Thermal stability of SOC does not correlate with its biological stability

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Background and Introduction

Soil organic carbon (SOC) is the largest terrestrial carbon pool. Stabilization of SOC due to interaction with the mineral phase makes it more resistant against microbial degradation hence promoting potential long-term storage of carbon. A range of thermal analysis techniques have been developed to determine the thermal stability of SOC. All methods assume a correlation between thermal and biological stability of SOC. However, the correlation is still under debate and not clear.

In this study the link between thermal and biological stability of SOC in topsoil was investigated by using thermal oxidation (**FIG. 1**) of three different soil types and natural $\delta^{13}C$ label due to C_3-C_4 vegetation change. The SOC fractionation by using thermal oxidation was compared with density fractionation for validation.

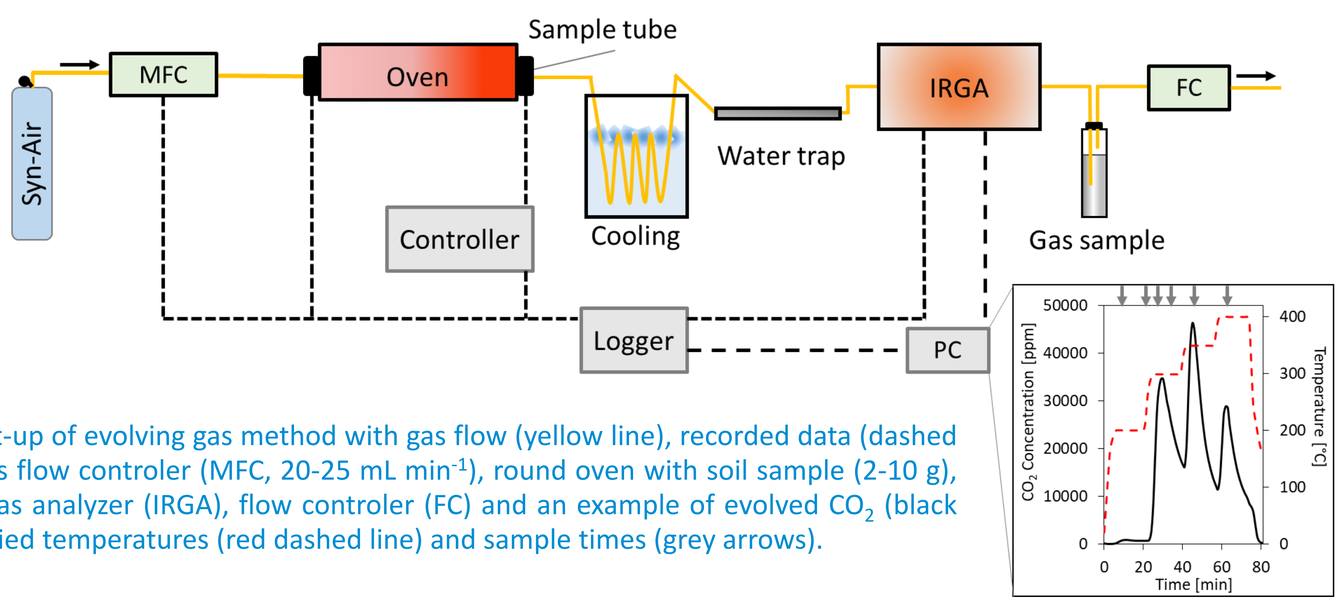

FIG. 1: Set-up of evolving gas method with gas flow (yellow line), recorded data (dashed line), mass flow controler (MFC, 20-25 mL min^{-1}), round oven with soil sample (2-10 g), infrared gas analyzer (IRGA), flow controler (FC) and an example of evolved CO_2 (black line), applied temperatures (red dashed line) and sample times (grey arrows).

Conclusions

Fractions of thermal oxidized SOC were not comparable to density fractions.

Young and labile SOC showed increased thermal stability compared to old and stabilized SOC.

Thermal oxidation is an unsuitable method to separate SOC pools of differing biological stability.

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Results and Discussion

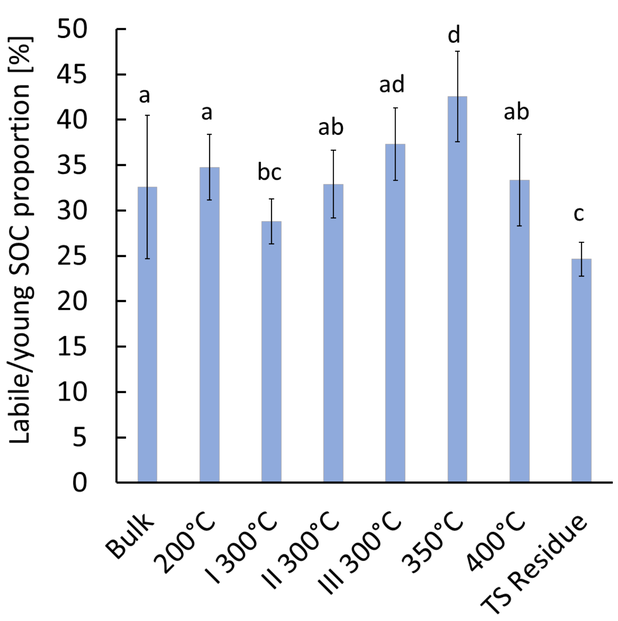

FIG. 2: Proportion of labile/young (*Miscanthus* derived) SOC [%] on total combusted SOC as a mean of three sites.

