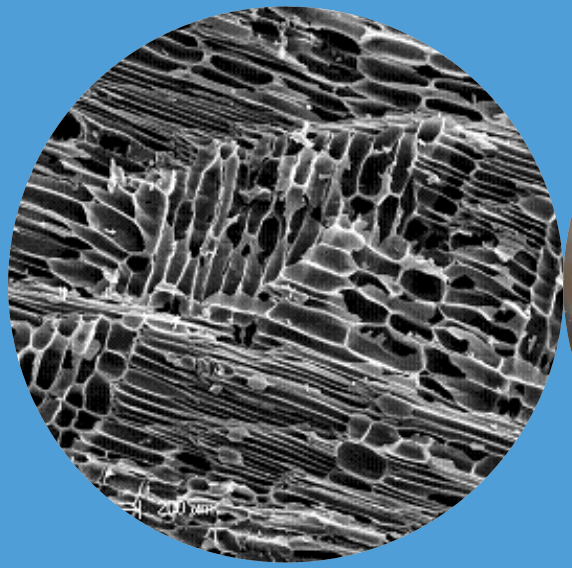
Key Functions of Biochar in Soil

Biochar: can it replace Soil Organic Matter?

Kor Zwart

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region
European Union The European Regional Development Fund
KB-13-005-008



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Studievoormiddag Biochar Waar staan we nu, ILVO, 17-12-2013

Alterra Introduction

- Wageningen UR
  - University
  - 6 Research Institutes
  - Alterra:
    - Soil, Water & Climate, Ecology, Landscape
    - Ca. 500 staff
    - Project Organisation
    - 50-60 Million €/year
- Team: Sustainable Soil Management

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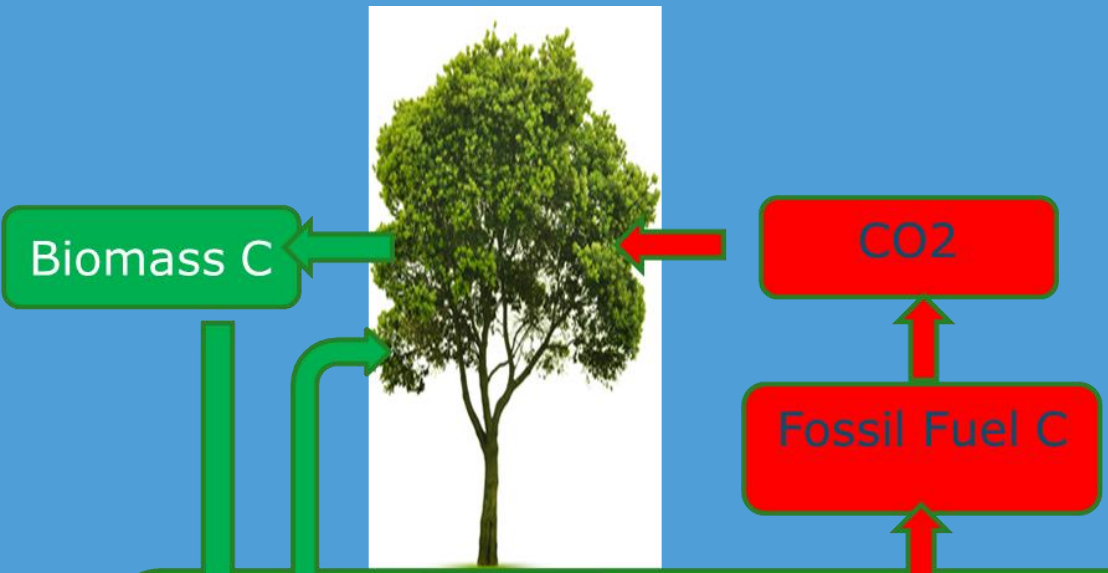
Kor Zwart Introduction

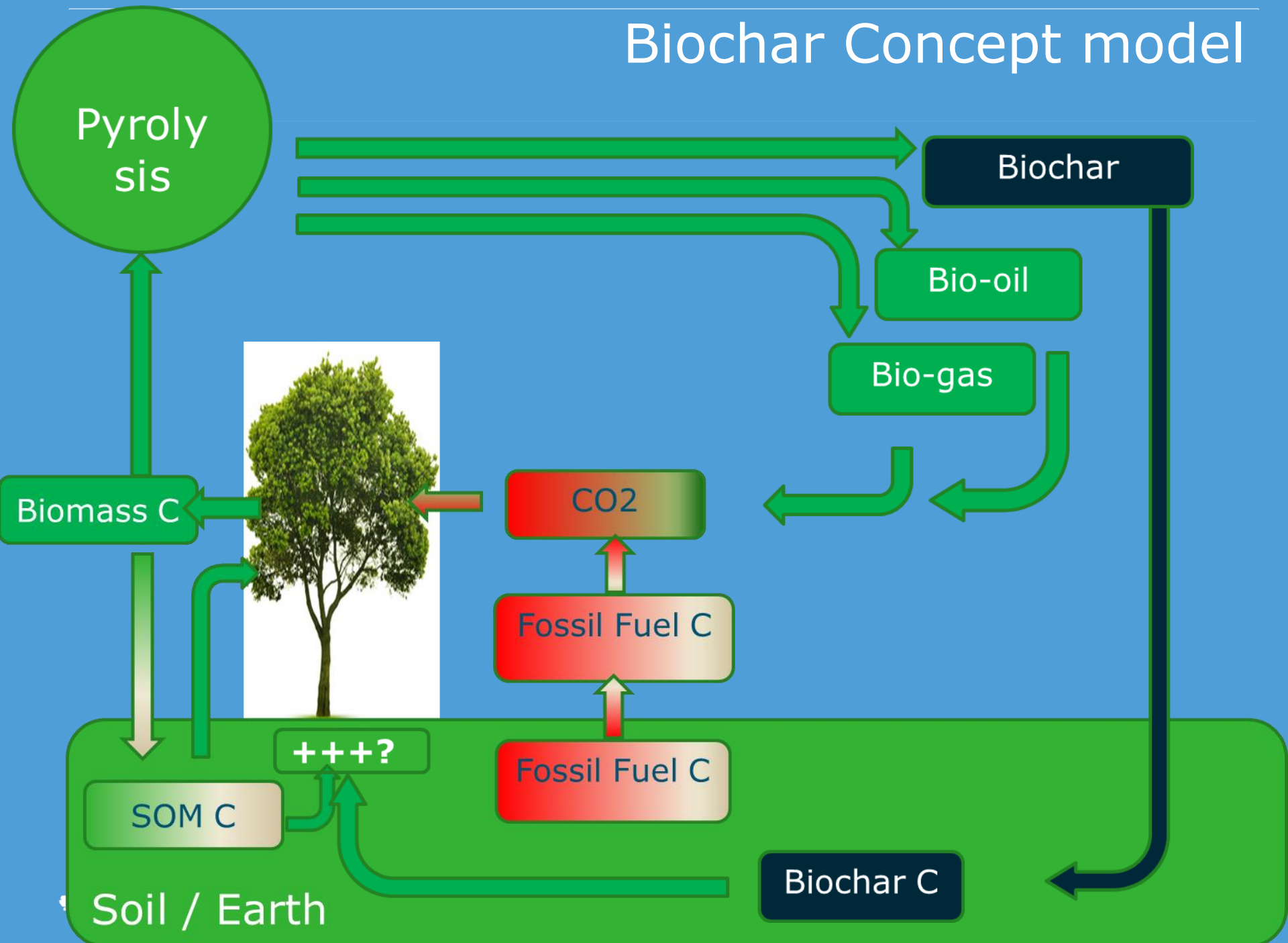
- Biobased Economy
  - Bioenergy, sustainability,
  - Biochar application
  - Biorefinery
  - ‘New’ Organic Fertilizers from waste
- Nitrates Directive evaluation in EU-27
- Sustainable Soil Management

Biochar concept

Current situation



Biochar Concept model



Trade offs / Considerations

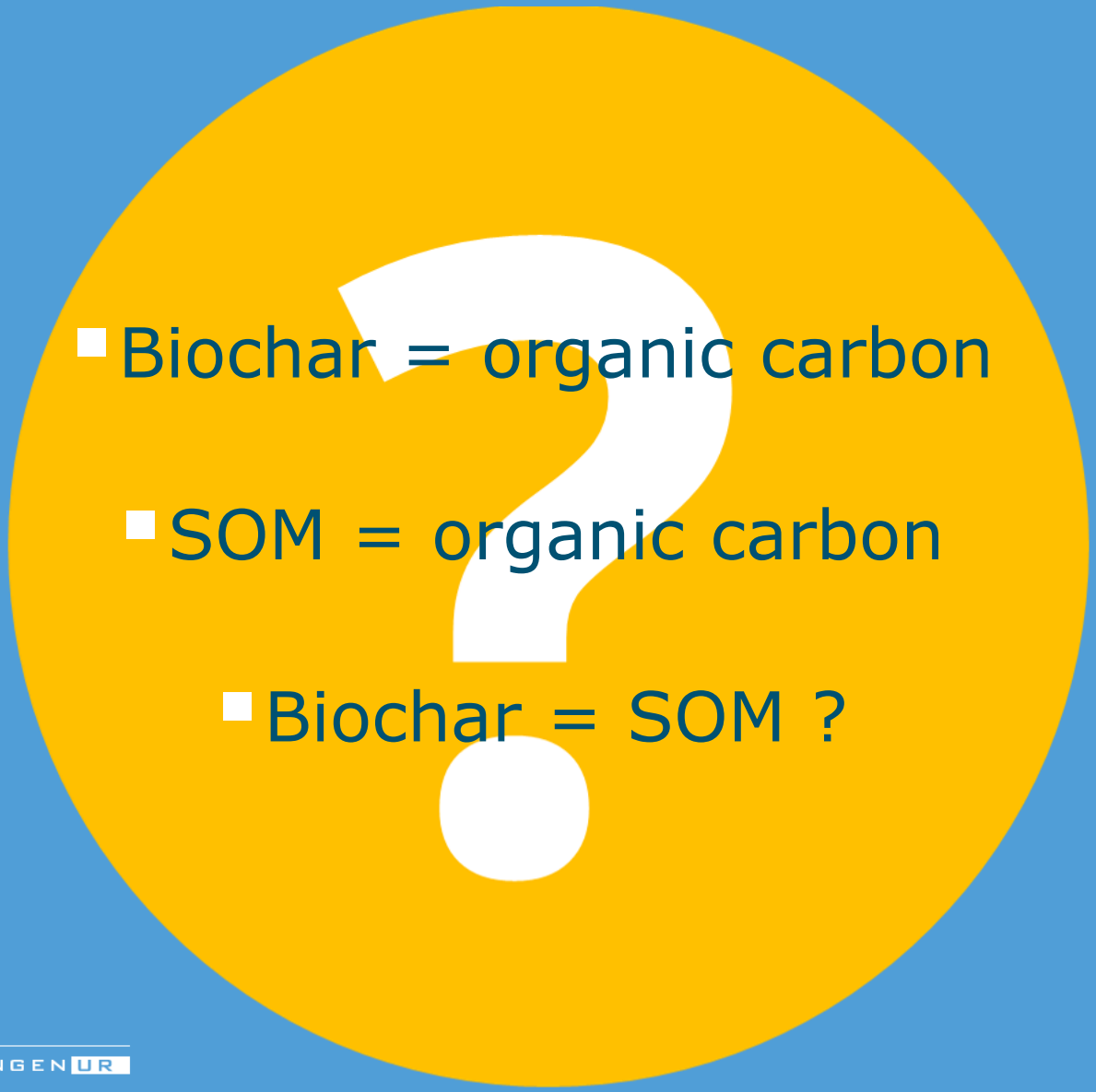
Biochar for climate mitigation and soil improvement?

- Which are the important questions to be addressed?

Trade offs / Considerations

- Biochar stability > 100 years?
- Is biochar improving Soil fertility / Soil quality and how?
- Biochar C for energy or for C-sequestration?

Is Biochar similar to Soil Organic Matter?



