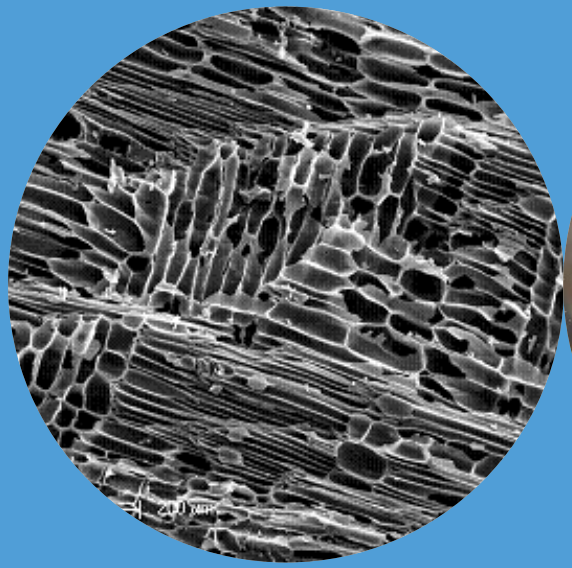
Key Functions of Biochar in Soil (CH 4)

Biochar: can it replace Soil Organic Matter?

Kor Zwart and Peter Kuikman

KB-13-005-008



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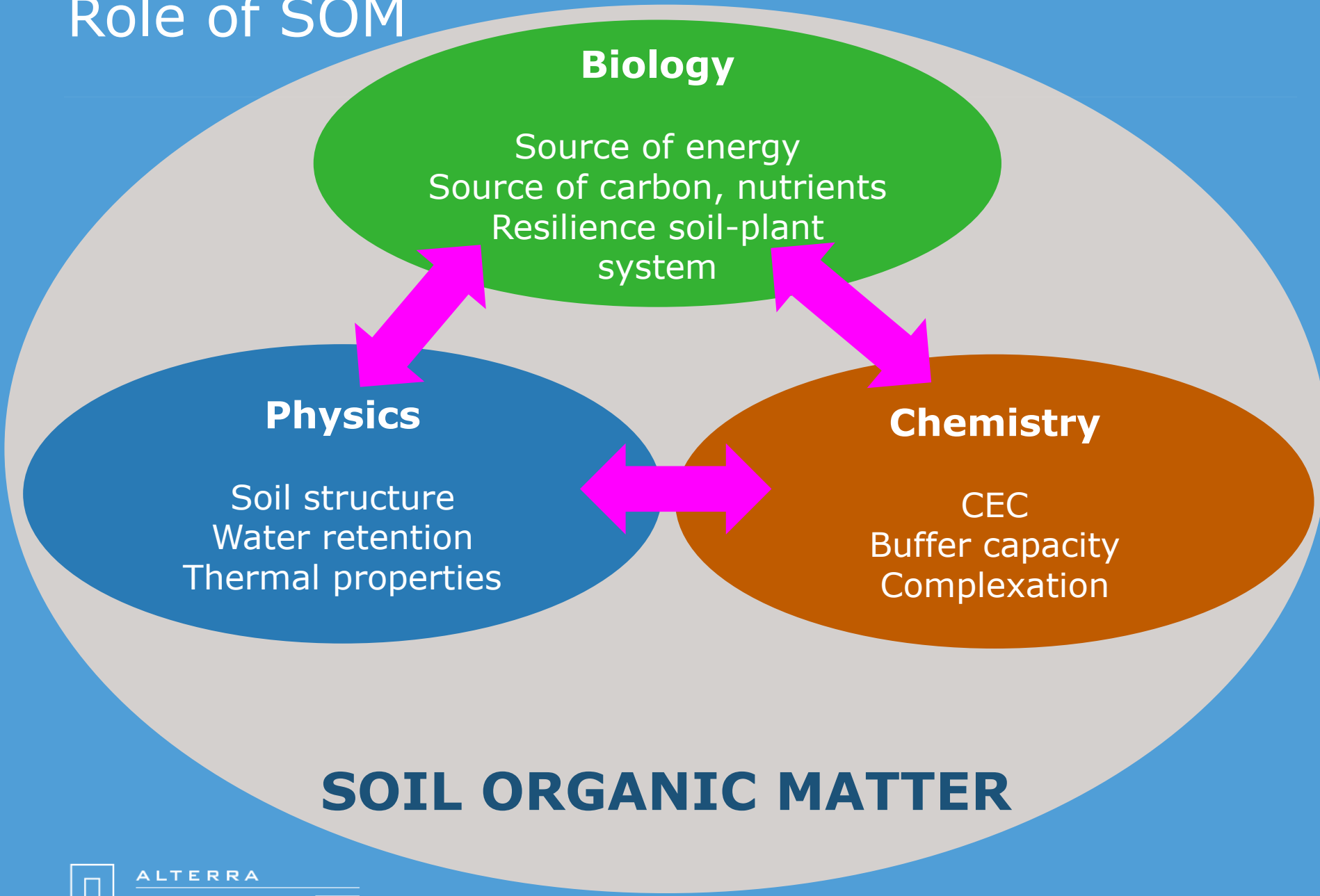
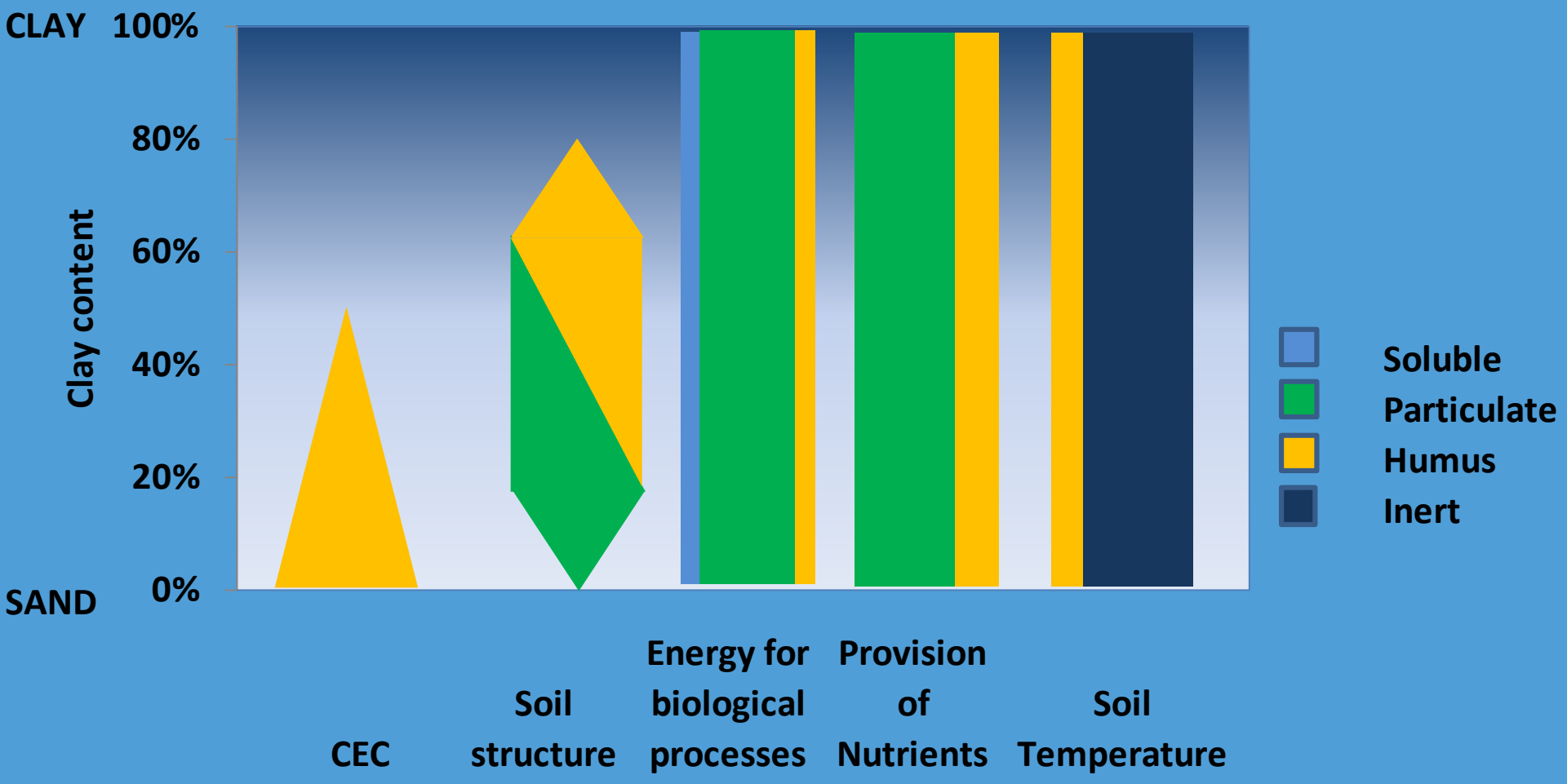
BCD 2013 Biochars Composts Digestates
October 17 to 20, 2013 - Bari (Italy)