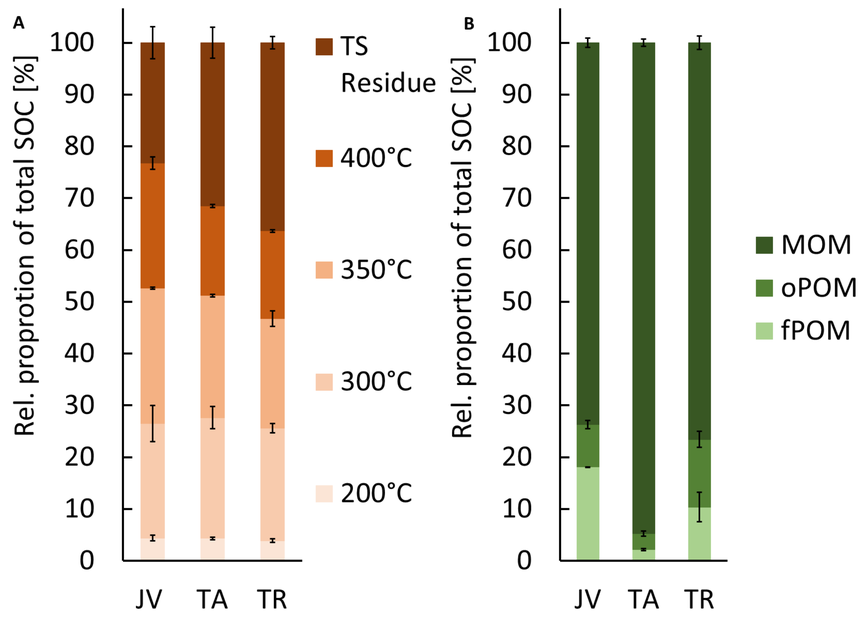

FIG. 3: Relative thermal oxidation (A) and density fractionation (B) proportion [%] of SOC from bulk soil for three sites (sand (JV), sandy loam (TR) and clayey loam (TA)).

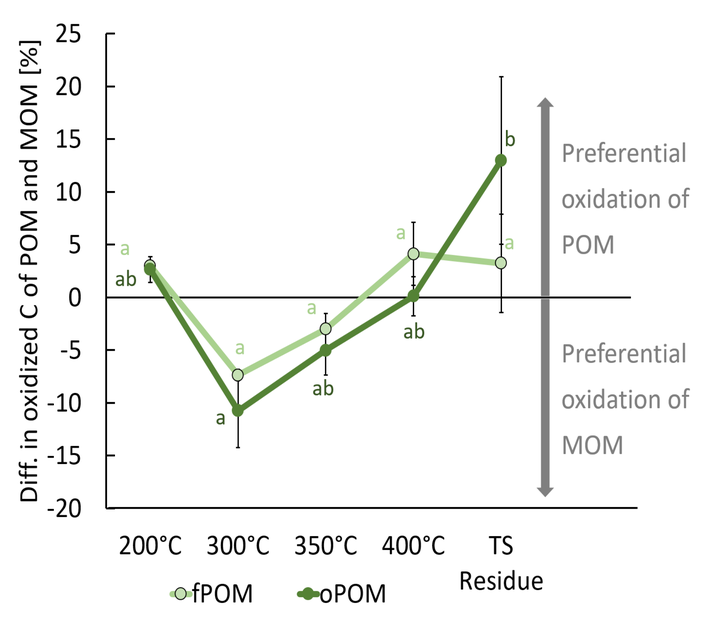

FIG. 4: Differences in oxidized carbon [%] between particulate organic matter (POM) and mineral associated organic matter (MOM) as means of three sites.

- Young and labile SOC oxidized preferentially at higher temperatures of 350°C (42.5 ± 5.0% of total SOC) rather than low temperatures (**FIG. 2**).
- The pattern of SOC fractions obtained by thermal oxidation and density fractionation did not match at all (**FIG. 3**).
- Thermal oxidation was not able to identify effects of texture on SOC stability and showed similar proportions of oxidized SOC for three diverse soils.
- In contrast to the initial assumption, the labile POM fraction was predominantly oxidized at higher temperatures compared to the stabilized MOM which oxidized at lower temperatures (**FIG. 4**).
- Thermal oxidation evidenced the fractionation of SOC component classes with distinct ^{13}C signatures.
- The stability of component classes (recalcitrance), however, is an unsuitable indicator for biological stability of SOC.

Material and Methods

- With *Miscanthus* cultivated (>17 years) sites in Europe with different texture: sand (JV), sandy loam (TR) and clayey loam (TA).
- Topsoil samples from 0-10 cm.
- Natural ^{13}C labeling to distinguished young (labile) *Miscanthus* derived SOC (C_4-plant) and older (stabilized) SOC (C_3-Plant).
- Fractionation with 15 minutes constant thermal oxidations of bulk soil and density fractions (**FIG. 5**).
- Evolved gas was sampled and analyzed for ^{13}C.
- Density fractionation with SPT (1.6 g cm^{-3}) and ultrasonic treatment (60 J mL^{-1}) to obtain MOM for validation.

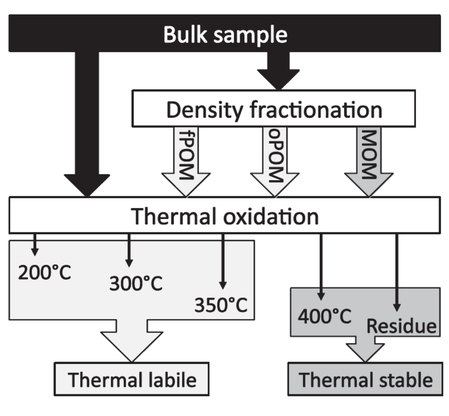

FIG. 5: Methodological approach and assumptions.