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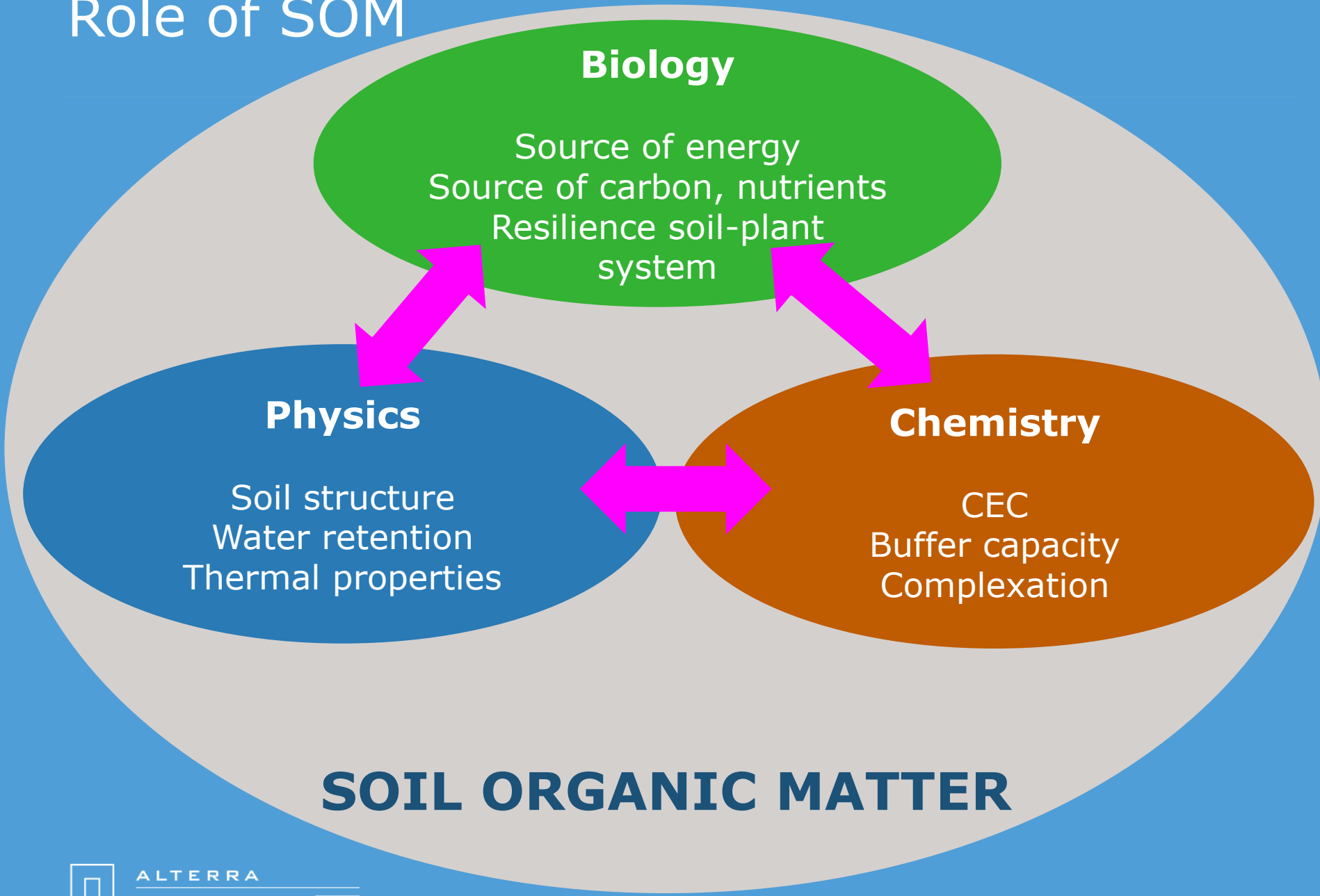
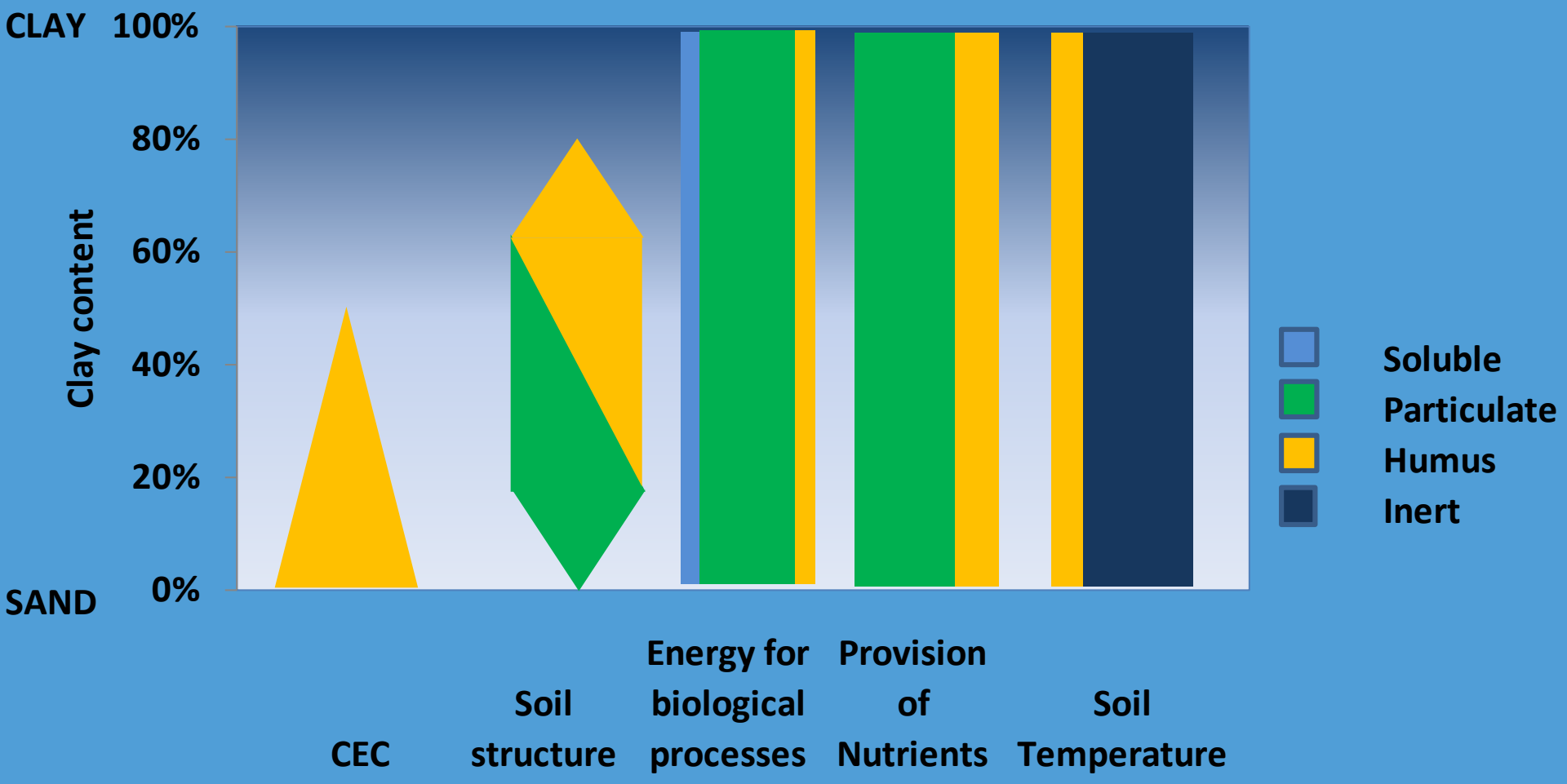
Role of SOM


Biology
Source of energy
Source of carbon, nutrients
Resilience soil-plant system
Physics
Soil structure
Water retention
Thermal properties
Chemistry
CEC
Buffer capacity
Complexation
SOIL ORGANIC MATTER

SOM types in SOIL types

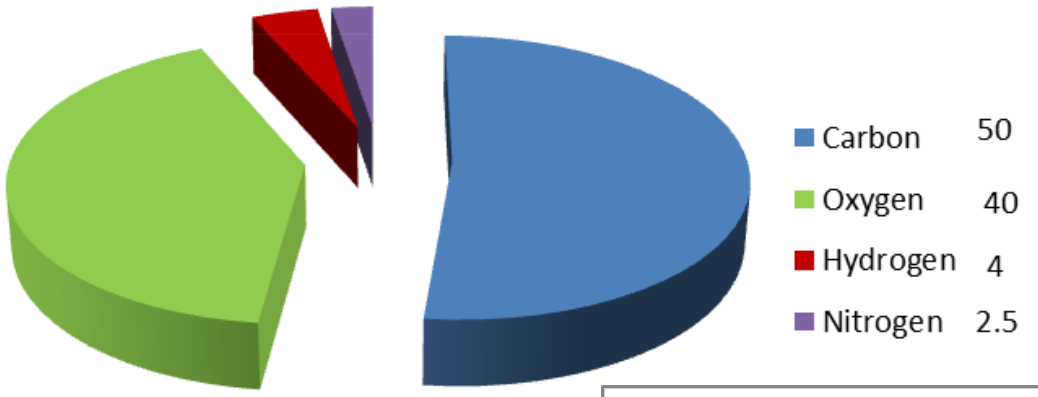


After: http://grdc.com.au/uploads/documents/cso000291.pdf

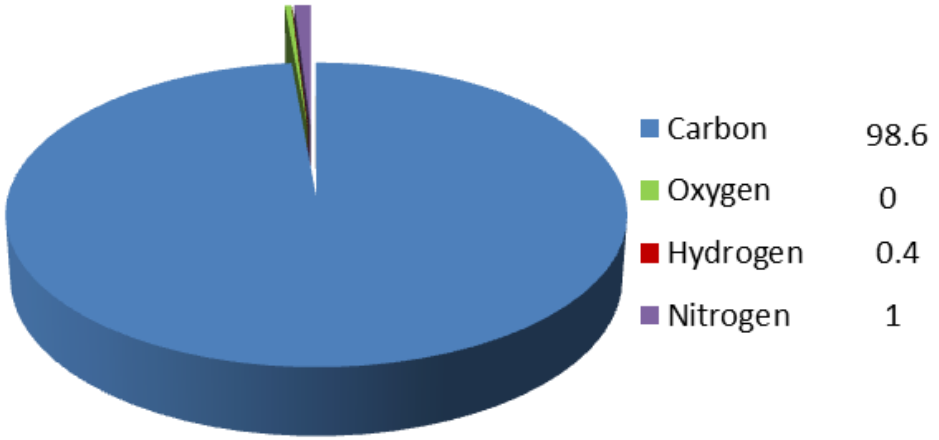
Biochar **Claims** in Soil Properties

- Soil biology: nutrients, energy, carbon
- Water retention
- Nutrient buffering (CEC)

Natural Organic Matter



Biochar



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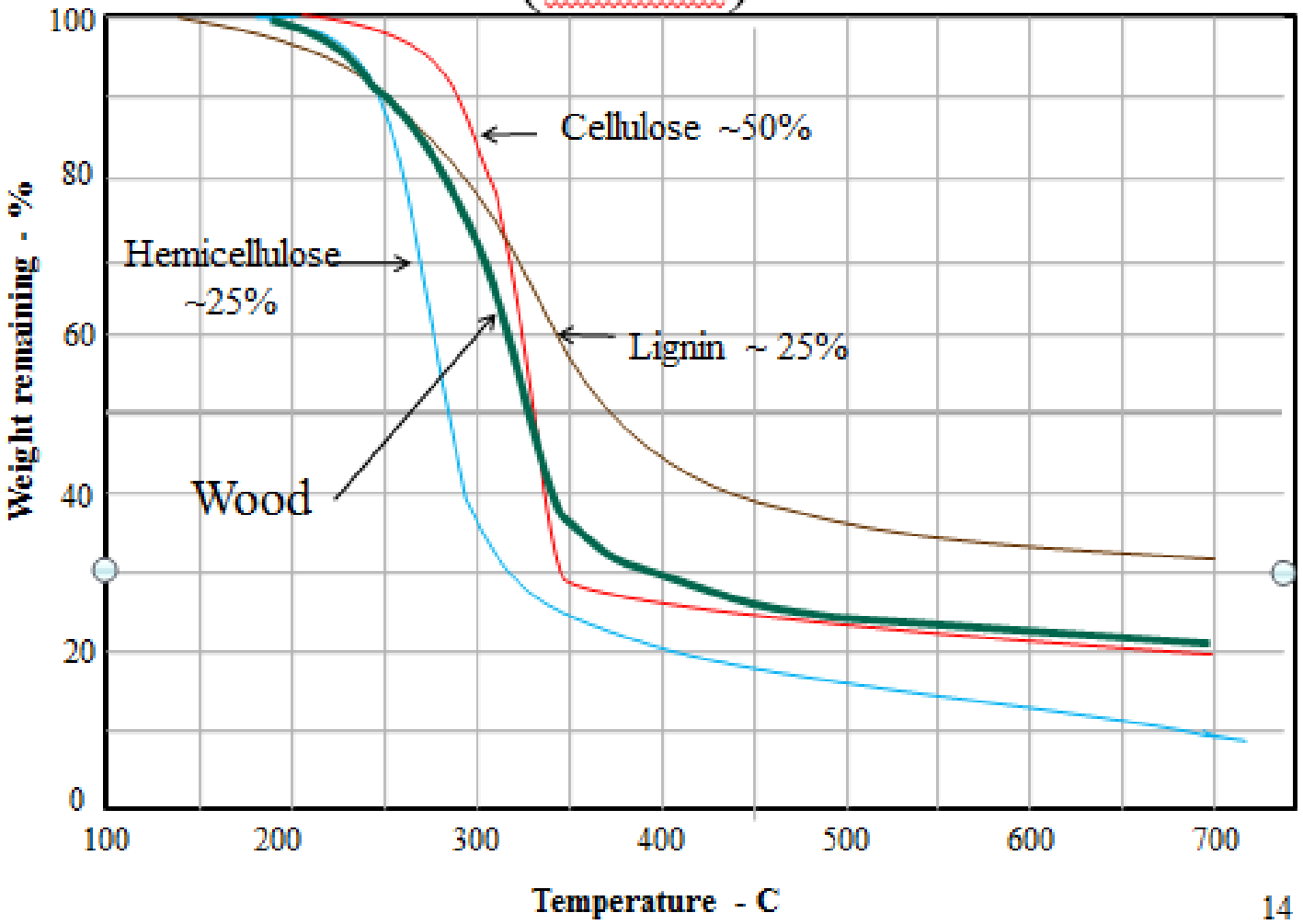
http://www.treepower.org/biochar/main.html

Pyrolysis of Biomass Components (TGA)



