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Century scale char and non-char C co-stabilization in soil free C fractions

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Fate of char particles and reasons of char C stabilization in soils is not well understood especially due to difficulties of its quantification. In this study we showed how char C content could be estimated from elemental analysis along with its size redistribution and co-stabilization with non-char C in long-term.

We studied C dynamics in the size and density fractons of soil samples from a historical collection of 80 years bare fallow (no plant input plus tillage) experiment in Versailles, France (1929, 1939, 1949, 1962, 1972, 1991, 2008 years). Coarse char particles were observed in the soil substantially contributing to total organic C. Thus, char C study in this soil was carried out as a nessessary step for estimation of non-char C dynamics. Physical fraction allowed us to follow separately the dynamics of mineral-associated and free C. We analyzed bulk soils, fractions and picked out char particles for C, N and 13C contents.

Total organic carbon concentrations in fractions pointed to char C input during 1939-1949 years. After that patterns of C and C/N and δ 13C changes in all fractions suggested redistribution of char C from coarse to finer fractions. Evolution of C/N and δ 13C suggested that all free C fractions, although enriched in char, still contained non-char C in the end of the 80 years C depletion chronosequence. Especially high proportion of non-char C was observed in the silt-size free C fraction.

Linear combinations of contrasting char and non-char C C/N values allowed estimation of their proportions from the C/N evolution in the fractions. No substantial admixture of char C was observed for mineral-associated C fractions.

Stable C pool in 2008 comprised of 4.6 g C kg-1 soil and was composed of mineral-associated C (3.5 g C kg-1 soil) and char-associated C (1.1 g C kg-1 soil). In both cases organic matter could be stabilized through adsorption and/or occlusion with solid particles (mineral or char). Stabilization capacities of different size class minerals reflected in C concentrations of fractions were 1.2 g C kg-1 for silt-size minerals and 19.4 g C kg-1 for clay-size minerals, contrastingly three orders of magnitude more C was associated with char particles or about 1.2 kg non-char C kg-1 sand-size char and about 1.4 to 3.5 kg non-char C kg-1 silt-size char. Such a high capacity of stabilization by char particles could not be explained by adorbtion alone.

In conclusion, combination of C/N and δ13C signature allowed estimation of char content in this soil.

Total char C content (sum up of redistributed char C in free fractions) remained not significantly different in the C depletion experiment during five decades after char input.

Century scale char and non-char C co-stabilization in this soil could be explained by combination of adsorption and physical protection in microaggregates constructed of mineral and char particles.