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Assessment of nitrogen and organic carbon stocks in agricultural soils: uncertainties and significance of temporal evolution

Lucas Tabaud, Christian Walter, Clotilde Blancfene, Chantal Gascuel, Blandine Lemercier, Didier Michot, and Pascal Pichelin
UMR SAS, INRAE, Institut Agro, Rennes, France

Soils are crossroads of carbon and nitrogen geochemical cycles and were consequently identified as a potential sink for carbon (C) and a compartment storage for nitrogen (N). Monitoring the joint evolution over time of organic C and total N stocks in soils appears interesting because of the C/N ratio is an indicator of changes in the organic matter quality. Nevertheless, the temporal evolutions detected in most of the existing studies are in the order of a few $gC.m^{-2}.yr^{-1}$ (C) and $mgN.m^{-2}.yr^{-1}$ (N). This study aims to assess uncertainties of soil organic carbon (SSOC) and soil total nitrogen (SSTN) stocks in the topsoil layer (0-25 cm) using three different methods (stochastic, deterministic and experimental), in order to identify the main sources of uncertainty and to evaluate the significance of SSOC and SSTN evolutions over the time. This study was based on a 1200 ha agricultural catchment area in Brittany (France) where systematic soil sampling was repeated at 108 sites in 2013 and 2018. Moreover, soil sampling was repeated three times in 2020 at the same sites by 3 different teams of experienced samplers. Comparing the three methods of uncertainty assessment, we found they provided equivalent results with a SSOC standard deviation of 0.85, 0.74 and 0.68 $kgC.m^{-2}$ respectively for stochastic, deterministic and experimental approaches and 0.08, 0.07 and 0.06 $kgN.m^{-2}$ for SSTN. Variance decomposition identified variations of fine earth mass as the main source of uncertainty (77 % of total variance) and attributed at least 16% of the uncertainties due to the operator procedure and were therefore reducible. Using the stochastic approach, the width of the 90 % confidence interval was estimated at each sampling site for C, N and C/N temporal changes. Changes were considered significant at respectively 59, 77 et 99 sites for SSOC, SSTN and C/N: a majority of sites lost organic carbon (-0.03 ± 0.07 $kgC.m^{-2}.yr^{-1}$), gained total nitrogen (0.006 ± 0.005 $kgN.m^{-2}.yr^{-1}$) and the $C.N^{-1}$ (-0.17 ± 0.09 yr^{-1}) ratio decreased. Finally, stock measurements uncertainty was mainly explained by soil natural variability but may still be reduced by a better control of the measurement procedure. In the agricultural context of the study area, the accuracy of the direct measurement appeared sufficient to detect SSOC and SSTN evolution over a time span of 5 years.