Role of SOM

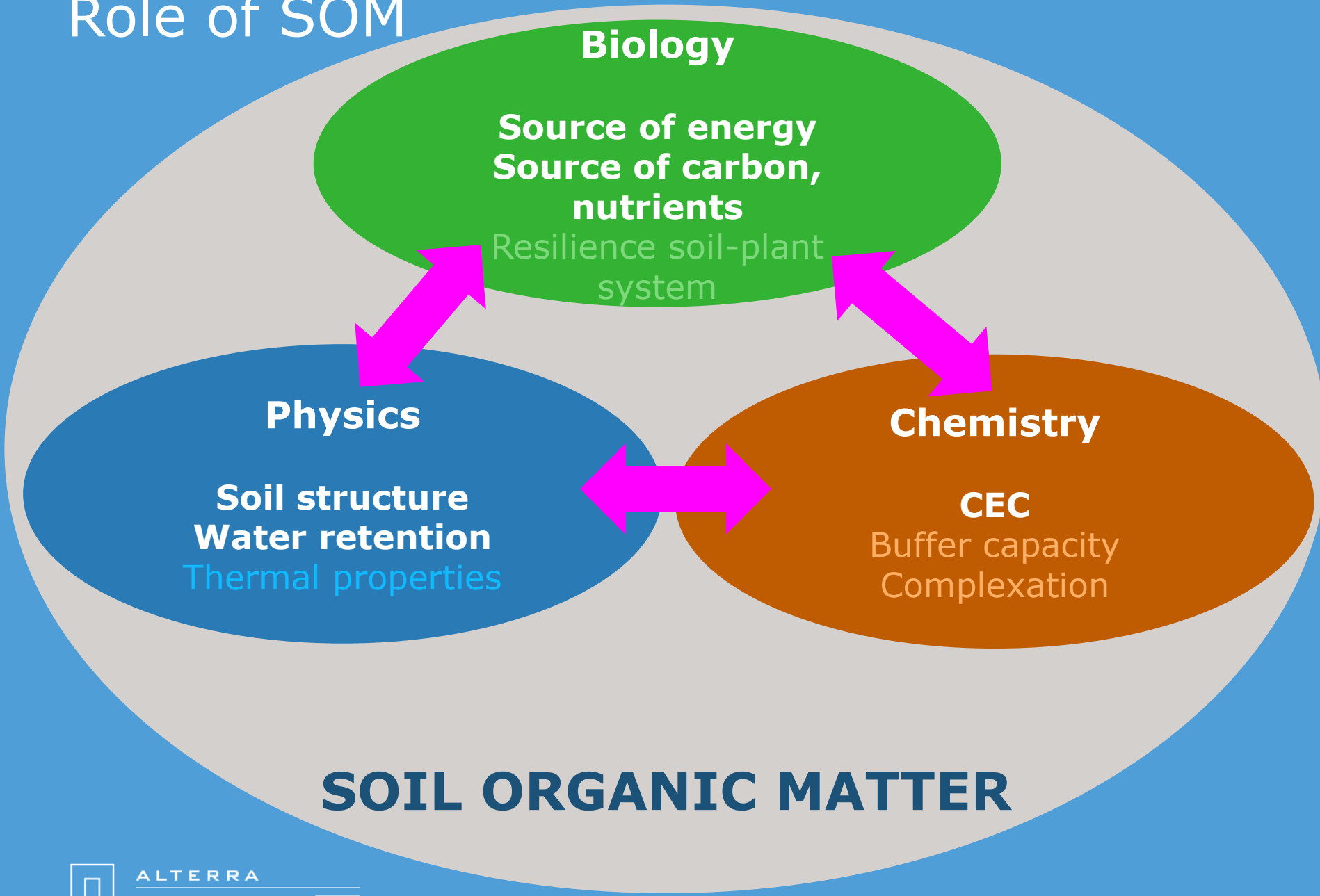

Biology
Source of energy
Source of carbon, nutrients
Resilience soil-plant system
Physics
Soil structure
Water retention
Thermal properties
Chemistry
CEC
Buffer capacity
Complexation
SOIL ORGANIC MATTER