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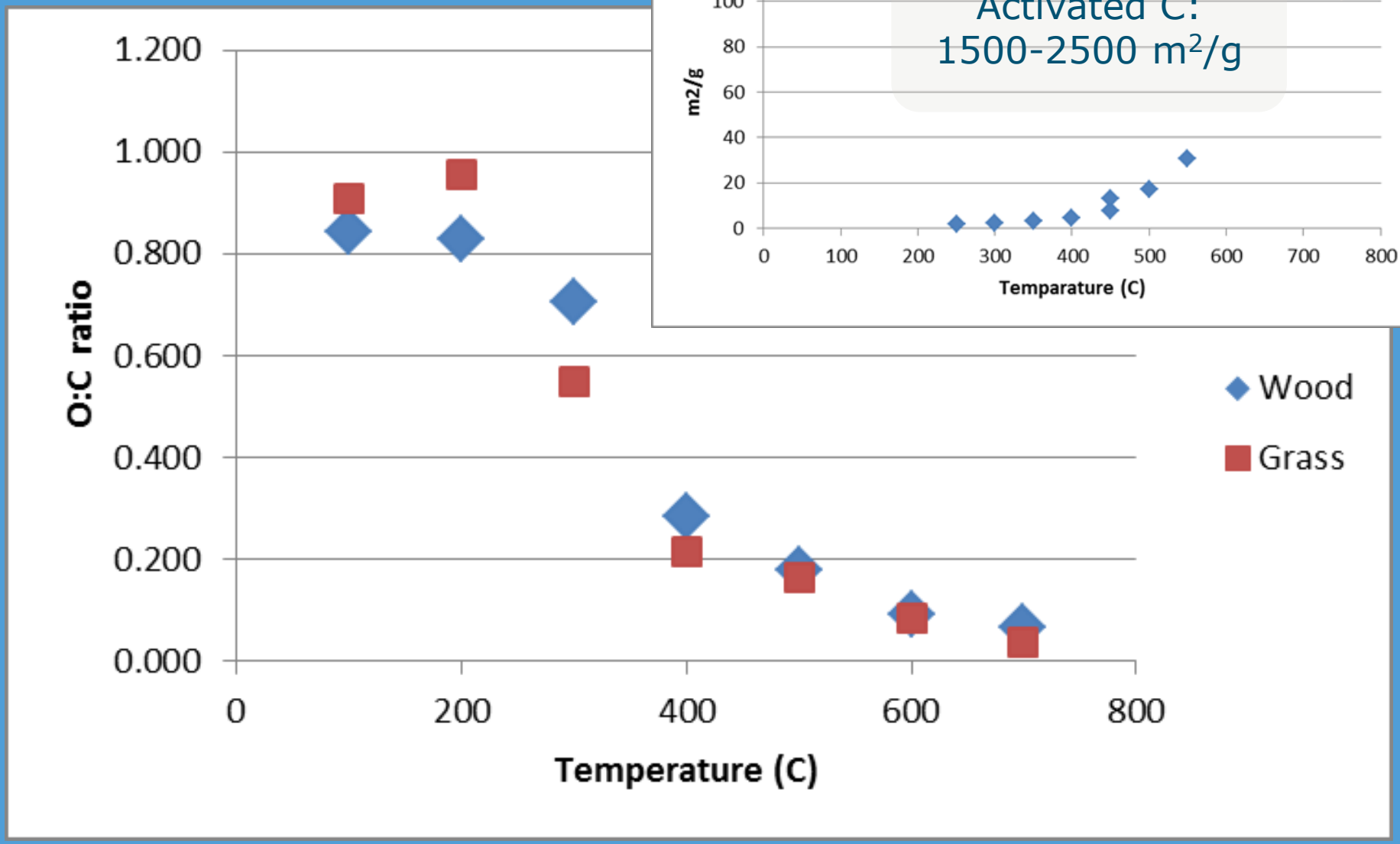
Reed and McLaughlin North American Biochar 2009

Pyrolysis conditions



Activated C:
1500-2500 m^2/g

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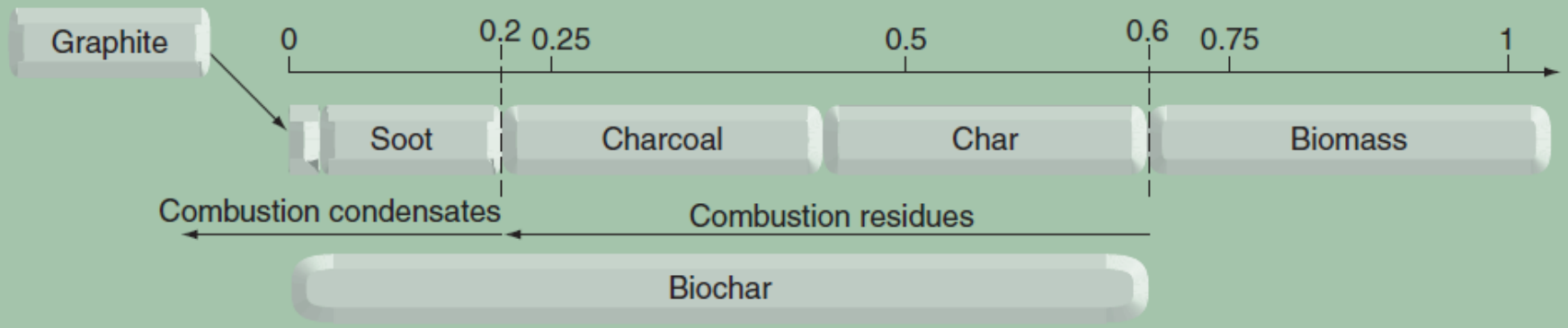
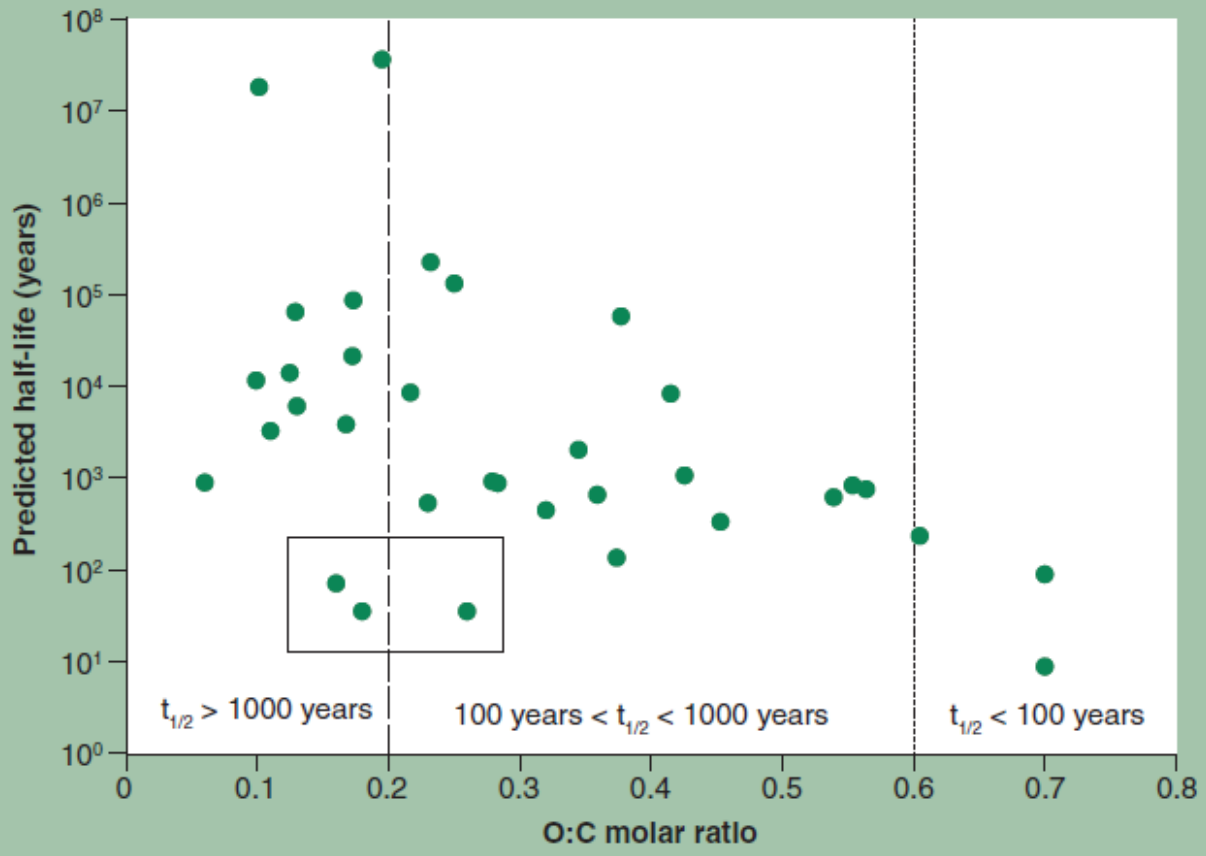
Keiluweit et al, (2010) Environ. Sci. Technol.





Spokas (2010) Carbon Management (2010) 1(2)

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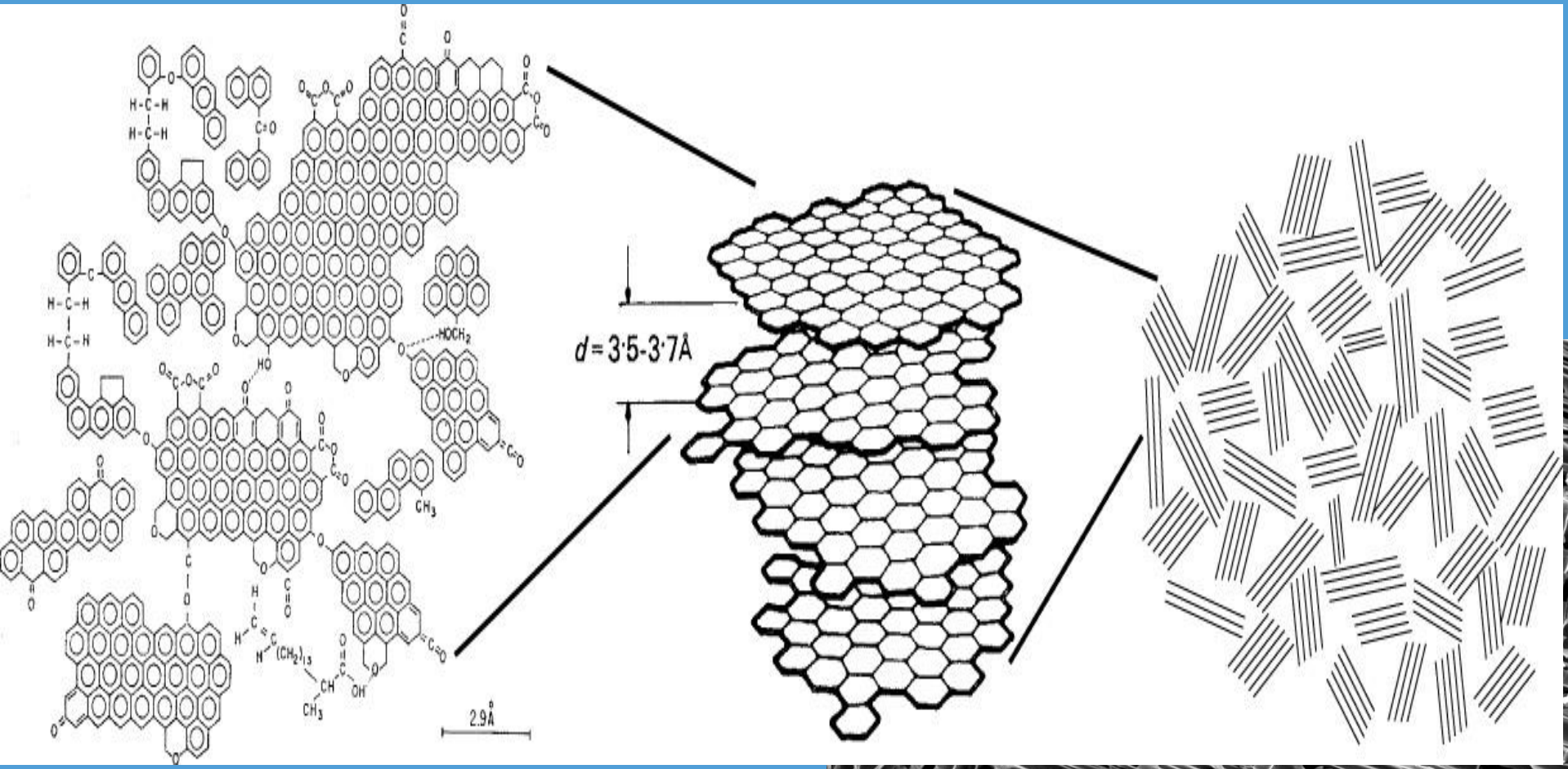
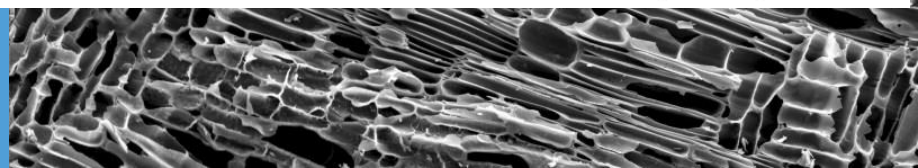
Conclusions stability

- Stable biochar can be produced, fits C-sequestration in soils
- Stability depends on pyrolysis conditions -> biochar composition
- Composition also determines other biochar properties

Biochar Carbon & Energy for micro-organisms ?





