On Quantifying Active Soil Carbon using Mid-Infrared Spectroscopy

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ABSTRACT

Soil organic matter (SOM) is derived from plant or animal residues deposited to soil and is in various stages of decomposition and mineralization. Total SOM is a common measure of soil quality, although due to its heterogeneous composition SOM can vary dramatically in terms of its biochemical properties and residence times, which ultimately affect soil heath and function. One operationally defined SOM fraction is “active soil carbon” (ASC) which is thought to consist of readily oxidizable SOM that is responsive to management practices and may provide one measure of “soil health” closely associated with soil biological activity. ASC can be a useful indicator to assist farmers and land managers in their selection of soil management practices to maintain ASC or to build total SOM. ASC has generally been measured using permanganate oxidation, a costly and time-intensive procedure. Chemometric modeling using mid-infrared spectroscopy (MIR) has been successfully used to estimate a range of soil properties, including total organic carbon (TOC) and particulate organic carbon (POC). Consequently, we hypothesized that we could use MIR to estimate ASC. Here we report on a method that uses MIR and chemometric signal processing to quantify TOC and ASC on a variety of soils collected serially and seasonally from a maximum of 76 locations across the United States. TOC was measured using high temperature oxidation and ASC was measured as permanganate-oxidizable carbon. These data were used to calibrate and validate MIR-based partial least squares (PLS) regression models that were used to estimate TOC and ASC using MIR alone. Signal processing included 1st or 2nd derivatives of the spectra with various gaps in the data and continuum removal. We used a goodness of fit statistic (R^2) and the lowest root mean square error of prediction (RMSEP) to select the most robust models. The best predictive model for TOC was built on spectral data following continuum removal with 9 components, and had an R^2 of 0.95 and RMSEP of 0.18. For ASC, the model was built on a 1st derivative of the spectral data with a gap of 8, and had an R^2 of 0.86 and RMSEP of 0.22. We conclude that ASC can be reasonably estimated with MIR. When combined simultaneously to estimate ASC and other soil properties (e.g., TOC, POC), MIR becomes a cost effective means of characterizing large numbers of samples and could easily provide repeatable measures of the status and condition of soil carbon due to land management practices. Our presentation will describe the details of developing these models and the utility of ASC as one metric for quantifying “soil health”.