial in a rural area. Similarly corrected turnover times for these fractions from the Halle soil corresponded to data obtained for the uncontaminated soil. This demonstrates the reliability of this calculation.

References

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