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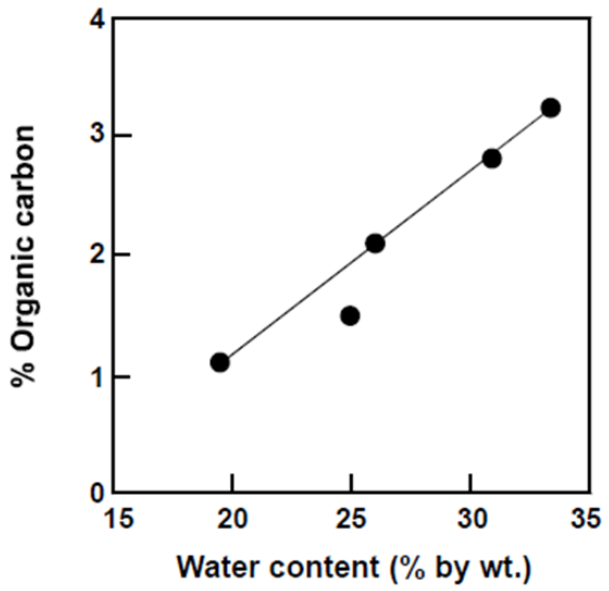
Relation SOM-plant available water (pF 2-4.2)



SOM %	Plant available water mm
2	50
4	66
5	70
6	75
8	81
10	86

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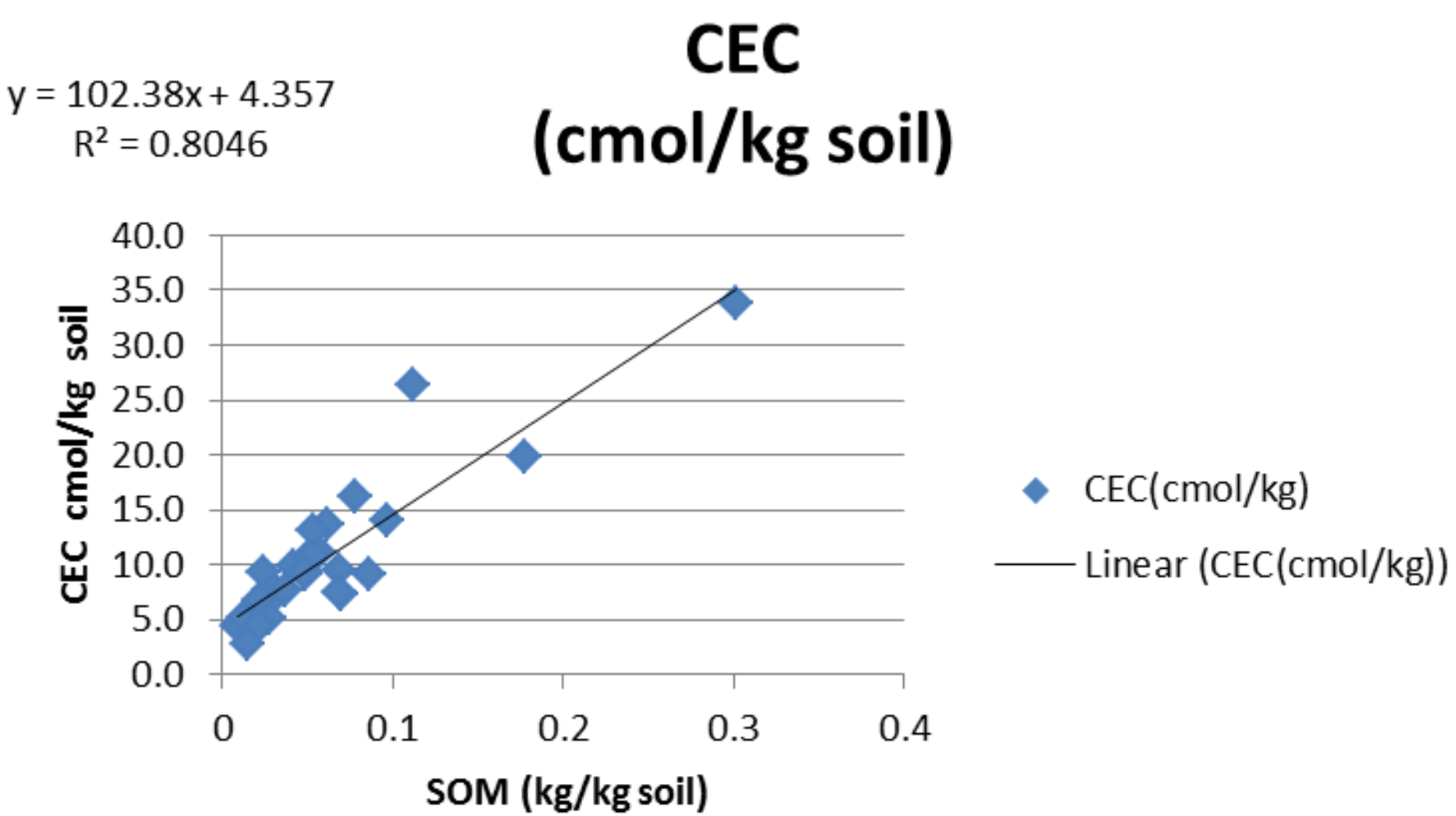
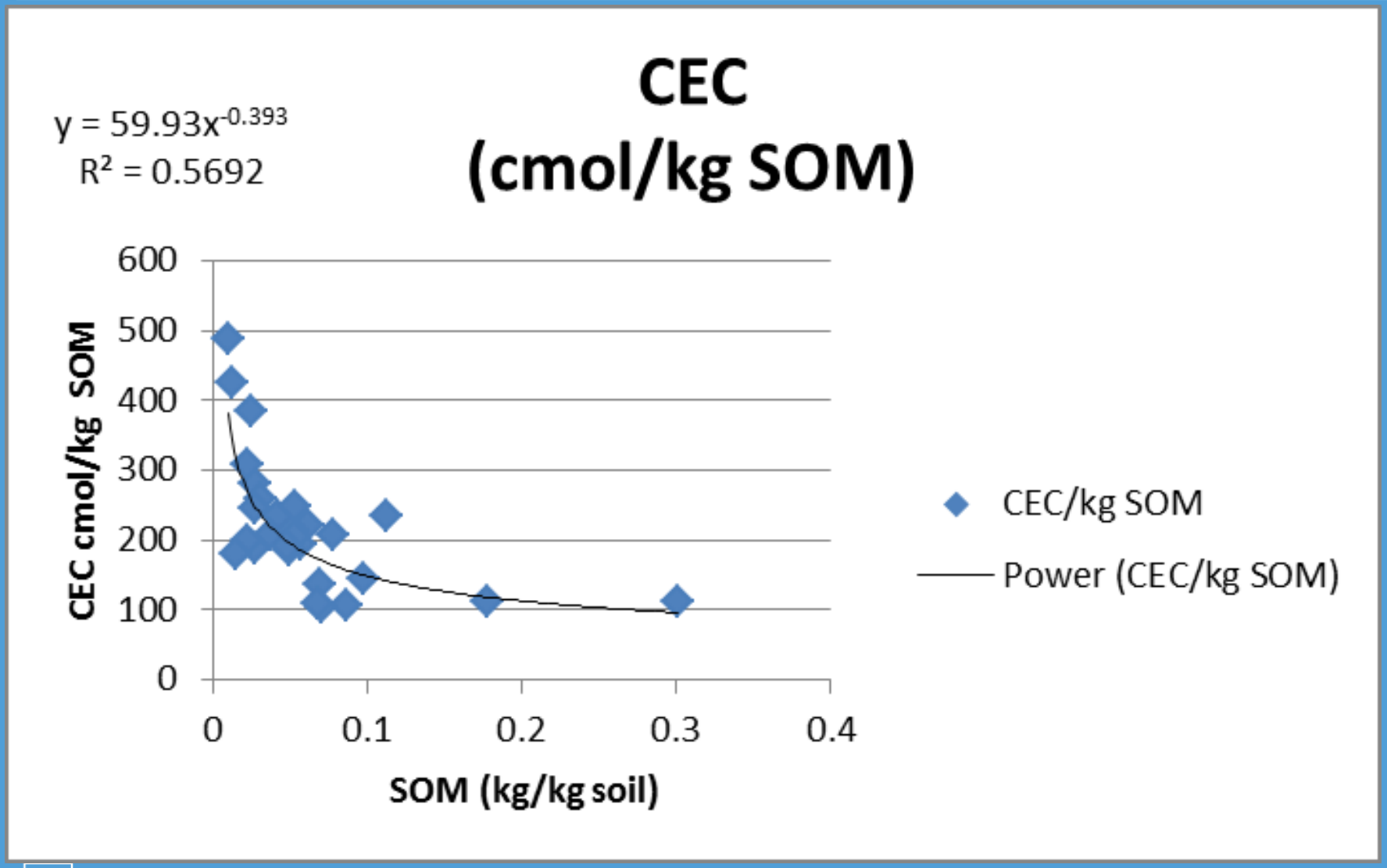
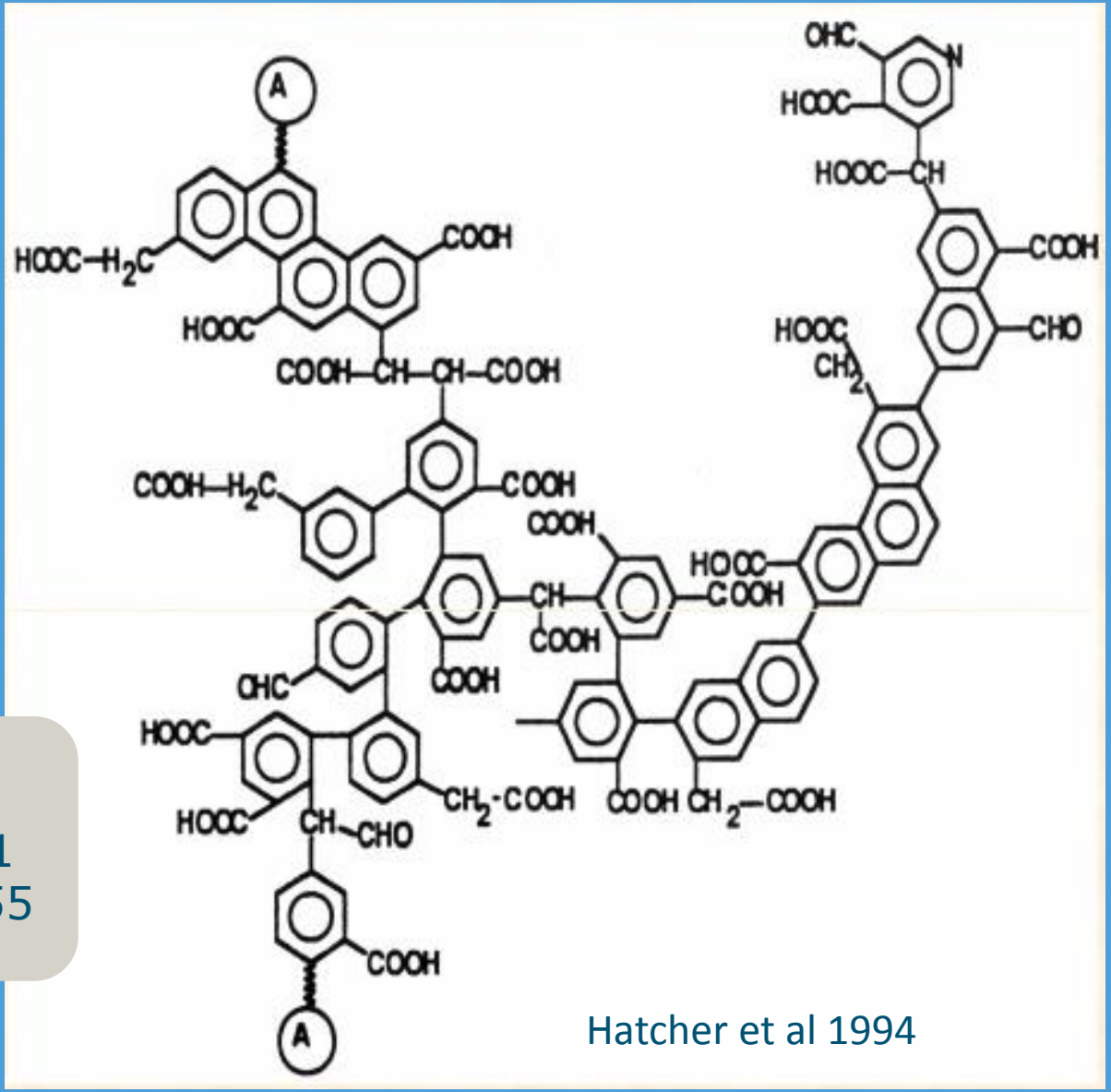
CEC reclaimed peat soils