SOM types in SOIL types



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

Role of SOM



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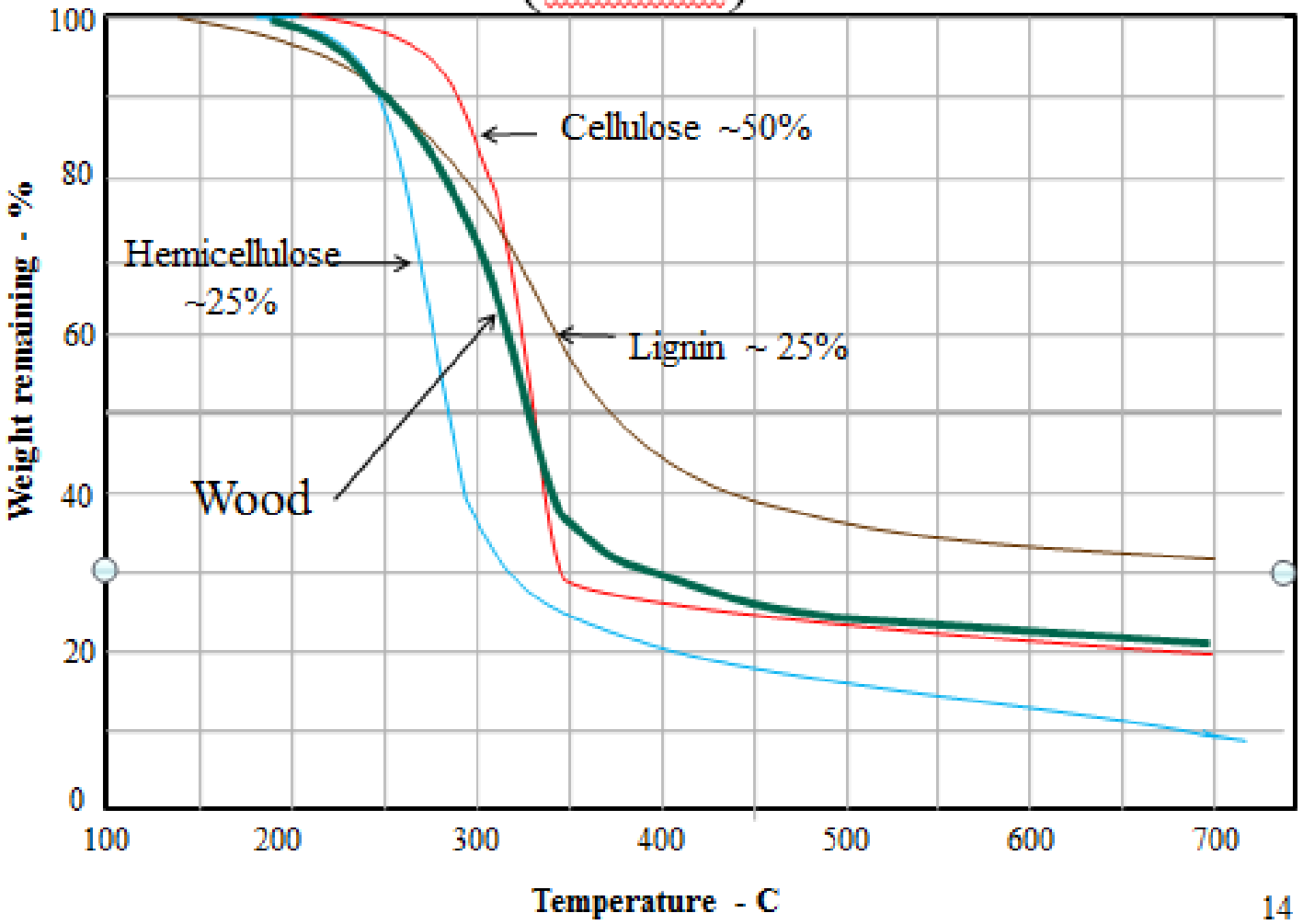
After Baldock and Skjemstad, 1999

