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Tracing black carbon in soil using SEM/EDX, biomarker analyses, and compound-specific radiocarbon analyses

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Mollisols are known to contain stable, black humus components which originate from charred or coal-derived particles. As such black carbon (BC) significantly affects soil fertility and interferes with models on soil organic matter dynamics, an accurate prediction of BC input into soils and an elucidation of the mechanisms of BC turnover is essential. The main aims of this study were (i) to identify the sources of BC in the Mollisols of the long-term field experiment in Halle and Bad Lauchstädt, Germany, (ii) to quantify and localize the BC contents in different soil C pools, and (iii) to elucidate the mechanisms affecting BC decay. After fractionation of soil into particle-size, density, and aggregate-density pools BC was characterized by scanning electron microscopy (SEM) and energy-dispersive X-ray spectrometry (EDX). Benzenepoly-carboxylic acids (BPCA, revised method) served as specific molecular BC markers, the sources of which having been characterized using compound-specific natural ^{14}C abundance measurements. For the assessment of the stability of BC, a long-term incubation experiment was performed.

The SEM/EDX analysis identified BC as particles of low O/C ratio. The BC particles itself had a round to irregular shape, with smooth to rough surfaces. This morphology was not specific for a given soil fraction. It indicated different BC sources that were variably distributed among the soil C pools. Black carbon in the surface soil of Bad Lauchstädt mainly derived from coal combustion and vegetation fires. Compound-specific radiocarbon measurements ascertained that a significant part of black carbon

(about 60% in the surface soil of Halle) was of fossil origin. The analysis is currently extended to archived samples and particle size fractions to better trace back the fossil C input. First results indicate that major fossil C inputs originated from the last 50 years. This fossil BC, however, was not stable but incorporated into soil humus. The incubation experiment revealed that initial BC decay may be rapid and cannot be assigned to one single, stable C pool. Investigations by REM strongly indicated that there are chemical interactions of BC with the mineral phase, however. Aggregate and aggregate-density fractionation suggested that BC was embedded into microaggregates. Both chemical interactions and physical entrapment contribute, therefore, to a stabilization of various soil BC forms in the long-term run.