CarbonZero®
Biochar Production Technology

A Novel Biochar Production Technology

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Mission?

Realize biochar's ideals at scale

General plan of action

- Thermally decompose biomass - heat it up to break it apart into smaller molecular components
- Develop multiple potential products to maximise financial viability from those smaller components
- Increase soil fertility and organic carbon content
- Be sustainable agriculturally & environmentally (prevent leeching, recycle carbon, etc)

Biochar's soil fertility claims*

- Primary:
  - Biochar increases cation-exchange capacity
- Secondary:
  - Moderates soil acidity (*lime is much less costly*)
  - Increases water retention (*marginal, dependent on soil type*)
  - Increases number of beneficial soil microbes (*inoculated char too expensive in almost all crop contexts, soil microbe numbers increase when and where they have a preferred "food" available, and these may or may not be beneficial*)
  - Improves soil structure (*marginal, dependent on soil type, perlite is much cheaper*)

* through the lens of affordability

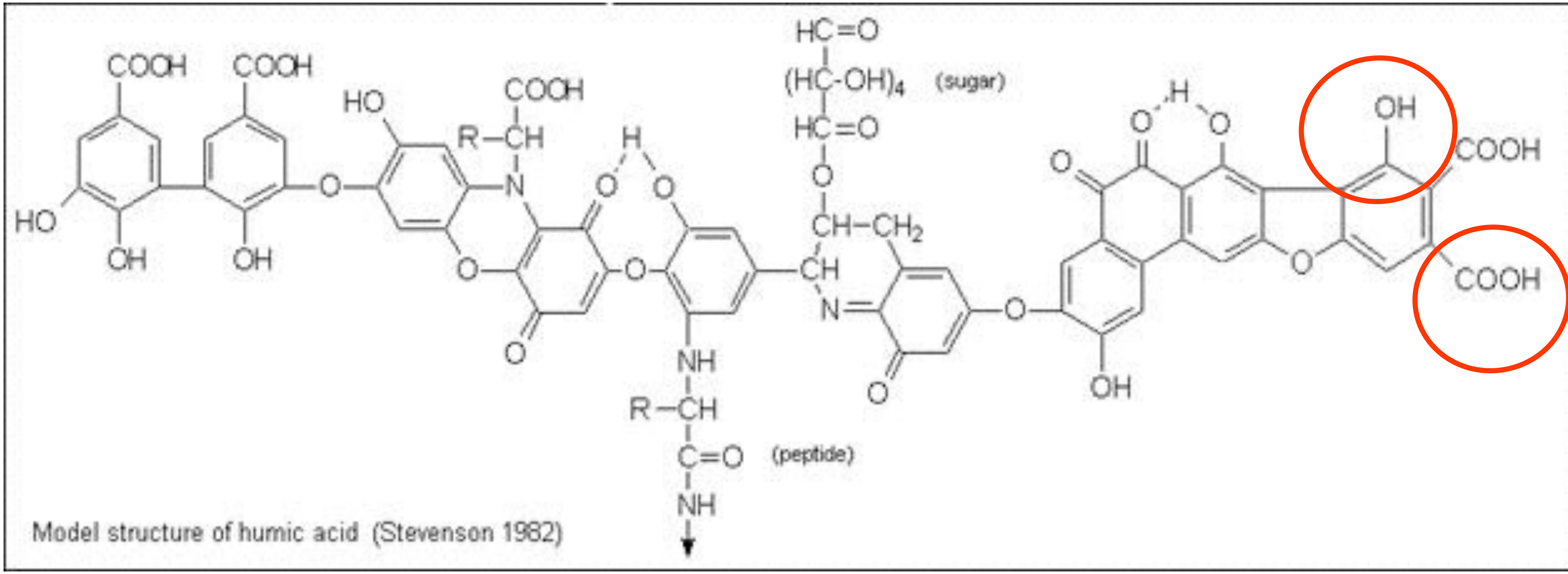
Cation exchange capacity

- Cation-exchange capacity (CEC) is a measure of how many cations (positively charged plant nutrients) can be retained on negatively charged soil particle surfaces in plant-available form.