CEC reclaimed peat soils

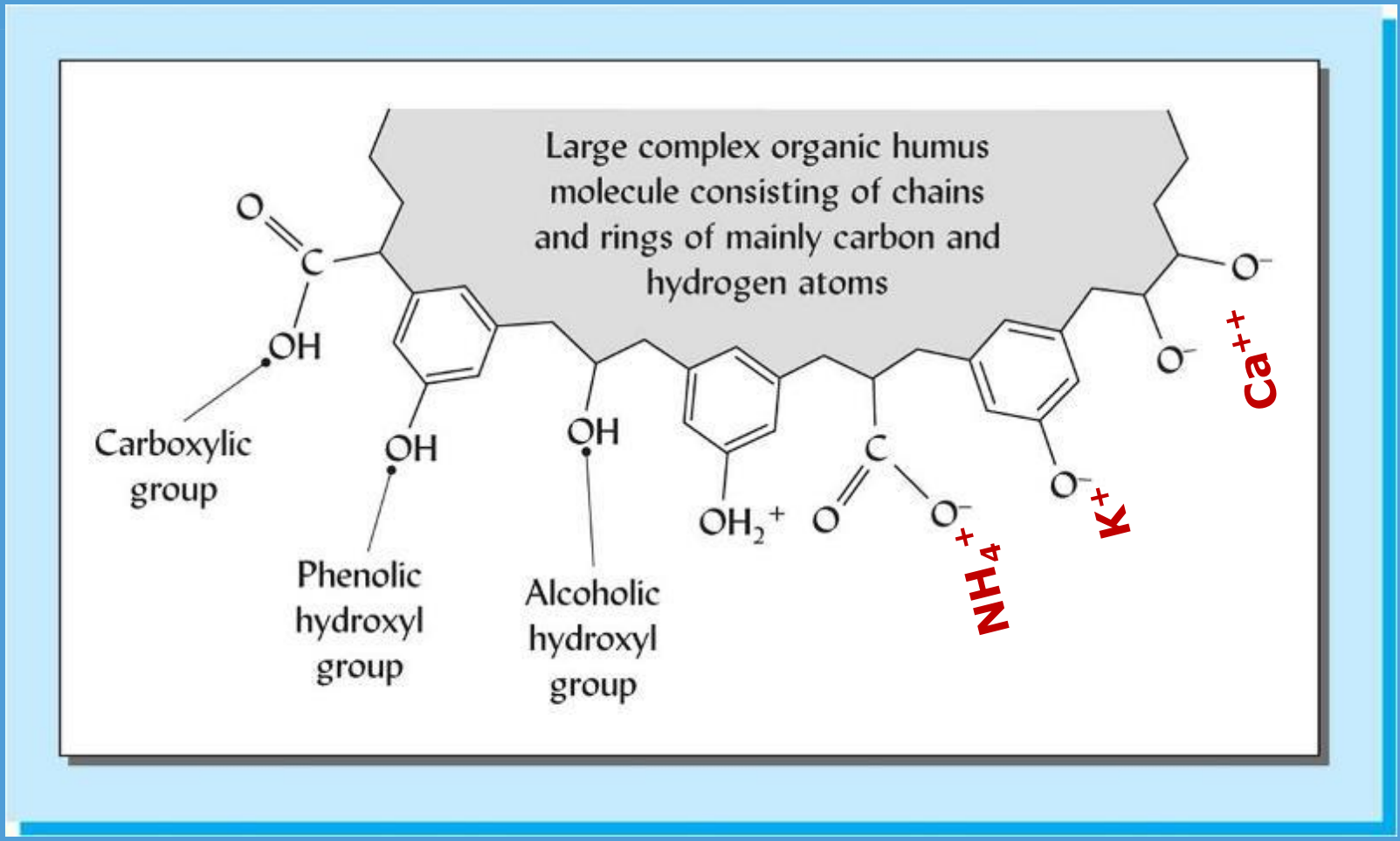


Humic Acid structure



Hatcher et al 1994

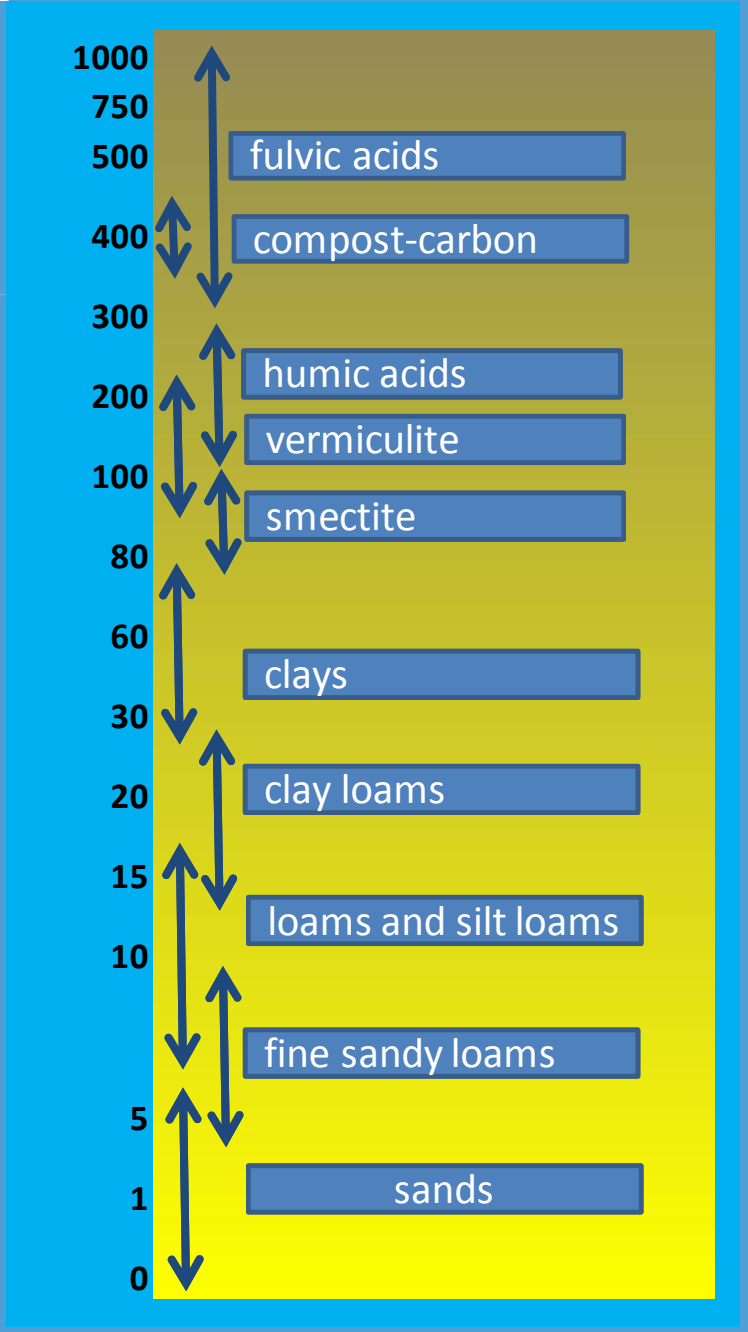
C:O
Fulvic acids: 1
Humic acids : 0.55

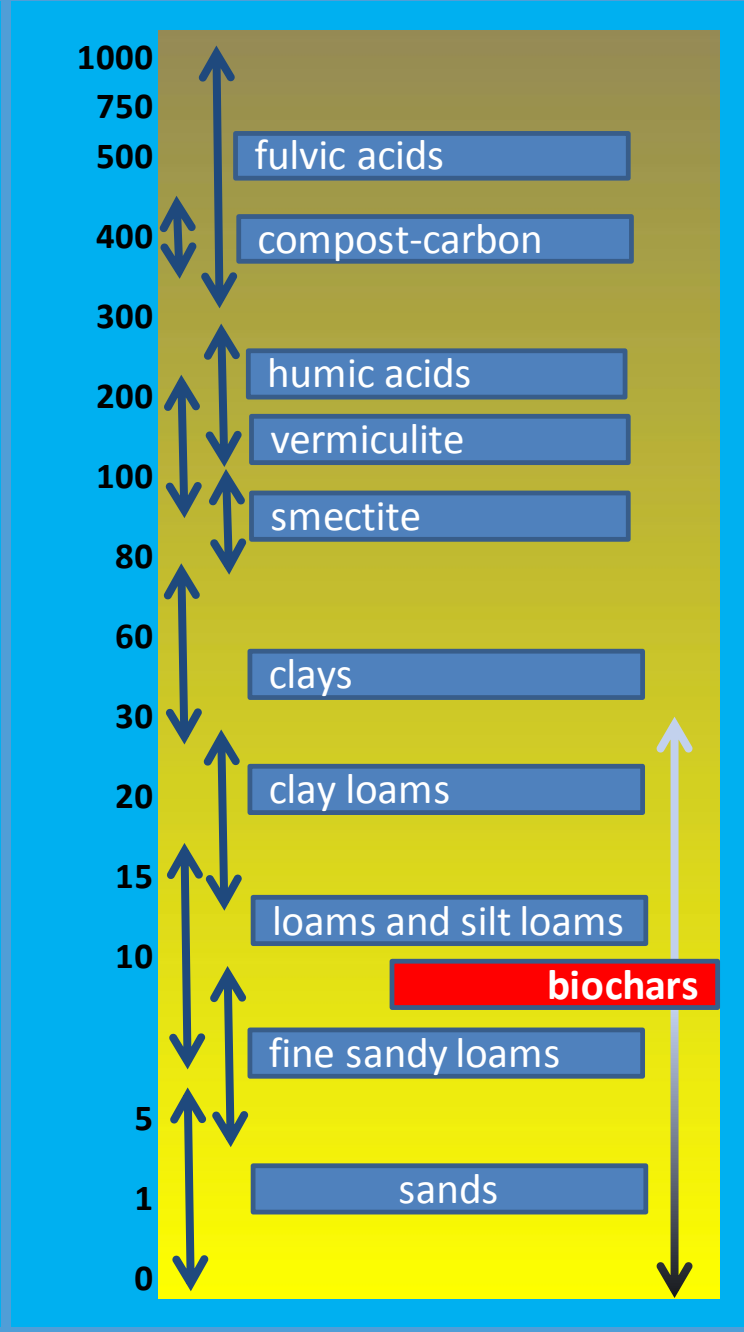


NO_3^- NO_3^-

NH_4^+ K^+ Ca^{++}

CEC (cmol/kg)


1000
750
500
400
300
200
100
80
60
30
20
15
10
5
1
0
fulvic acids
compost-carbon
humic acids
vermiculite
smectite
clays
clay loams
loams and silt loams
fine sandy loams
sands


1000
750
500
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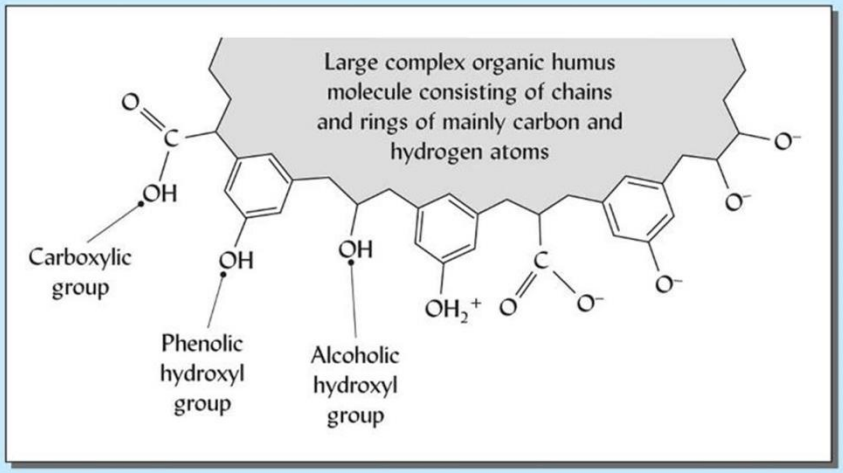
300
200
100
80
60
30
20
15
10
5
1
0
fulvic acids
compost-carbon
humic acids
vermiculite
smectite
clays
clay loams
loams and silt loams
biochars
fine sandy loams
sands

Modification of Biochar

- Activation (?)
- Adsorption of SOM
- Biological modification (?)
- Chemical modification, strong acids, bases, oxidation
    - Functional groups CEC
    - Functional groups AEC (NR_4^+)



BIOCHAR = SOM?

- Biochar = organic carbon
- SOM = organic carbon

- Biochar ~~=~~ SOM

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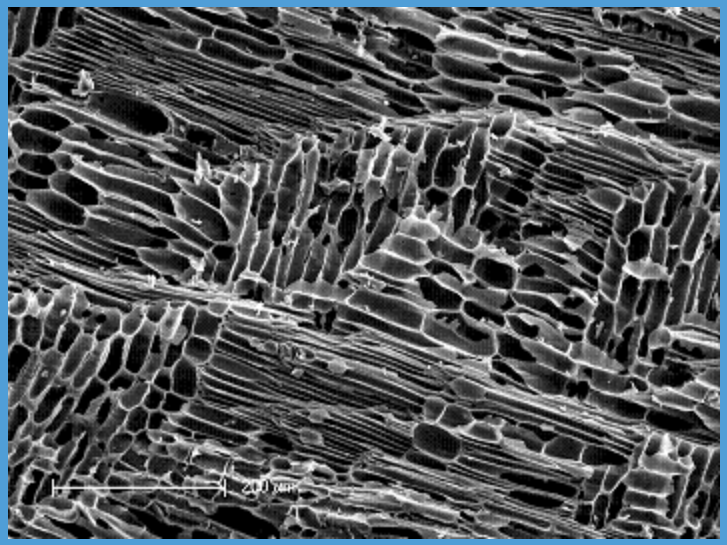
Conclusions

- Biochar can be used to sequester short cyclic C in the soil
- Fresh biochar is rather different from SOM
- It seems rather unlikely that (fresh) biochar can completely replace SOM
- Modification of biochar to improve its functionality is needed and possible

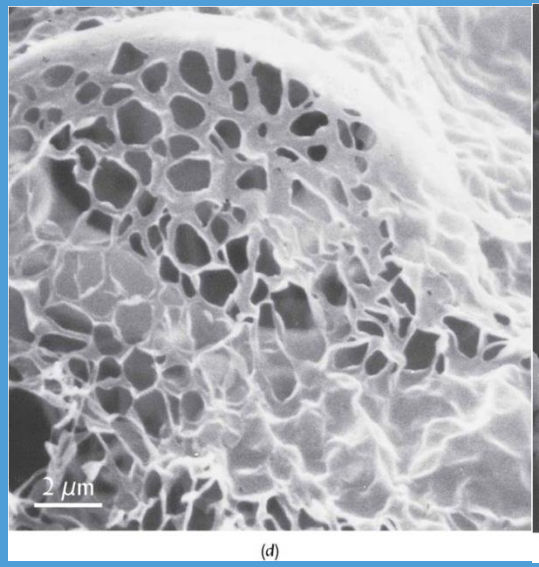
Biochar Refuge for micro-organisms ?