Pyrolysis of Biomass Components (TGA)



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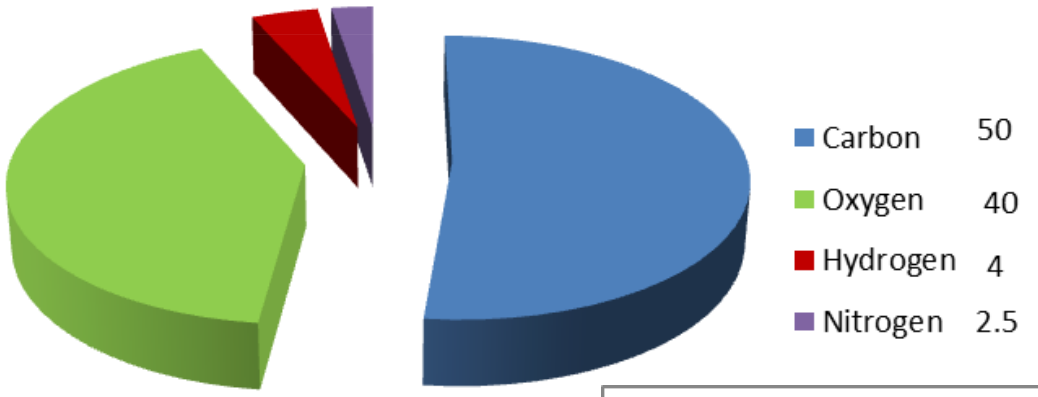
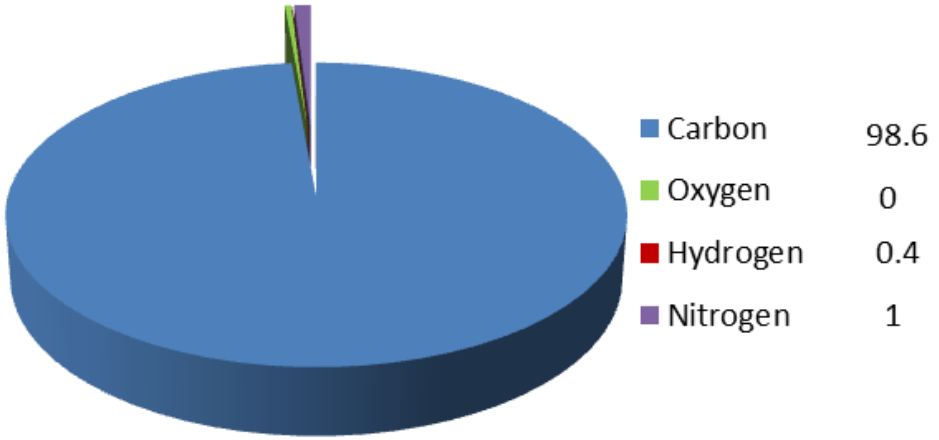
Reed and McLaughlin North American Biochar 2009