- Measured in milliequivalents per 100 g of soil, which is 6.023×10^{23} (one mole) of atomic charges (an "equivalent") divided by 1000.

- 602,300,000,000,000,000,000,000 : one mole

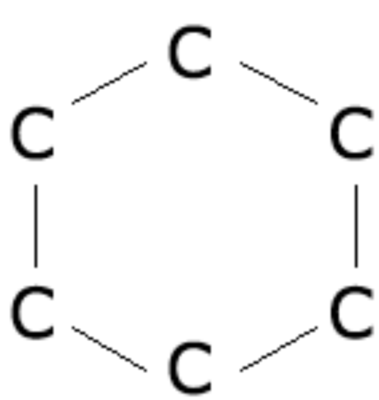
- 602,300,000,000,000,000,000 : one milliequivalent



Model structure of humic acid (Stevenson 1982)

Humic acid *model* - endless variety, like snowflakes

Aromatic rings

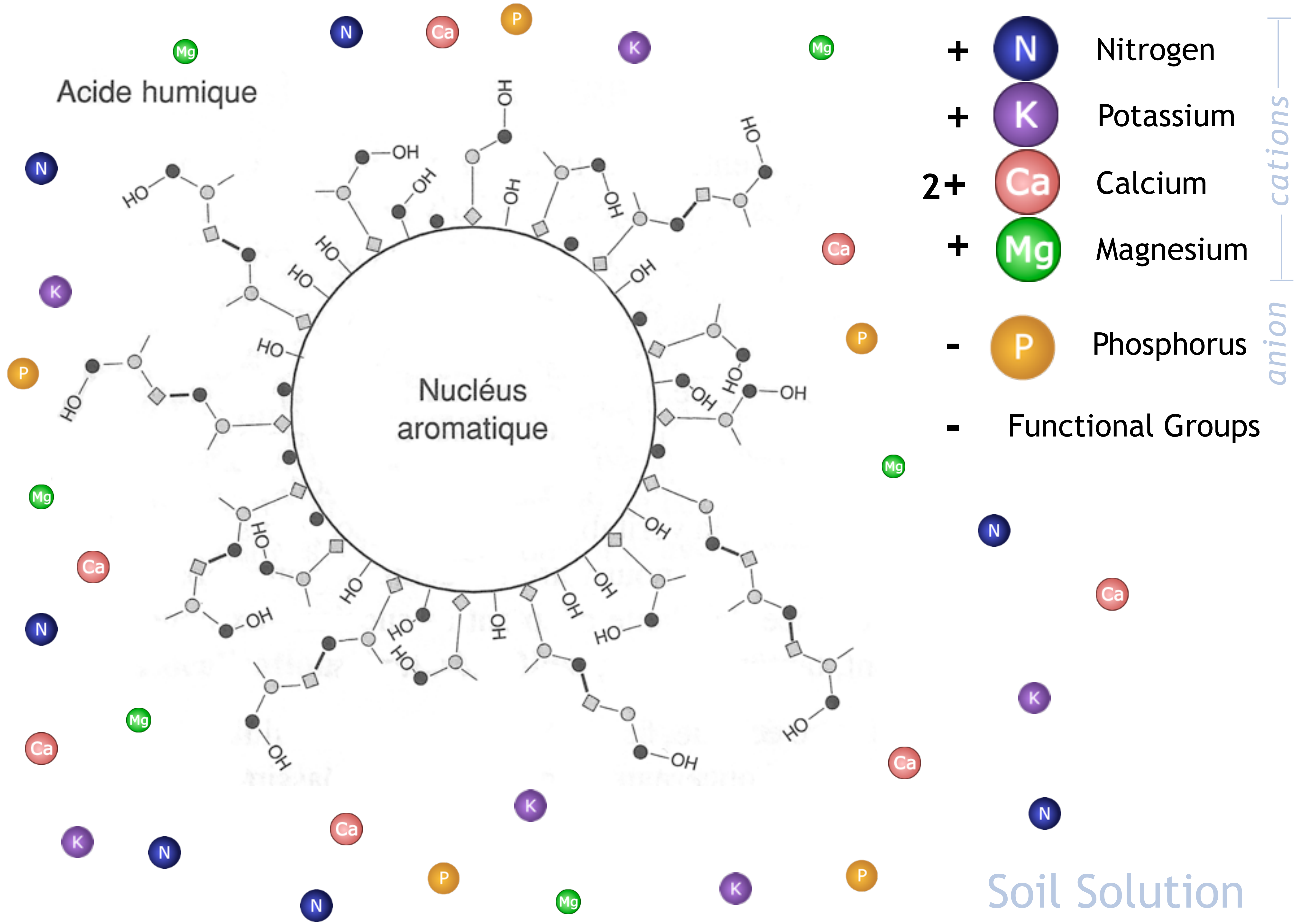


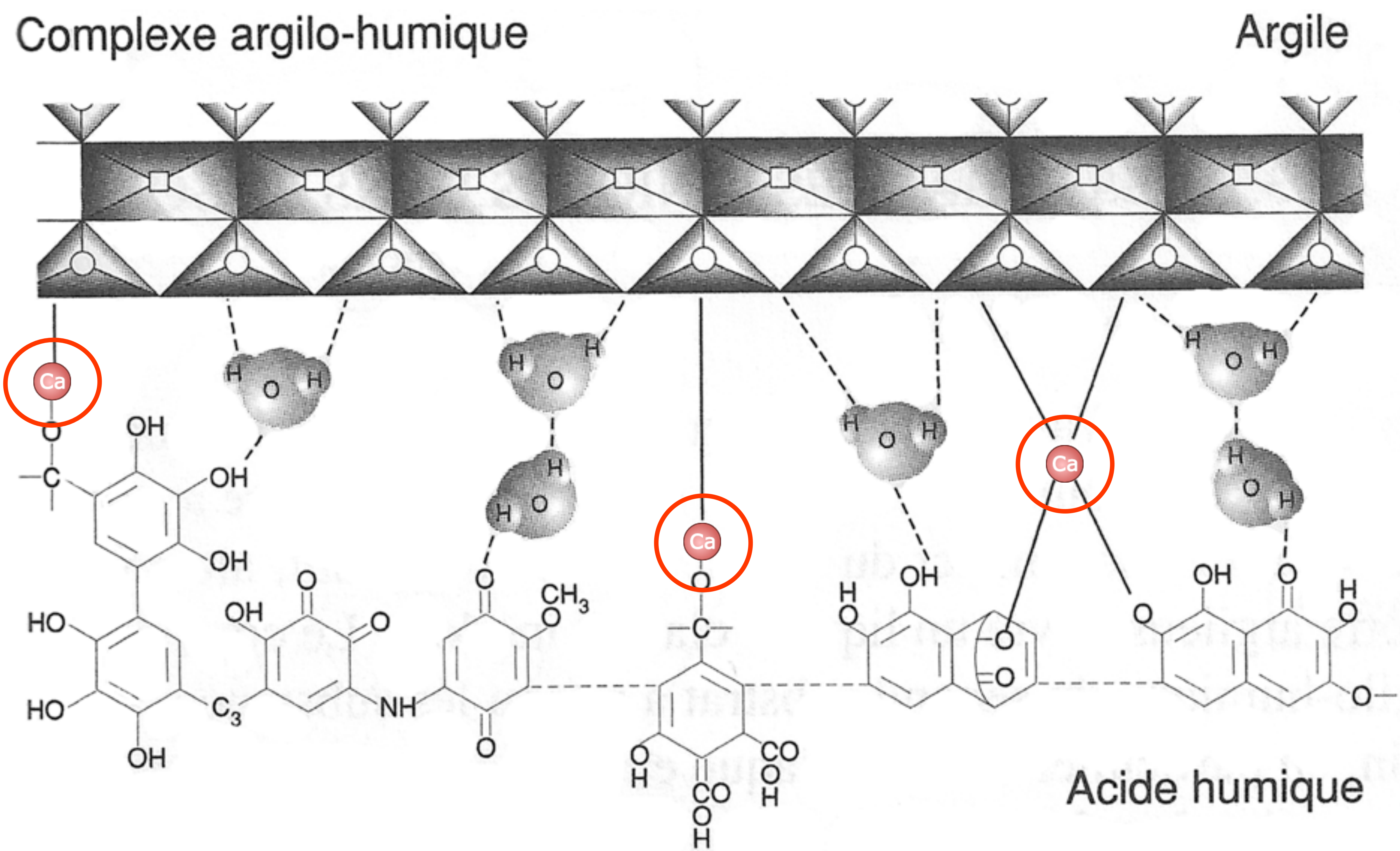
Functional groups

Negatively charged

OH - Hydroxyl group
COOH - Carboxyl group

Plants compose these molecular structures mainly from H^2O and CO^2. Similar structures are seen in all decomposition products of biomass, including biochar.


Acide humique
Nucléus aromatique
+ N Nitrogen
+ K Potassium
2+ Ca Calcium
+ Mg Magnesium
cations
- P Phosphorus
anion
- Functional Groups
Soil Solution



Cation bridge, typically Ca++ or Fe++

Clay Humic Complex - increases long term stability of humics in soil as well as CEC

Plant root response to OH functional groups

- Increased root growth in the presence of very slight negative charges of OH functional groups in soil, and they grow towards these areas.

