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Organic matter stabilization in constructed soils manufactured with clay-rich waste.

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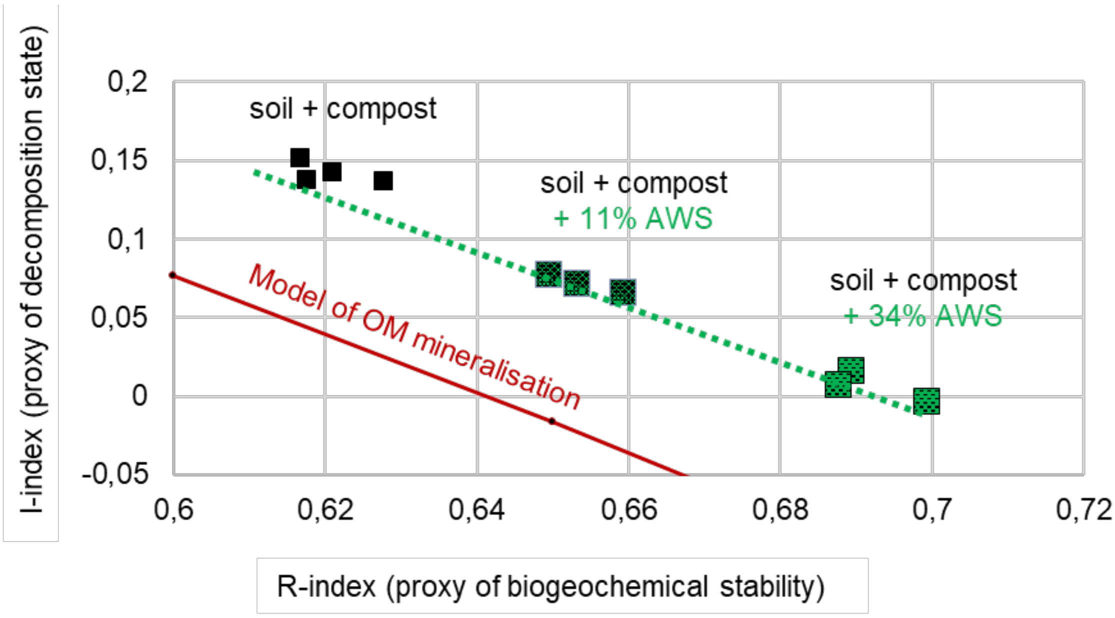
Abstract:
Soil is a fundamental and finite resource that fulfils a number of functions and services crucial to the health and well-being of the planet and all ecosystems. Humans are integral components of the global ecosystem. As climate change risks continue to intensify, it becomes imperative to thoroughly investigate the advantages of efficient soil management and the role of waste materials in enhancing soil quality within a circular economy. Soil degradation has emerged as a critical and growing global issue. One potential approach to address the erosion and depletion of topsoil involves the formulation of soils from otherwise waste materials, to restore healthy and functioning soil. These soils are referred to constructed soils and their applications include manufacture of topsoil for agriculture. Waste materials, e.g. clay-rich waste materials, can be used in constructed soils due to their capacity to enhance soil structure, soil moisture content and soil agronomic properties. Furthermore, there is a prevailing assumption that the inclusion of clay materials can protect a proportion of soil organic matter (SOM) from biogeochemical degradation.
In this study, we seek to investigate whether certain clay-rich waste materials can indeed contribute to enhancing the biogeochemical stabilization of SOM. Our research was conducted within the framework of the INTERREG project ReCon Soil at the Caté applied research station (Brittany, France). Constructed soils were formulated by mixing aggregate washing sludge (AWS) obtained from a quarry close to Caté with agricultural soil coming from Caté. They were set in ~1m^3 outdoor lysimeters. The following proportions were used: respectively 34 % and 11 % of AWS, mixed with 66 % and 89 % of agricultural soil from Caté. These mixtures were further amended with green waste compost at a rate of 30 t/ha. A control was set by using 100% of agricultural soil from Caté also amended with green waste compost at the same rate. Lettuce (little gem, cv. Alborada) were grown on these soils for 9 months (3 growing cycles). Following the final harvest, we measured soil CO_2 fluxes at the soil/atmosphere interface for each lysimeter to assess soil respiration processes in the soil. Flux measurements were obtained using the accumulation chamber method (Echo Instruments) with external recirculation. Then, topsoil (0 – 5 cm) samples were collected for performing biological, chemical and physical analysis. SOM status was assessed through ramped pyrolysis using the Rock-Eval® method. The Rock-Eval® data were treated to plot the I-index (thermal decomposition) as a function of R-index (thermal stability).
The Rock-Eval® results suggest that biogeochemical stability of SOM increases with addition of AWS (see annexed figure). These results were correlated with CO_2 flux measurements for the soil with 11% of AWS, since CO_2 emissions coming from this modality were significatively lower than the soil without any sludge. Our preliminary results enable us to conclude that AWS seems suitable to increase SOM stabilization, but these results will be confirmed by forthcoming microbiological analyses.



The I-index quantifies the relative quantity of hydrocarbons present in labile OM, while the R-index quantifies the relative quantity of hydrocarbons in both resistant and stable OM, during Rock-Eval® pyrolysis. These indices serve as proxies for assessing the decomposition state and biogeochemical stability, respectively.

Figure: Stability status of organic matter within the soil+compost+AWS mixtures after 9 months of lettuce cultivation