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Soil pyrogenic carbon lacks long-term persistence

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In the context of climate change, one mitigation technique currently investigated is the use of pyrogenic organic carbon (PyOC) -which is biomass turned into charcoal- to sequester carbon in soils with the hypothesis that PyOC is persistent and will not be biodegraded (or mineralized). In this study, we use the unique opportunity offered by five long term bare fallow (LTBF) experiments across Europe (Askov in Denmark, Grignon and Versailles in France, Ultuna in Sweden and Rothamsted in the United Kingdom) to compare the dynamics of PyOC and soil organic carbon (SOC) in the same plots at the decadal time scale (from 25 to 80 years of bare fallow depending on the site).

Bare fallow plots were regularly sampled throughout the bare fallow duration and these samples were carefully archived. In bare fallow plots, with negligible external carbon input and with continuing biodegradation, SOC is depleting. Using the Benzene Polycarboxylic Acid (BPCA) technique to estimate the PyOC quantity and quality in the soils at different sampling dates, we investigated if PyOC content was also decreasing and compared the rates of depletion of PyOC and SOC. We found that PyOC contents decreased rapidly in soils at all sites. The loss of PyOC between the first and the last soil sampling ranged from 19.8 to 57.3% of the initial PyOC content. Furthermore, PyOC quality exhibited a similar evolution at all sites, becoming more enriched in condensed material with time. We applied a one pool model with mono-exponential decay to our data and found an average mean residence time of native PyOC of 116 years across the different sites, with a standard deviation of 15 years, just 1.6 times longer than that of SOC.

Our results show that, though having a longer residence time than total SOC, PyOC content can decrease rapidly in soils suggesting that the potential for long-term C storage in soil by PyOC amendments is less than currently anticipated. Our results therefore question the concept of biochar production as a climate change mitigation strategy.