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Assessing SOC labile fractions through respiration test, density-size fractionation and thermal analysis – A comparison of methods

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Soil organic matter (SOM) is the biggest terrestrial carbon reservoir, storing 3 to 4 times more carbon than the atmosphere. However, despite its major importance for climate regulation SOM dynamics remains insufficiently understood. For instance, there is still no widely accepted method to assess SOM lability.

Soil respiration tests and particulate organic matter (POM) obtained by different fractionation schemes have been used for decades and are now considered as classical estimates of very labile and labile soil organic carbon (SOC), respectively. But the pertinence of these methods to characterize SOM turnover can be questioned. Moreover, they are very time-consuming and their reproducibility might be an issue. Alternate ways of determining the labile SOC component are thus well-needed. Thermal analyses have been used to characterize SOM among which Rock-Eval 6 (RE6) analysis of soil has shown promising results in the determination of SOM biogeochemical stability (Gregorich et al., 2015; Barré et al., 2016).

Using a large set of samples of French forest soils representing contrasted pedoclimatic conditions, including deep samples (up to 1 m depth), we compared different techniques used for SOM lability assessment. We explored whether results from soil respiration test (10-week laboratory incubations), SOM size-density fractionation and RE6 thermal analysis were comparable and how they were correlated. A set of 222 (respiration test and RE6), 103 (SOM fractionation and RE6) and 93 (respiration test, SOM fractionation and RE6) forest soils samples were respectively analyzed and compared. The comparison of the three methods (n = 93) using a principal component analysis separated samples from the surface (0–10 cm) and deep (40–80 cm) layers, highlighting a clear effect of depth on the short-term persistence of SOC. A correlation analysis demonstrated that, for these samples, the two classical methods of labile SOC determination (respiration and SOM fractionation) were only weakly positively correlated (Spearman's = 0.26, n = 93). Similarly, soil respiration had only a weak negative correlation (Spearman's = −0.24, n = 93; = −0.33, n = 222) with the RE6 parameter T50 CH pyrolysis. This parameter, previously used as an indicator of labile SOC (Gregorich et al., 2015), represents the temperature at which 50% of the OM was pyrolyzed to effluents (mainly hydrocarbons) during the pyrolysis phase of RE6. Conversely, POC content (% of total SOC) showed a higher negative correlation with T50 CH pyrolysis (= −0.66, n = 93; = −0.65, n = 103) and was positively and negatively correlated to the hydrogen index, HI (mg HC/g TOC; = 0.56/0.53) and the oxygen index, OI (mg CO_2/g TOC; = −0.63/−0.62) respectively.

Our results showed that RE6 results are consistent with respiration and fractionation results: SOC with higher respiration rate and higher POC content burns at a lower temperature. RE6 thermal analysis could therefore be viewed as a useful fast and cost effective alternative to more time-consuming methods used in SOM fractions determination.

Barré, P. et al. Biogeochemistry 2016, 1-12, 130.
Gregorich, E.G. et al. Soil Biol. Biochem. 2015, 182-191, 91.