A preliminary investigation into the reliability of soil carbon analytical techniques.

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Introduction

The accurate estimation of soil carbon is essential to land management recommendations and policy realisation for climate change abatement and Net Zero. The measurement of soil carbon relies on techniques that are of uncertain reliability but nevertheless provide the basis for carbon-related farming subsidies and carbon calculations. If carbon analysis can be performed accurately, effective soil management has the potential for significant carbon sequestration and could potentially open a resource stream to help land managers move to sustainable practice.

Methods

We conducted a series of simple experiments to examine the recovery rates of spiked materials using two important standard techniques for solid soil analysis: loss-on-ignition (LOI) following BS EN 15935:2021 and combustion catalytic oxidation with NDIR detection via a TOC Analyser (Shimadzu, UK). Carbon was removed from samples of standard loamy clay soil, vermiculite and horticultural sand by incineration and were subsequently spiked with organic compounds naturally occurring within soil organic matter (SOM) with different structural properties; glucose, stearic acid, glycine, humic acid and cellulose. These compounds represented major organic chemical groups found in soil organic matter (SOM) and were added to the solid substrates at concentrations of 1-6% carbon (w/w). LOI and TOC analyses were performed simultaneously and the corresponding carbon recovery of these compounds calculated using standard methods.

Results

A

B

C

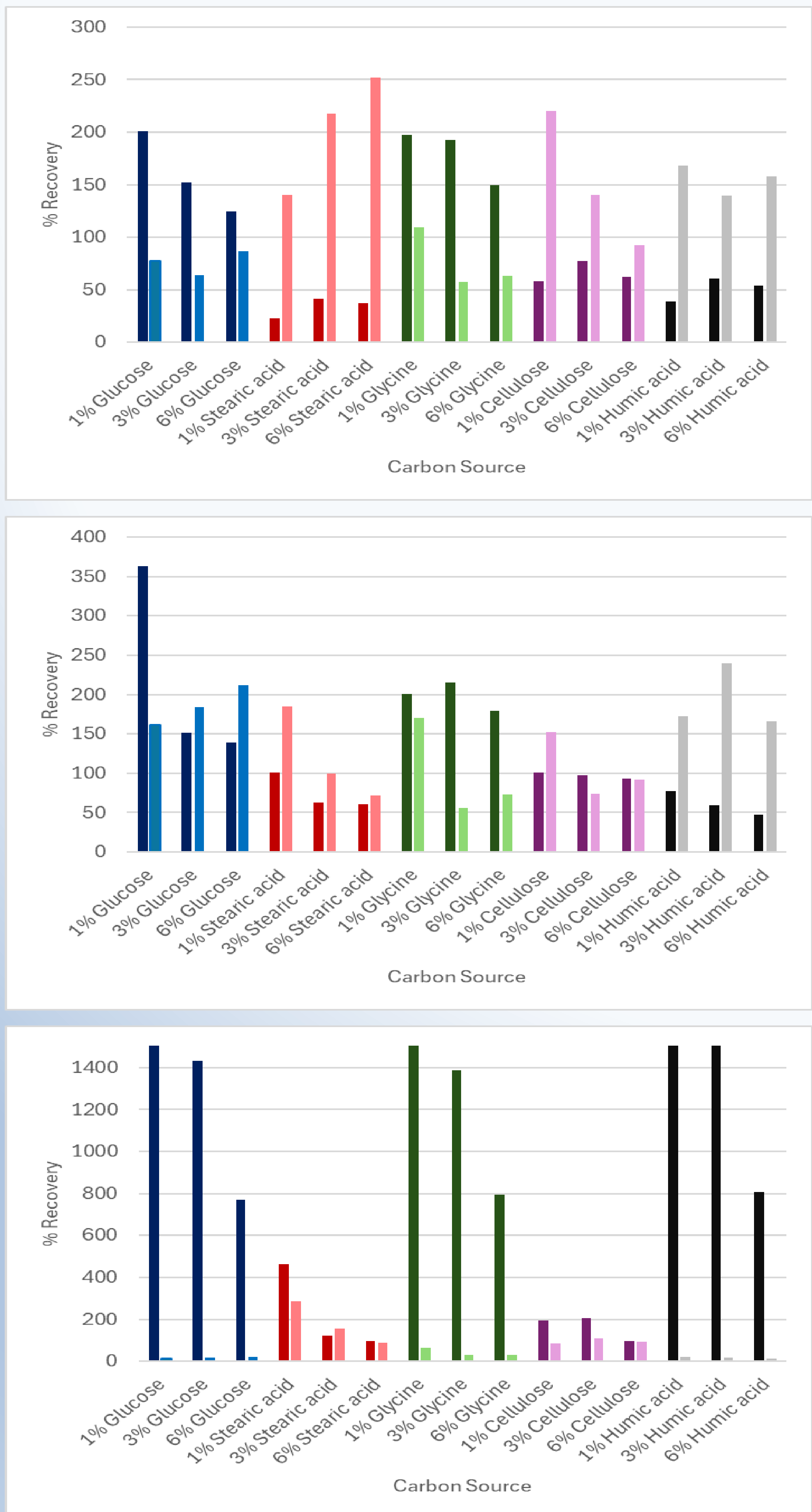

Fig 1. Mean percentage recoveries using LOI (dark bars) and TOC (light bars) for (**A**) clay loam soil, (**B**) sand, and (**C**) vermiculate.

Figure 1 shows the recoveries of the compounds demonstrated that both techniques revealed significant errors in estimating the percentage carbon (%C) of the spiked material. LOI generally overestimated %C from glycine and glucose added to all materials and from all compounds added to vermiculite (Fig. 1C). The extent of the overestimation was inconsistent and between 125% and 1400%. LOI tended to increasingly overestimate at low concentrations of the individual compounds and the overestimation was not related to the complexity or resilience of the structure of the compounds present.

TOC overestimated %C in more specific circumstances: humic acid in loamy clay soil (Fig. 1A) and sand, glucose in sand (Fig. 1B), and stearic acid in loamy clay soil and vermiculite (Figs 1A and 1C). However, the extent of the overestimation by TOC was more limited than LOI at a maximum of 250% at low concentrations and generally within 150% at medium or high concentrations. The TOC method tended to underestimate compounds in the vermiculite except stearic acid, contrary to the results from LOI. TOC also underestimated %C from the more complex organic compounds in the loamy-clay soil and sand. As with LOI, TOC recoveries appeared to be unrelated to compound type, but contrary to LOI, the recoveries appeared more consistent across concentrations

The results demonstrate the urgent need to critically evaluate methods used for routine soil carbon analysis for soil health monitoring. SOM or %C is the benchmark for soil monitoring and further evaluation and method development is required to ensure reliability and accuracy to inform effective land management and confidence in engagement with soil-related climate change abatement measures.