- The stronger the charge, the more vigorously the roots grow toward it. Plants are able to sense that's where they can obtain nutrients.

- For cation exchange capacity, it's the functional groups that are essential, not the biochar that acts as the supporting molecular structure.

PERSPECTIVE

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Persistence of soil organic matter as an ecosystem property

Michael W. I. Schmidt[1]*, Margaret S. Torn[2,3]*, Samuel Abiven[1], Thorsten Dittmar[4,5], Georg Guggenberger[6], Ivan A. Janssens[7], Markus Kleber[8], Ingrid Kögel-Knabner[9], Johannes Lehmann[10], David A. C. Manning[11], Paolo Nannipieri[12], Daniel P. Rasse[13], Steve Weiner[14] & Susan E. Trumbore[15]

Globally, soil organic matter (SOM) contains more than three times as much carbon as either the atmosphere or terrestrial vegetation. Yet it remains largely unknown why some SOM persists for millennia whereas other SOM decomposes readily—and this limits our ability to predict how soils will respond to climate change. Recent analytical and experimental advances have demonstrated that molecular structure alone does not control SOM stability: in fact, environmental and biological controls predominate. Here we propose ways to include this understanding in a new generation of experiments and soil carbon models, thereby improving predictions of the SOM response to global warming.

http://www.css.cornell.edu/faculty/lehmann/publications/index.html

When organic matter is thermodynamically unstable*, why does it persist in soils, sometimes for thousands of years?

–Michael Schmidt et al

* = it rots very easily, transformed into gases

Persistence of soil organic matter as an ecosystem property points:

- The persistence of soil organic matter is not primarily because of its molecular structure, but due to physical, chemical and biological influences from the surrounding environment that reduce the rate of decomposition.

- Char has been observed to decompose faster than other types of organic matter in the same soil in some experiments.

- Physical protection and interactions with soil minerals play a significant part in char stability over long periods of time [as in *terra preta* soils].