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Prediction of SOC and SOC fractions using Vis-NIR spectroscopy. A comparison of devices for spectra recording

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Visible and Near-Infrared Reflectance Spectroscopy (Vis-NIRS) is a fast, economical, and destruction-free alternative method for analyzing soil properties. Our objectives were: (i) to compare the accuracy of two different spectra recording devices used with prediction models of soil organic carbon (SOC); and (ii) to explore the suitability of Vis-NIRS technology for rapid measurement of different SOC fractions (unprotected, physically, chemically and biochemically protected). 266 soil samples were taken at different depth from two dehesa farms with different land use. The soil samples were dried at 40 °C and passed through a 2-mm sieve. Soil reflectance spectra were measured with LabSpec 5000 spectrophotometer (Analytical Spectral Devices, Inc., Boulder, CO, USA) with a spectral range 350 to 2500 nm. The spectral resolution was 3 nm for the range 350-1000 nm and 10 nm for 1000-2500 nm. Spectra were recorded with: (i) a low-intensity contact probe; and (ii) a muglight accessory with a circular tray adapter. Each sample was measured four times and averaged to generate a representative spectral signature of each soil sample. SOC concentration was determined by Walkley & Black method. SOC fractions were analyzed in a set of 32 samples, following Six et al., (2002) method. Spectral data were preprocessed and calibrated against SOC (216 dataset) and each SOC fraction (32 dataset) using a modified partial least-squares regression model (PLSR-m). The accuracy of the prediction models was verified by cross-validation and, for SOC models, by external validation (50 dataset), using the coefficient of determination (R2), the root mean squared error (RMSE), the residual predictive deviation (RPD) and range error ratio (RER). Concerning cross-validation, the accuracy of SOC models was excellent. R2 and RPD were always higher than 0.95 and 4, respectively. In addition, RER reached values higher than 20. External validation provided more conservative accuracy metrics. Although RPD indexes were above 2.5, indicating excellent predictions, muglight model performed slightly better than contact probe model due to lower RMSE (0.222 vs 0.244) and higher R2 (0.90 vs 0.89). The accuracy of models for predicting some SOC fractions was remarkable, especially when the contact probe was used for recording spectra. Thus, unprotected SOC (g C unprotected/ g soil) model was moderately successful (R2=0.83, RPD=2.4 and RER=9.5). In addition, the accuracy of models for predicting SOC in soil fraction was excellent (R2=0.972, RPD=5.9, RER=24.1, chemically protected; R2 =0.954, RPD=4.6, RER=17.8, physically protected fraction), expressed (g C/g soil fraction). Based on our statistical comparison, SOC could be predicted accurately using the contact probe, which reduces the time needed to record the spectrum of a sample. In spite of the small size of our dataset, some SOC fractions could be measured with different degrees of accuracy using Vis-NIRS. The models' accuracy and robustness may be improved by adding samples of similar soil from other areas to the calibration dataset.

Reference

Six, J., Conant, R. T., Paul, E. a, & Paustian, K. (2002). Stabilization mechanisms of soil organic matter: Implications for C-saturatin of soils. Plant and Soil, 241, 155–176. https://doi.org/10.1023/A:1016125726789