Biochar

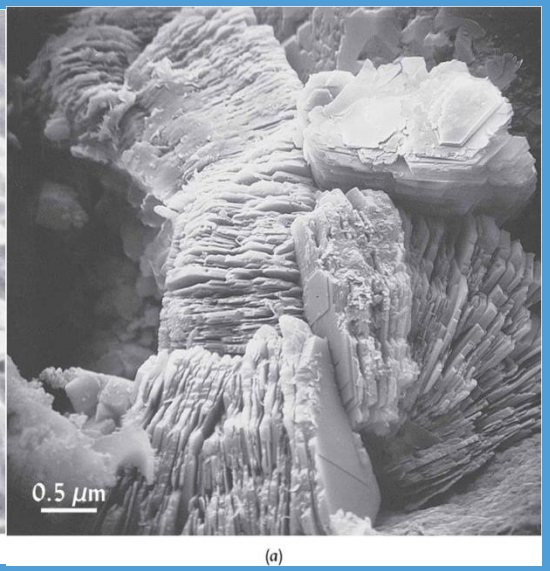


Sohi et al (2009)

Humic acid



Clay



faculty.yc.edu/ycfaculty/ags105/week08/soil_colloids/soil_colloids_print.html

Hydrophobic interaction bacteria and sand in a Fluidized bed reactor

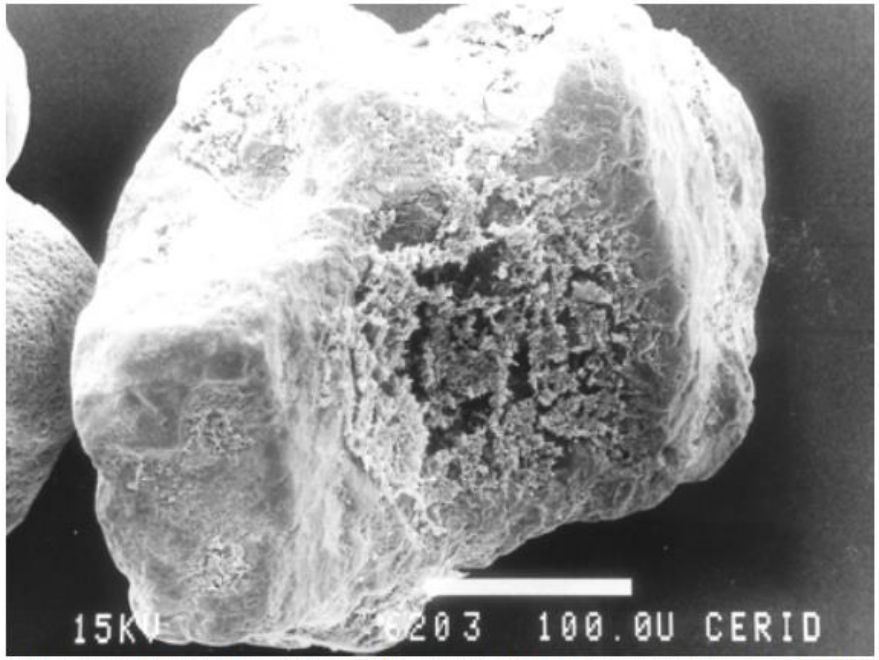


Figure 4. Representative sand particle partially covered with an anaerobic biofilm of thin thickness.

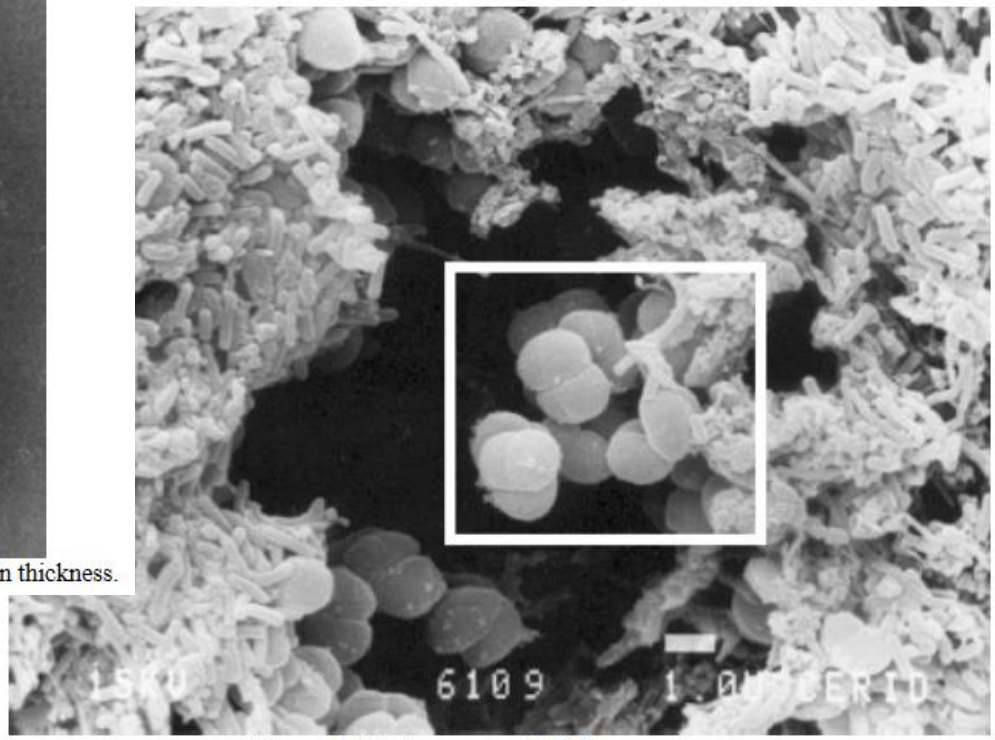
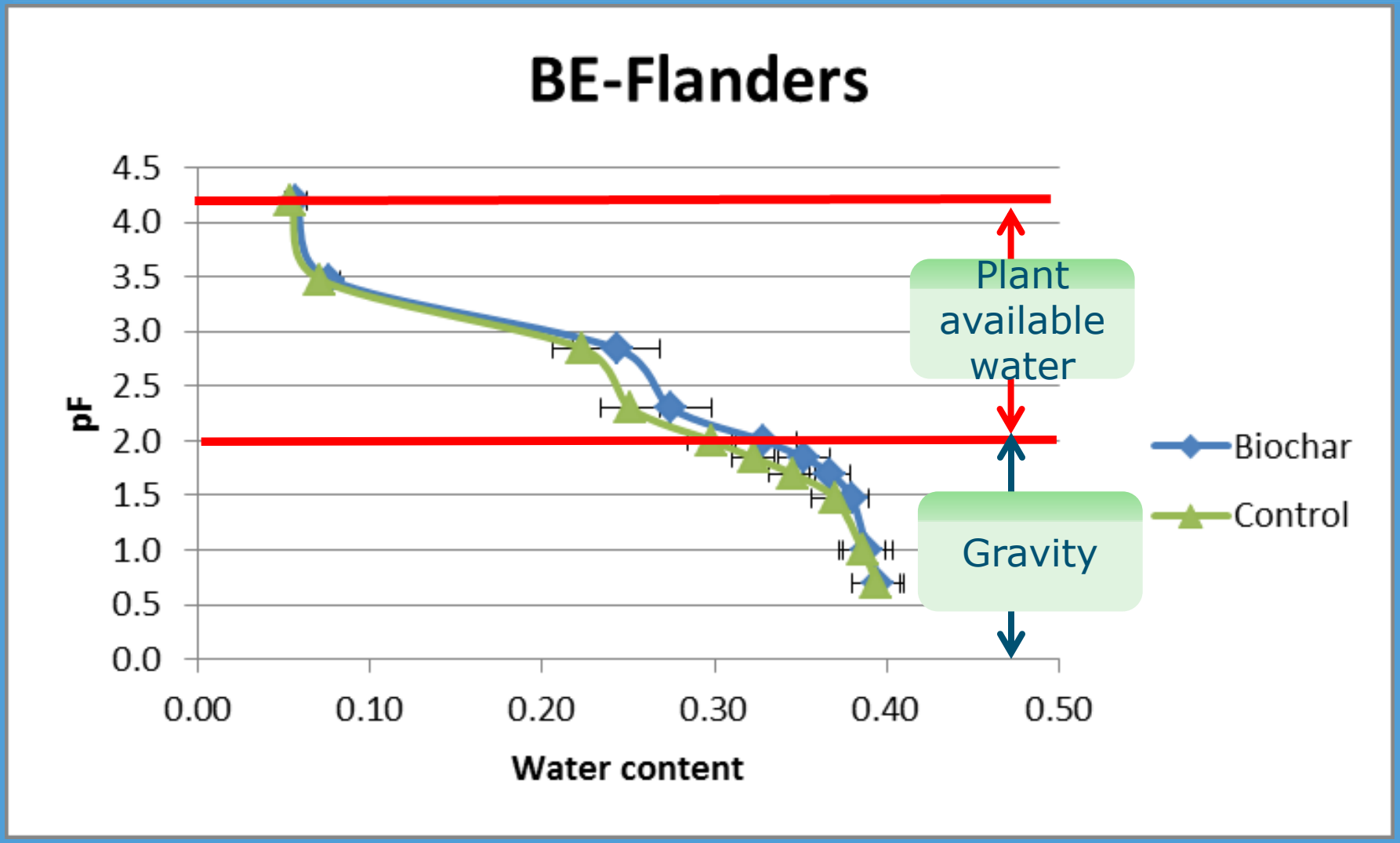


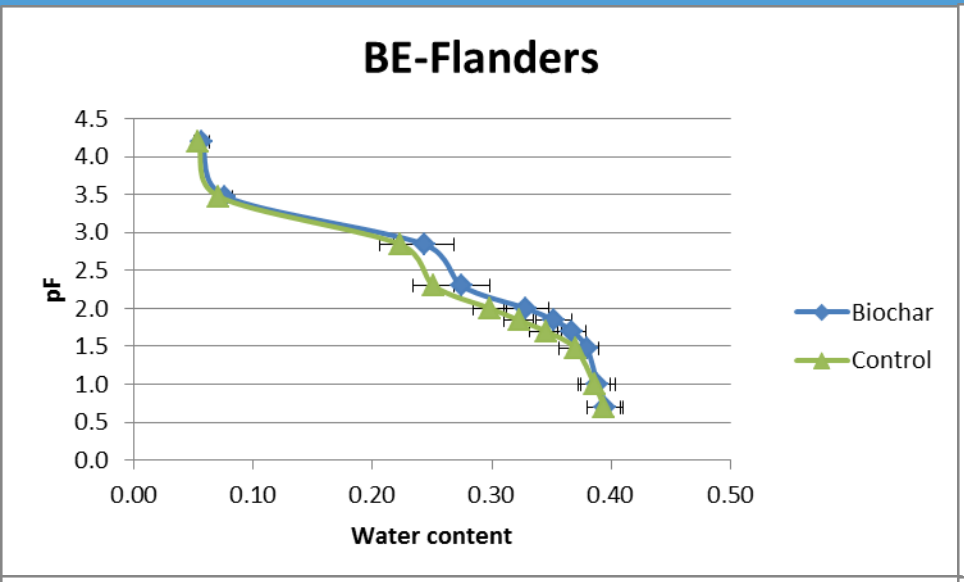
Figure 3. Methanogens: *Methanosarcina sp*

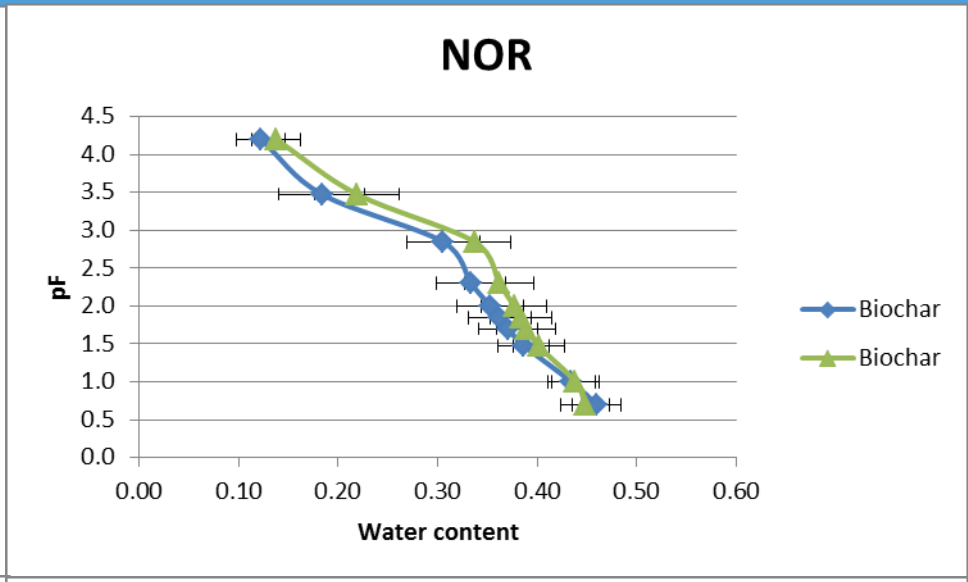
Mussati et al, 2005

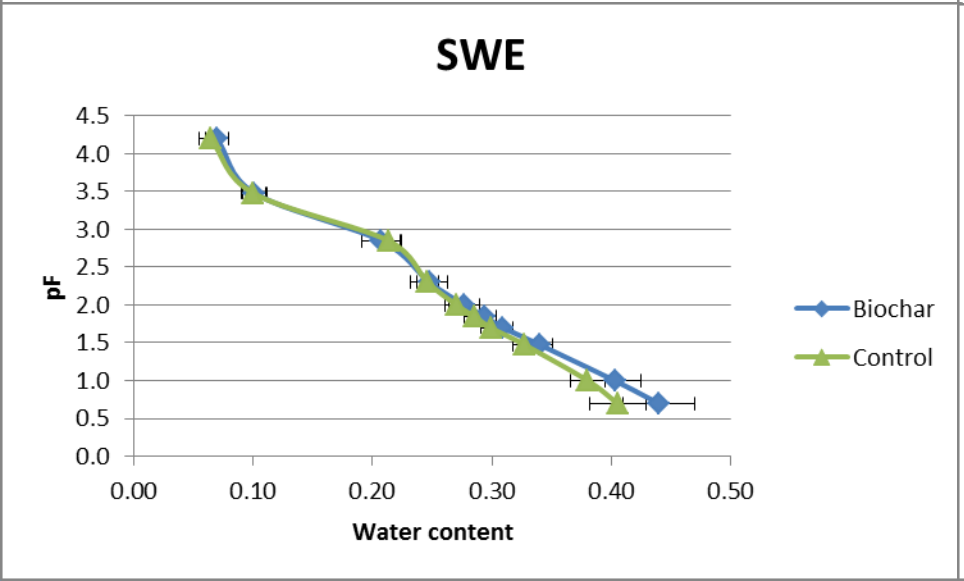
Biochar and Water retention ?

