A New Approach for Estimating Organic Carbon Oxidation State (Cox) and Oxidative Ratio (OR) in soils and sediments

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Abstract

We present a new approach in the measurement of two interconnected variables useful in the study of organic carbon (OC) storage and decomposition: OC oxidation state (Cox) and oxidative ratio (OR). OR is a measure of mols CO2 released/mols O2 consumed when a pool of OC decomposes. Although Cox and OR are proportional, we work with both terms because each is useful in different contexts: Cox can be related directly to the chemical composition of OC, while OR is critical in C cycle studies that partition land and ocean C sinks (Keeling et al, 1996).

Equations

Cox is a function of molar concentrations. For CxH2OxNw:

(1) Cox = \frac{2x - y + 3w}{x}

Cox values of many natural compounds stay close to zero

CH4 + \text{lignin} + \text{sugars} + \text{amino acids} \rightarrow \text{CO2} + \text{lipids}

Cox is also a function of the energy stored in the ecosystem.

Cox = 4 \times \frac{1.6}{[\mathrm{C}_{\text{mantle}}]} (0.06968 \Delta H - 0.065)

This can be derived from eqn (1) and Williams et al., 1987.

First look at results

Corn litter buried in agricultural soil becomes slightly more oxidized as it decomposes, due to initial preferential loss of carbohydrates (stable by 306 days). This is followed by fluctuation in the relative amounts of lipid, lignin, and protein.

Modeled composition of 0-5 cm (A horizon) Australian Haplustoll

<table>
<thead>
<tr>
<th>Carbohydrate</th>
<th>Protein</th>
<th>Lignin</th>
<th>Lipid</th>
<th>Carbyl</th>
<th>Char</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.3</td>
<td>28.9</td>
<td>19.8</td>
<td>19.1</td>
<td>1.3</td>
<td>2.5</td>
</tr>
</tbody>
</table>

In contrast to terrestrial material, as marine material decomposes, it becomes more oxidized. In these organic matter samples taken from equatorial Pacific sinking particle traps, molecular modeling suggests that, as organic matter is processed, the relative proportion of carbohydrate increases, while lipid and protein decreases.

Conclusions

Cox and OR are two tracers that can be used to link soil carbon cycling to ecosystem energy storage and trace gas emissions; soil OC becomes more reduced as it decomposes, possibly due to enrichment in microbial materials; because soil OC becomes more reduced, there may be an offset between the OR of soil respiration and the OR of carbon accumulated over decades/centuries; marine organic Cox values suggest different decomposition processes in oceanic samples.