Low-temperature ashing (LTA) approach for assessing the physically protected organic matter in soil aggregates

THEME 1

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INTRODUCTION

The assessment of stabilised OM in soil aggregates is of paramount importance for implementing strategies to increase C sequestration in soil and consequently mitigate climate change. Soil organic carbon dynamics are driven not only by the intrinsic properties of the organic matter itself but also by the environmental and biological influences, which may reduce the rate of decomposition, thereby allowing the organic matter to persist for long time (Schmidt *et al*., 2011). The physical protection of C in soil aggregates is a sound parameter to describe the processes that affect directly or indirectly the sequestration of C in soil.

METHODOLOGY

The proposed approach to disentangle the role of physical protection of aggregates to SOM is based on Low-Temperature Ashing (LTA) by oxygen plasma,which enables a controlled removal of SOM from the surface of soil samples inwards without damaging the inorganic constituents or the aggregate fabric. On this basis, it is possible to obtain a dynamic of C removal from soil aggregates. Aggregates of 0.5 to 1.0 mm were allocated in the LTA reactor and exposed to different treatment times: 5h, 24h, and 48h by LTA and residual C was measured by dry combustion with a Carlo Erba NA 1500 CHNS Analyzer (Milan, Italy).

Since, no further C removal was obtained beyond 48h, this treatment, was selected as longest LTA exposition time andthe residual C assumed as "physically protected C".

Such physical protection was however proved by the fact that, after grinding the 48h LTA treated aggregates and successively subjected again to LTA, they lost almost completely their C content.

Fig. 1: Generator and matching network

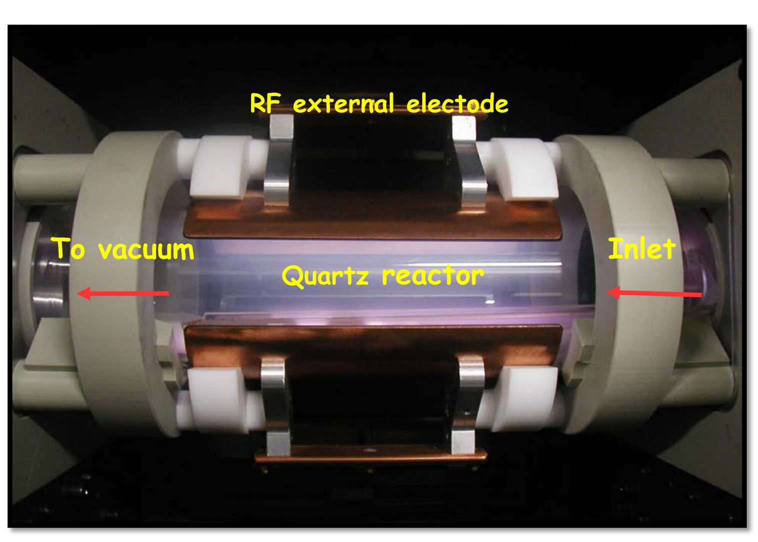


Fig. 2: Reactor. The LTA treatment was performed by a self-assembled equipment described in D'Acqui *et al.* (1999)

OBJECTIVES

The main objective of this work is revealing the possibility to measure the actual C stabilized in soil aggregates. For this purpose a reclaimed minesoil, cultivated or afforested with different species since 30 years was investigated. In particular, the studied land uses were: 1) a managed (thinned and mowed) English oak (*Quercus robur* L.) plantation; 2) a similarly managed 1:1 mixed plantation of Italian alder (*Alnus cordata* Loisel.) and English oak; 3) an unmanaged portion of the mixed plantation; 4) a cropland tilled and manured every year (D'Acqui *et al*., 2017).