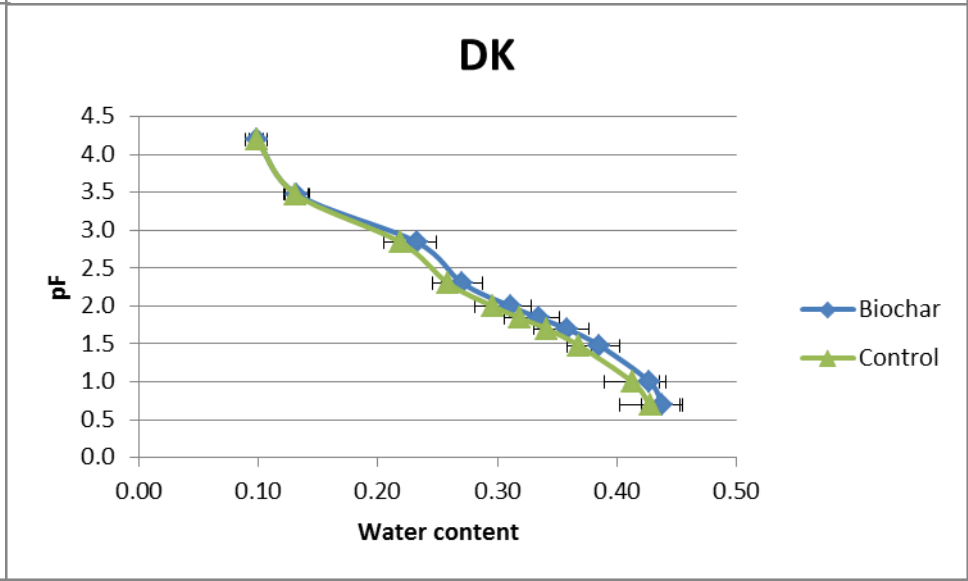


Water retention Interreg Biochar Project

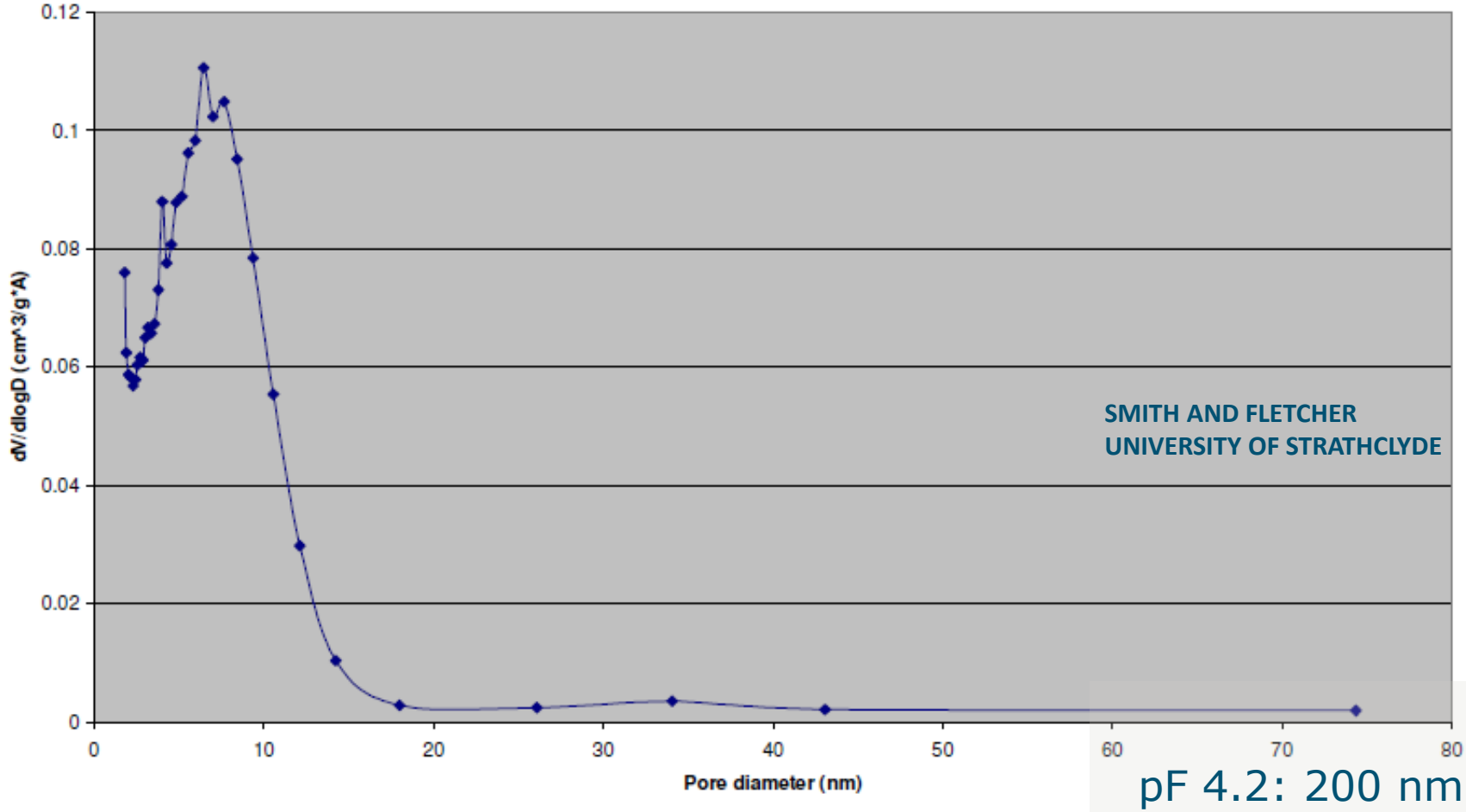








Pore size distribution



pF 4.2: 200 nm

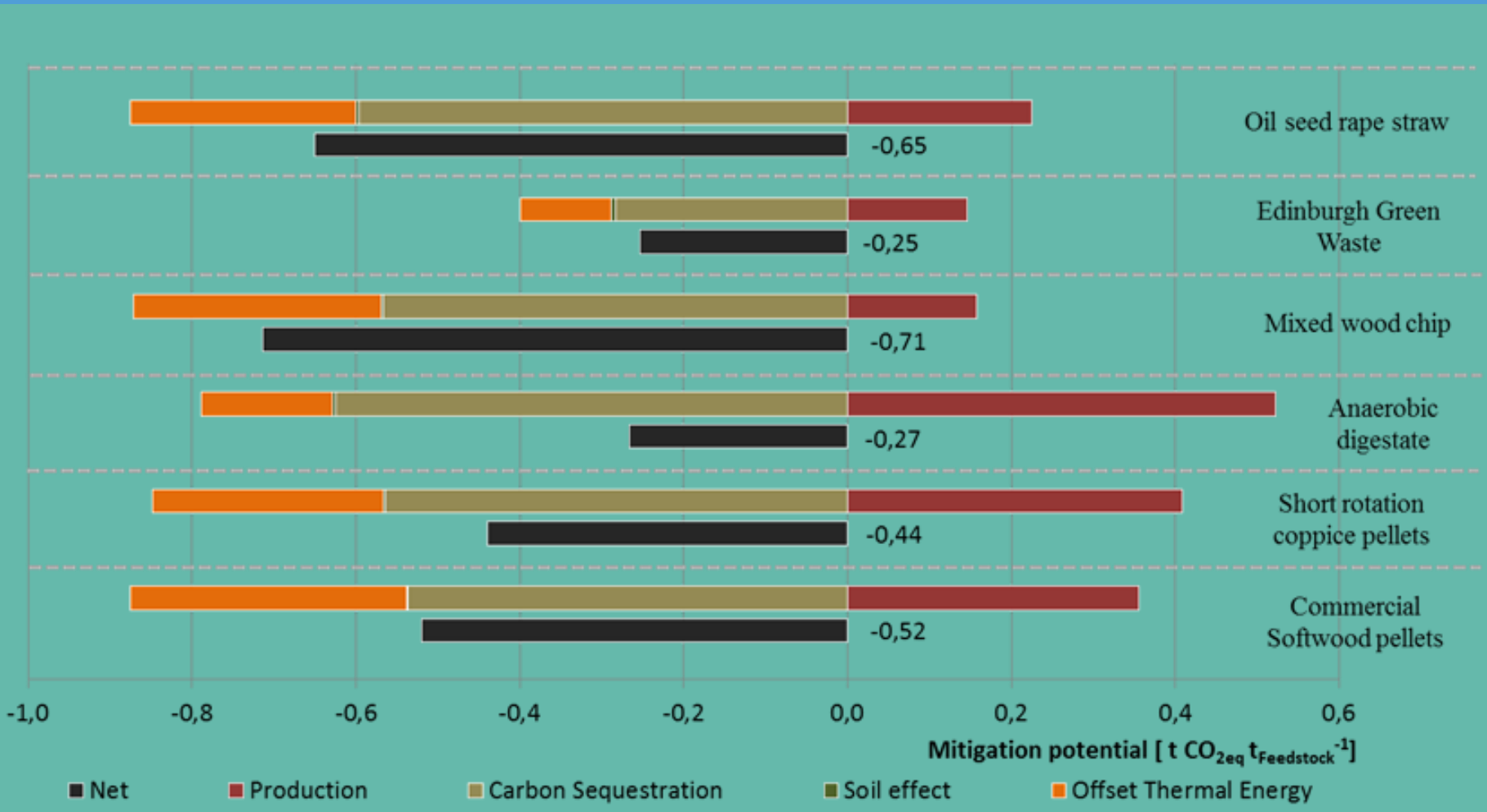
FIGURE 2.4: PORE SIZE DISTRIBUTION FOR COARSE CHAR

Biochar energy content MJ/kg^{-1}

	Pyrolysis	Commercial Softwood Pellets	Anaerobic Digestate	Mixed Wood Chip	Green Waste
Biochar	HHV	33.6	16.9	32.2	8
Liquid	HHV	12.8	10.9	13	13.8
Syngas	HHV	15.3	11.3	13.3	11.5

