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A Novel Method to Quantify Soil Aggregate Stability by Measuring Aggregate Bond Energies

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Soil aggregate stability is a key indicator of soil quality because it controls physical, biological and chemical functions important in cultivated soils. Micro-aggregates are responsible for the long term sequestration of carbon in soil, therefore determine soils role in the carbon cycle. It is thus vital that techniques to measure aggregate stability are accurate, consistent and reliable, in order to appropriately manage and monitor soil quality, and to develop our understanding and estimates of soil as a carbon store to appropriately incorporate in carbon cycle models.

Practices used to assess the stability of aggregates vary in sample preparation, operational technique and unit of results. They use proxies and lack quantification. Conflicting results are therefore drawn between projects that do not provide methodological or resultant comparability. Typical modern stability tests suspend aggregates in water and monitor fragmentation upon exposure to an un-quantified amount of ultrasonic energy, utilising a laser granulometer to measure the change in mean weight diameter.

In this project a novel approach has been developed based on that of Zhu et al., (2009), to accurately quantify the stability of aggregates by specifically measuring their bond energies. The bond energies are measured operating a combination of calorimetry and a high powered ultrasonic probe, with computable output function. Temperature change during sonication is monitored by an array of probes which enables calculation of the energy spent heating the system (P_h). Our novel technique suspends aggregates in heavy liquid lithium heteropolytungstate, as opposed to water, to avoid exposing aggregates to an immeasurable disruptive energy source, due to cavitation, collisions and clay swelling. Mean weight diameter is measured by a laser granulometer to monitor aggregate breakdown after successive periods of calculated ultrasonic energy input (P_i), until complete dispersion is achieved and bond energy (P_b; input energy used in aggregate breakdown) can be calculated by the following equation:

$$\Sigma P_i - P_h = P_b$$

The novel technique was tested by comparing the bond energies measured from a series of soil aggregates sampled from different land management histories, to the samples corresponding stability measurement obtained from standard modern stability tests. The effectiveness of the heavy liquid as a suspension (as opposed to water) was evaluated by comparing the bond energies of samples measured in both suspensions. Our results determine i) how disruptive water is in aggregate stability tests, ii) how accurate and representative standard aggregate stability tests are, and iii) how bond strength varies depending on land use.

Keywords: Aggregate; Bond; Fragmentation; Soil; Sonication; Stability

References:

Zhu, Z. L., Minasny, B. & Field D. J. 2009. Measurement of aggregate bond energy using ultrasonic dispersion. European Journal of Soil Science, 60, 695-705