MAIN RESULTS

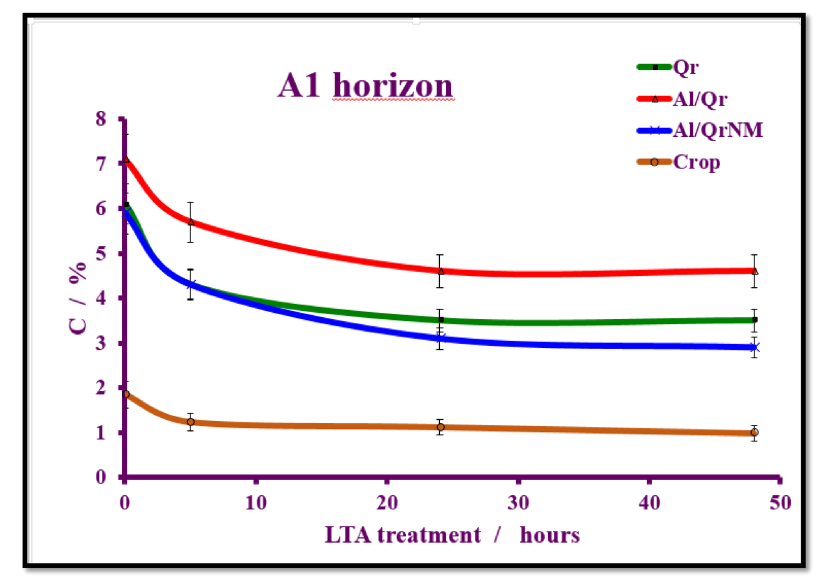
The Carbon removal from the aggregates is related to the nature and organization of soil particles that, in turn, determine the size, shape and network of pores and the exposition of organic matter at the plasma-substrate interface. The diffusion of plasma into micro-aggregates is low, similarly to gases in soil, hence its oxidative power mimics natural oxidative processes. There is a relatively rapid reduction of C in the first 5 hours of treatment (Figure 1), then the slope decreases much up to reach a "plateau" phase at around 20 h, when evidently no further C is removed. Protection within the aggregates entails the inaccessibility of soil microbes to organic compounds and a limitation in O_2 availability with the consequent reduction of bio-chemical activities. Protection within the aggregates The physically protected SOM undergoes lower rate of decomposition and longer turnover time than the rest of SOM. The significant C loss in the first 5 hours of LTA treatment (around 30%) is most probably due to the oxidation of matter located in easily accessible niches of aggregates and not closely associated with minerals. Such a SOC fraction could be assumed as the one most prone to bio-chemical decomposition processes, hence with shorter turnover time.

Tab. 1 (and Graph 1): Both show that almost half of initial C content (0h LTA treatment) of all soils was physically protected

Residual C

A1 horizon

	Qr	Al/Qr	Al/QrNM	Crop
LTA treatment	C (%)			
0 h	6.1 (±0.3)	7.1 (±0.3)	5.9 (±0.3)	1.8 (±0.2)
5 h	4.3 (±0.2)	5.7 (±0.3)	4.3 (±0.2)	1.2 (±0.1)
24 h	3.5 (±0.2)	4.6 (±0.2)	3.1 (±0.1)	1.1 (±0.1)
48 h	3.5 (±0.2)	4.6 (±0.2)	2.9 (±0.1)	1.0 (±0.1)



Graph 1: Carbon removal by LTA from 0.5-1.0 mm aggregates in the A1 horizon of afforested or 0-5 cm layer in cropped soil. Qr=managed English oak (*Quercus robur* L.) plantation, Al/Qr=managed mixed plantation of English oak and Italian alder (*Alnus cordat* Loisel.),Al/QrNM=unmanaged mixed plantation of English oak and Italian alder

CONCLUSION

The approach used in this study provided insights into the amount of "physically protected C" and confirmed that LTA technique could give an important help for the assessment of the potential of soils in sequestering C and\or of the responses of individual ecosystems to changes in land use and management. In addition, this approach could be useful for the establishment of the baseline of organic C level in different soils giving the actual amount of stabilized C in the soil.