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Mobility and age of black carbon in two temperate grassland soils revealed by differential scanning calorimetry and radiocarbon dating

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Black carbon (BC) is a natural component of soil organic matter (SOM) and abundant in many ecosystems. Its stability, due to its relative resistance to microbial decomposition, means it plays an important role in soil C sequestration. A recent review suggests that BC may be mobile in soil; hence, its contribution to a stable SOM pool may change over time due to its lateral or vertical reallocation (Rumpel et al. 2014). However, direct evidence of the mobility of BC, particularly with reference to its vertical mobility, is scarce. We studied the amount of BC in two temperate grassland fields (eutric clayey Camibsol,) that were established in 2001 on former cropland. Volumetric soil samples (0-50 cm, 5 cm increments) were taken at 10 spots in each field in 2001, 2006 and 2011. One of the fields was ploughed in 2007 and the sward was re-sown. BC content was measured by differential scanning calorimetry for a total number of c. 500 samples. The mean BC/OC ratio was 0.10 ($\pm$0.05) and reached 0.25 in some samples. Radiocarbon measurements from 24 bulk soil samples revealed relatively small 14C contents in 2001 (92$\pm$2.7 pMC) which increased over time (2006: 99.0$\pm$1.1 pMC; 2011: 99.1$\pm$1.1 pMC). Thermal fractionation of BC by DSC revealed calibrated BC ages of 400 to 1000 years (pMC 87-94), suggesting that BC originates from medieval and post-medieval fire clearings. The change in soil signature may have been caused by a preferential transport of old BC down the soil profile, leading to a selective enrichment of younger soil C over time. In line with this interpretation the DSC measurements suggest that in both fields, BC concentrations significantly decreased for most layers between 2001 and 2006. However, between 2006 and 2011, no further vertical reallocation was observed in the continuous grassland, whereas BC contents of the field ploughed in 2007 significantly increased in the top layers. Together, these data suggest that ploughing in 2001 triggered subsequent downwards movement of BC, a process which ceased after a few years. Repeated ploughing lifted up some of the BC from deeper layers and this material will probably be transported downwards in the future.

Rumpel, C. et al. (2014) Movement of biochar in the environment. In: Lehmann, J. (Ed.): Biochar for the Environment, accepted.