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The SOC:clay ratio – a measure of the organic carbon saturation of soil indicative of its potential structural stability

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The soil organic carbon:clay (SOC:clay) ratio is more and more considered as a key indicator for the monitoring and management of agricultural soil quality. It has the advantages to: (i) provide a measure of the organic carbon saturation of soil and (ii) be closely related to soil structural quality. Accordingly, the SOC:clay ratio has been proposed as an indicator for the monitoring of soil organic matter loss in the *Proposal for a directive on soil monitoring and resilience* of the European Union[1] and for the implementation of a new agri-environment-climate measure (AECM) of the common agricultural policy (CAP) 2023-2027 in Wallonia, Belgium[2].

In this work, we aimed to assess how the SOC:clay ratio relates to: (i) SOC stocks; and (ii) soil structural stability of agricultural soils of central Belgium subject to various soil management practices. To meet this goal, we collected the soil of 42 agricultural plots with contrasting farming practices in four long-term field experiments (LTEs) of the agricultural domain of the Walloon Agricultural Research Centre, in the loess belt of Belgium. LTEs include arable crop and market gardening systems with a diversity of soil management practices regarding crop rotation, tillage, organic inputs, fertilization, and intercropping cover. The soil of each plot was sampled up to 1 m for five fixed depths (0-10, 10-25, 25-50, 50-75, and 75-100 cm) with gouge augers of known diameter to calculate SOC stocks by the equivalent soil mass method. SOC content was measured by dry combustion with a correction for inorganic C when necessary. Clay content was determined by sieving and sedimentation, according to Stokes law (norm NF-X31-107:2003). For the measurement of soil structural stability, structured topsoil samples of about 100 cm^3 were collected with Kopecky cylinders at a depth of 1-6 cm. Soil structural stability was estimated by the QuantiSlakeTest (QST) method[3], consisting in the dynamic weighting of soil under water and a quantitative interpretation of the resulting curve.

Total (14000 t/ha, corresponding to approximately 0-100 cm) SOC stock ranged from 54.9 to 117.8 t/ha, with the topsoil (2700 t/ha, corresponding to approximately 0-25 cm) contributing from 37 to 74 % of total SOC. SOC stocks appeared to be mainly related to the cropping history of the plot and to organic inputs. Topsoil SOC:clay ratio ranged from 0.047 to 0.168 and correlated strongly with total SOC stock (r=0.76). Nevertheless, this correlation was smaller than that between topsoil and total SOC stock (r=0.91), despite the small range of clay content at the scale of our dataset. This result underpins that the SOC:clay ratio provides a measure of the carbon saturation of soil with no straightforward link with the absolute SOC stock.

[1] https://environment.ec.europa.eu/publications/proposal-directive-soil-monitoring-and-resilience_en
[2] https://agriculture.wallonie.be/home/aides/pac-2023-2027-description-des-interventions/mesures-agro-environnementales-et-climatiques/maec-sol-a-partir-de-2024.html
[3] https://doi.org/10.5194/egusphere-2022-1092

Soil structural stability related mainly to tillage and soil cover. Overall, the SOC:Clay ratio correlated poorly ($r < 0.36$) with soil structural stability, regardless of the indicator calculated from the QST curves. This result contrasts with the strong correlation ($r = 0.93$) obtained for standardized conditions of soil preparation (rotary harrow + seed drill) and cover (winter wheat) in a previous campaign in 2019. This underlines that the SOC:clay ratio is an indicator of the "potential" structural stability of soil, whereas the expression of soil structural stability also depends on external factors such as tillage and crop development.