Markus Roedger, Biochar Climate Saving Soils

LCA results



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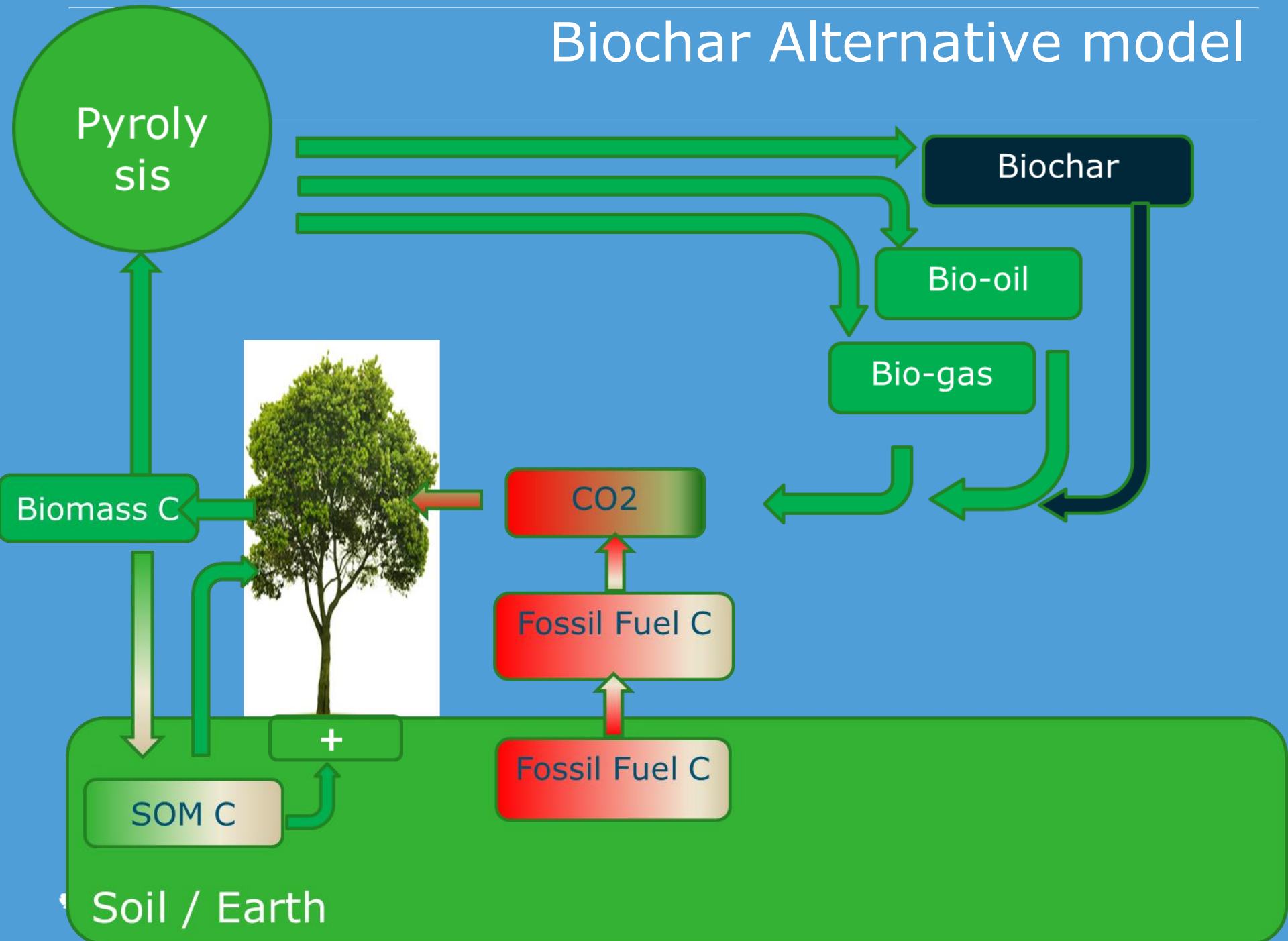
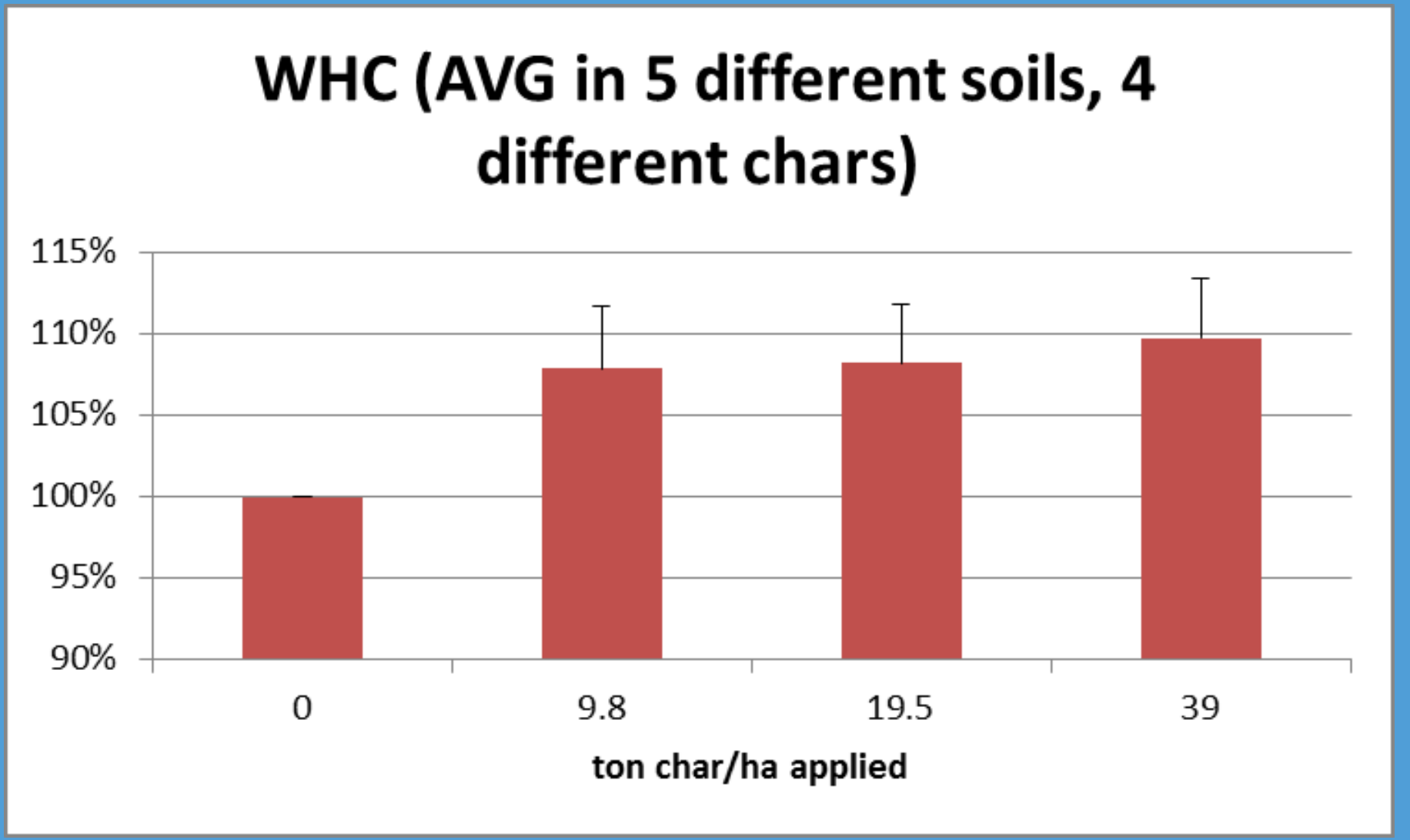
Biochar Alternative model



Biochar and WHC ?



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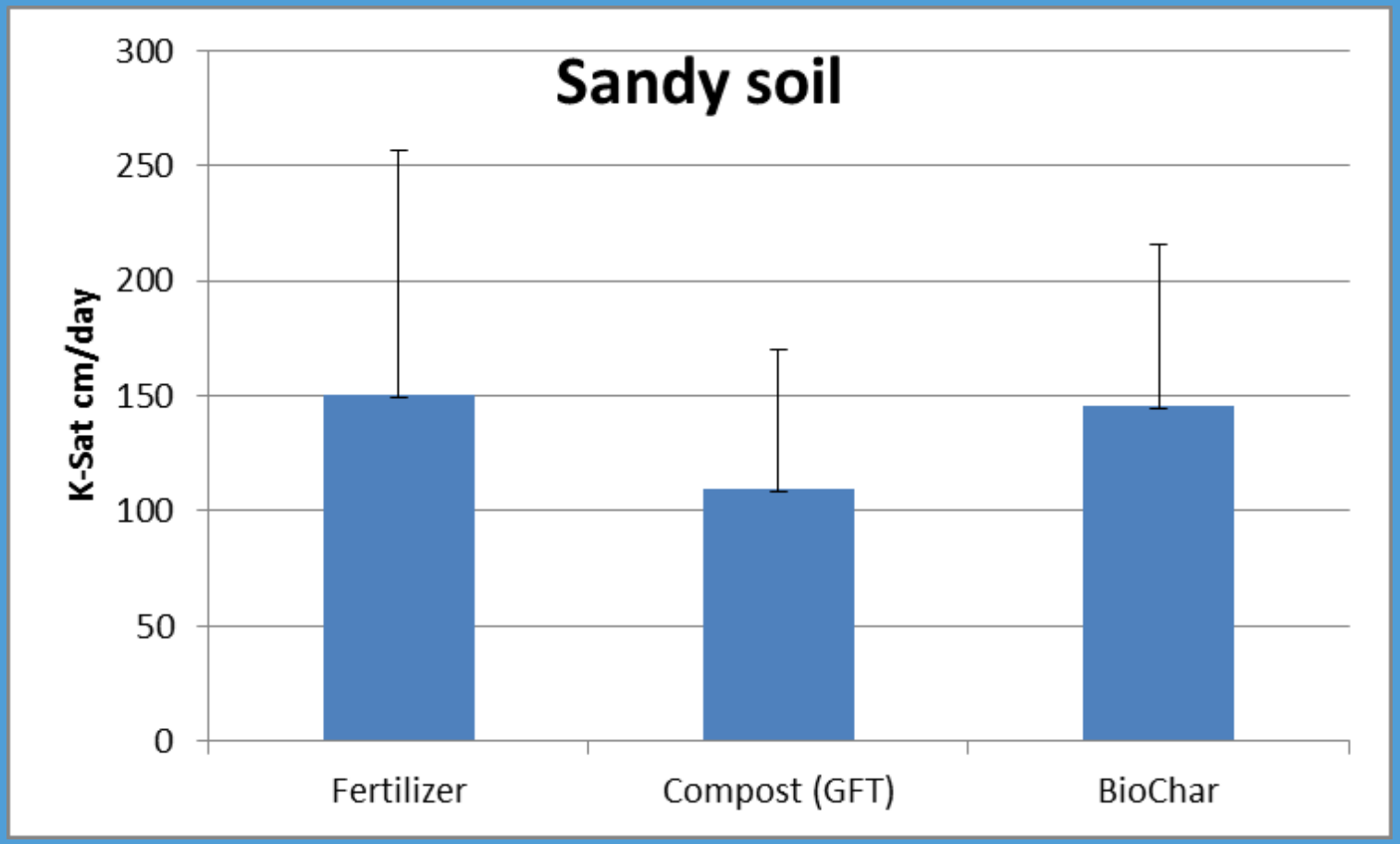
Streubel et al, 2011, JSSSA, 75:1402-1413

Water infiltration Interreg Biochar Project



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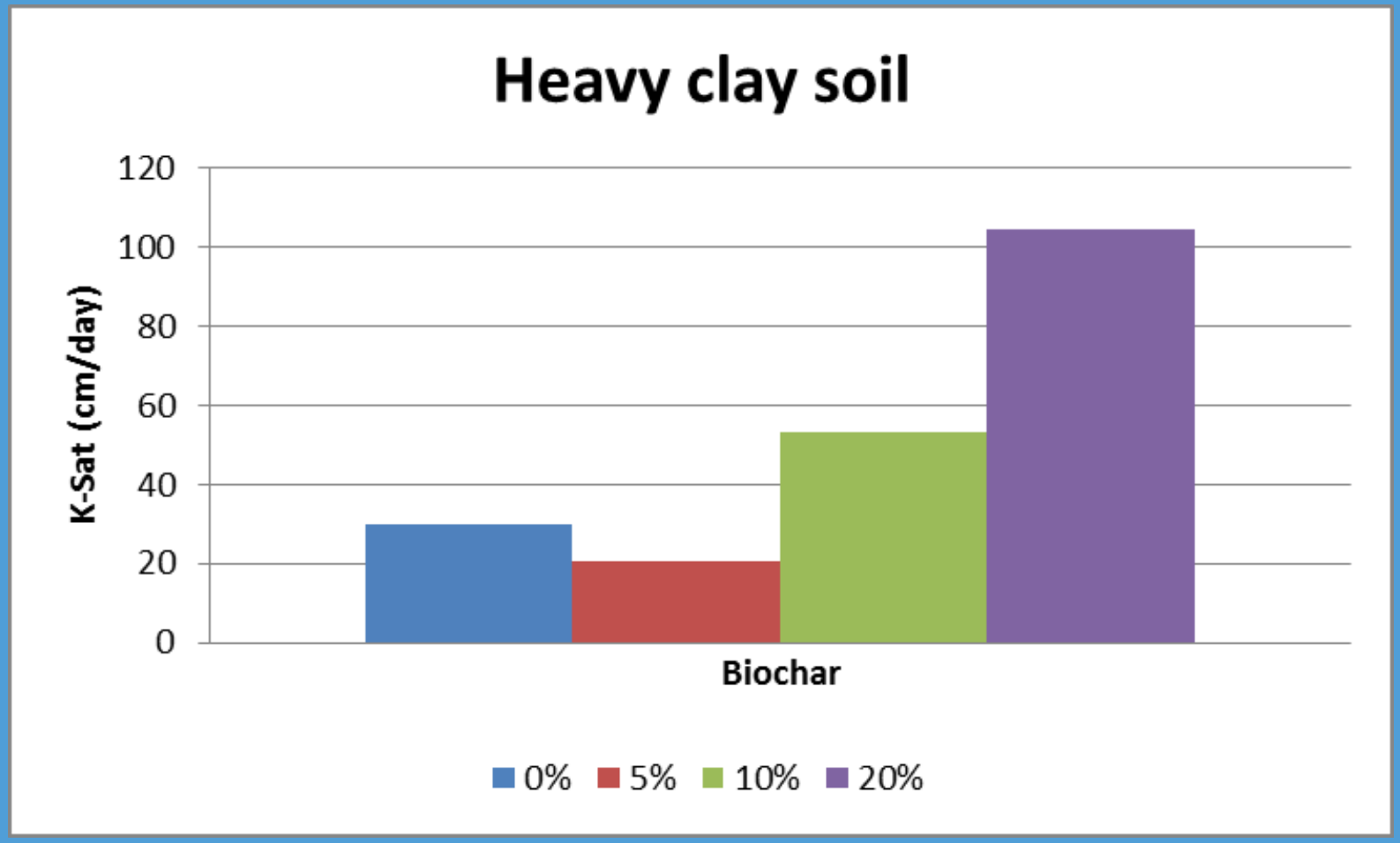
Water infiltration Interreg Biochar Project



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