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Age and thermal stability of particulate organic matter fractions indicate the presence of black carbon in soil

Jens Leifeld (1), Maria Heiling (2), and Irka Hajdas (3)

(1) Climate/Air Pollution Group, Agroscope, Zurich, Switzerland (jens.leifeld@agroscope..admin.ch), (2) International Atomic Energy Agency, Vienna, Austria, (3) Laboratory of Ion Beam Physics, ETH, Zurich, Switzerland

Black carbon (BC) from incomplete combustion is abundant in many soils. The age of black carbon is often higher than that of typical soil organic carbon (SOC) owing to its higher recalcitrance against microbial decomposition compared to plant residues. Also fossil BC may contribute to the high age of SOC. At the same time, the oxidative thermal stability of BC is known to be higher than that of SOC due to its chemical and physical structure. For a meaningful application of radiocarbon as an indicator for soil carbon age and turnover, the relative contribution of BC needs to be known but BC is difficult to separate physically from soil. Here we analyze particulate organic carbon (POC) fractions from four different field sites in Europe for their thermal stability using oxidative differential scanning calorimetry (DSC) and for their radiocarbon signature. POC may be particularly sensitive to BC 'contamination' because it was gained using a combination of size and density separation. One of these sites is essentially free of measurable amounts of BC. Each of the four sites comprised between five and eight individual POC samples taken from different spots. The radiocarbon signature and the calculated POC mean residence time of samples from three out of four sites indicated the presence of very old carbon, resulting in mean residence times (MRT) of several hundreds and up to 3700 years. In contrast, MRT's of POC from the virtually BC-free site were between 50 and 100 years. Two indicators for thermal stability of the POC fractions, i) the amount of heat released at temperatures > 450 °C and ii) the amount of heat released at 500 °C (where the latter represents the peak temperature of charcoal isolated from one of the samples) correlated both significantly and non-linearly with the samples MRT, indicating that samples with high BC content are older. Hence we can conclude that for an individual site with increasing abundance of BC both the age and the thermal stability of POC fractions increase. However, only in the case of samples from one site thermal stability proved to be a reliable predictor for the generic presence of BC whereas for the other two BC containing sites the thermal signals were not significantly different to the site free of BC.