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Decomposition of 14C labeled pyrogenic carbon and its incorporation into soil microbial biomass estimated during 4 years incubation

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Incomplete combustion of organics (vegetation or fossil fuel) led to accumulation of charred products in soils. Such charred and pyrogenic products, frequently called black carbon (BC), may act as an important long-term carbon (C) sink because its microbial decomposition and chemical transformation is very slow. Direct estimations of BC decomposition rates are absent. Estimations based on total CO2 efflux are unsuitable because the contribution of BC to CO2 is too small compared to soil organic matter (SOM).

We produced BC by charring 14C labeled residues of perennial ryegrass and incubated this 14C labeled BC in a Haplic Luvisol or in loess. The decomposition rates of BC were estimated based on 14CO2 sampled 46 times during the 3.8-years incubation period. We introduced five repeated treatments with either 1) addition of glucose as an energy source for microorganisms for cometabolic BC decomposition or 2) intensive mixing of the soil to check the effect of mechanical disturbance. BC addition amounting to 20% of Corg of the soil or 200% of Corg of loess did not change total CO2 efflux. The decomposition rates of BC calculated based on 14C in CO2 were similar in soil and in loess and amounted to 1.36•10-5 d-1 (=1.36•10-3 % d-1). This corresponds to a decomposition of about 0.5% BC a-1 under optimal conditions. Considering about 10 times slower decomposition of BC under natural conditions, the mean residence time of BC is about 2000 years.

The strong increase in BC decomposition rates (up to 6 times) after adding glucose and the decrease of this stimulation after 2 weeks allowed us to conclude cometabolic BC decomposition. The incorporation of BC into microorganisms (fumigation/extraction) after 624 days of incubation amounted to 2.6 and 1.5% of 14C input into soil and loess, respectively. The amount of BC in dissolved organic carbon (DOC) was below the detection limit (< 0.01%).

We conclude that applying 14C labeled BC opens new ways for very sensitive tracing of BC transformation products in released CO2, microbial biomass, DOC, and SOM pools with various properties.