Rapid Quantification of Soil Organic Carbon via Photocatalytic Kinetics

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Abstract:

Sequestering carbon as total organic carbon (TOC) in soil is seen as one way to mitigate climate change by reducing atmospheric carbon dioxide [1]. The primary goal of this research is to develop a protocol to rapidly measure TOC in soils via photocatalytic reaction kinetics. The developed protocol will be integrated into MANTECH's existing PeCOD analyzer to carry out rapid and informative soil TOC analysis. This technology is envisioned to enable farmers to adopt agricultural practices that increase TOC in soils for climate mitigation purpose more reliably, as ease and speed of analysis can enable more comprehensive field testing with greater areal and temporal accuracies.

The measurement of soil organic carbon (OC) fractions is currently carried out using techniques such as Walkley-Black method, dry combustion, heated persulfate, mid-infrared spectroscopy, etc. However, these analytical methods are either time consuming, technically demanding, costly, or employ toxic chemicals, which limits their applicability for large-scale and long-term soil carbon accounting. In this study, organic matter was extracted from several soil samples (of varying organic matter content) using low-frequency sonication and optimized aqueous media. Extractants were tested in the PeCOD, wherein the photocatalytic oxidation of OC generates electrical current proportional to the rate and extent of reaction. Calibration with standards and data analysis of the behaviour of the photocatalytic reaction enabled accurate (i.e., reproducible) and precise (i.e., comparable to conventional method) quantification of TOC levels in soils. The kinetics data from the photocatalytic reaction with the PeCOD sensor also shows that each soil sample with varying carbon levels have unique curve characteristics, allowing for potential differentiation of type of OC in these soil samples (e.g., labile vs. humus vs. recalcitrant).

The technology may be used to indicate the levels of TOC in soil, and potentially gauge its stability, in a fast and environmentally conscious manner. More research can be explored within this realm to further develop the precision of the TOC and carbon stability measurements.

References

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. Geoderma, 123(1-2), 1-22.