Natural Organic Matter



Biochar



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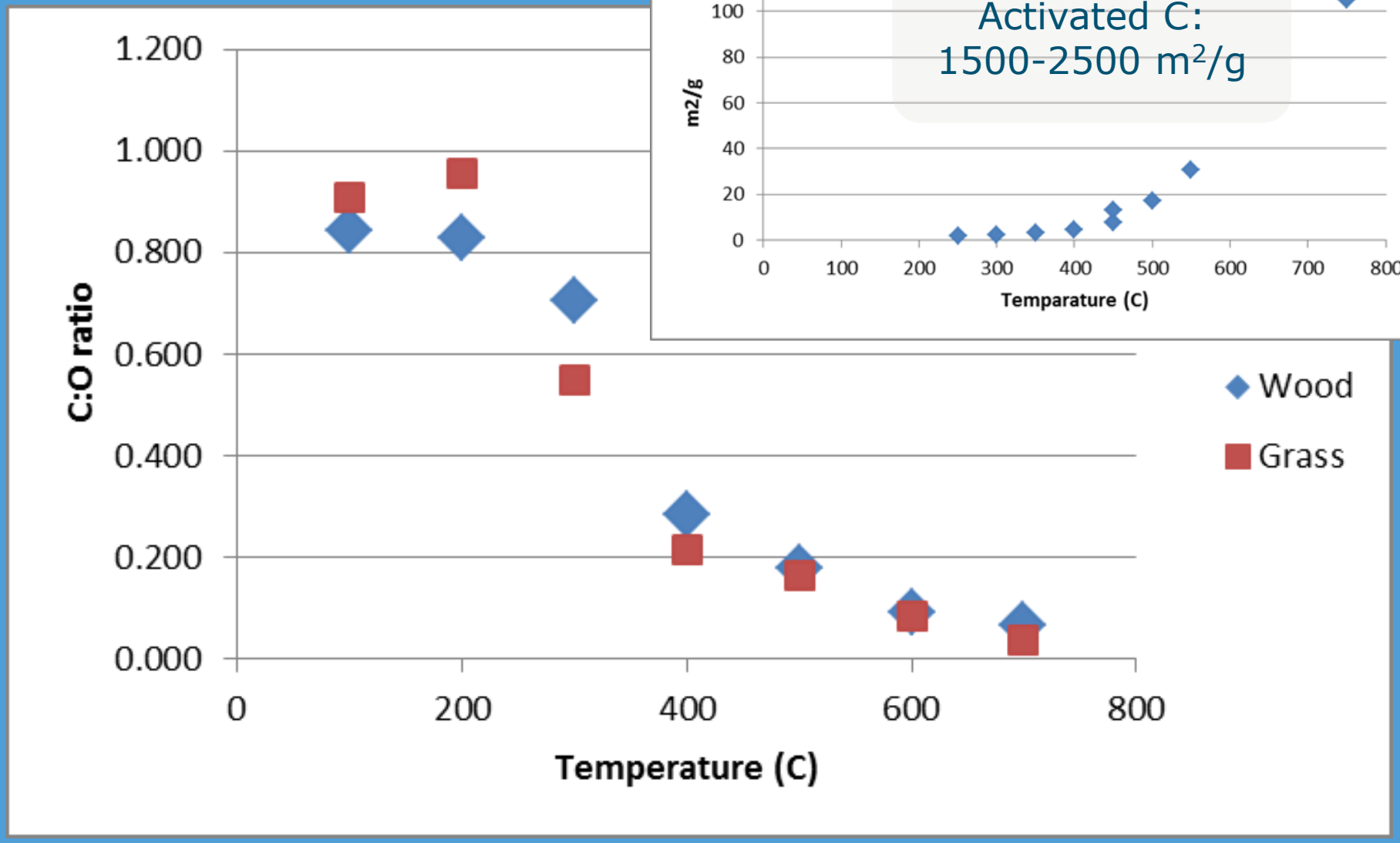
http://www.treepower.org/biochar/main.html

Pyrolysis conditions



Activated C:
1500-2500 m^2/g

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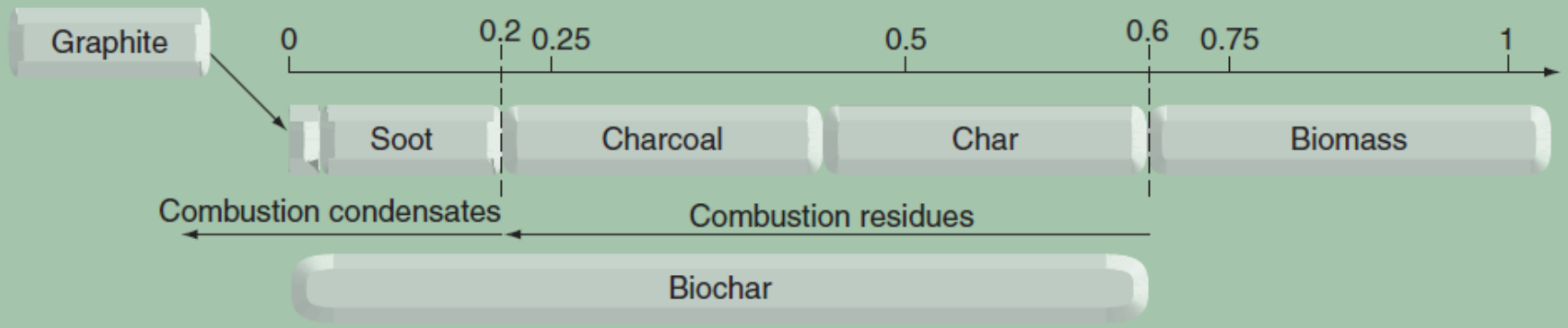
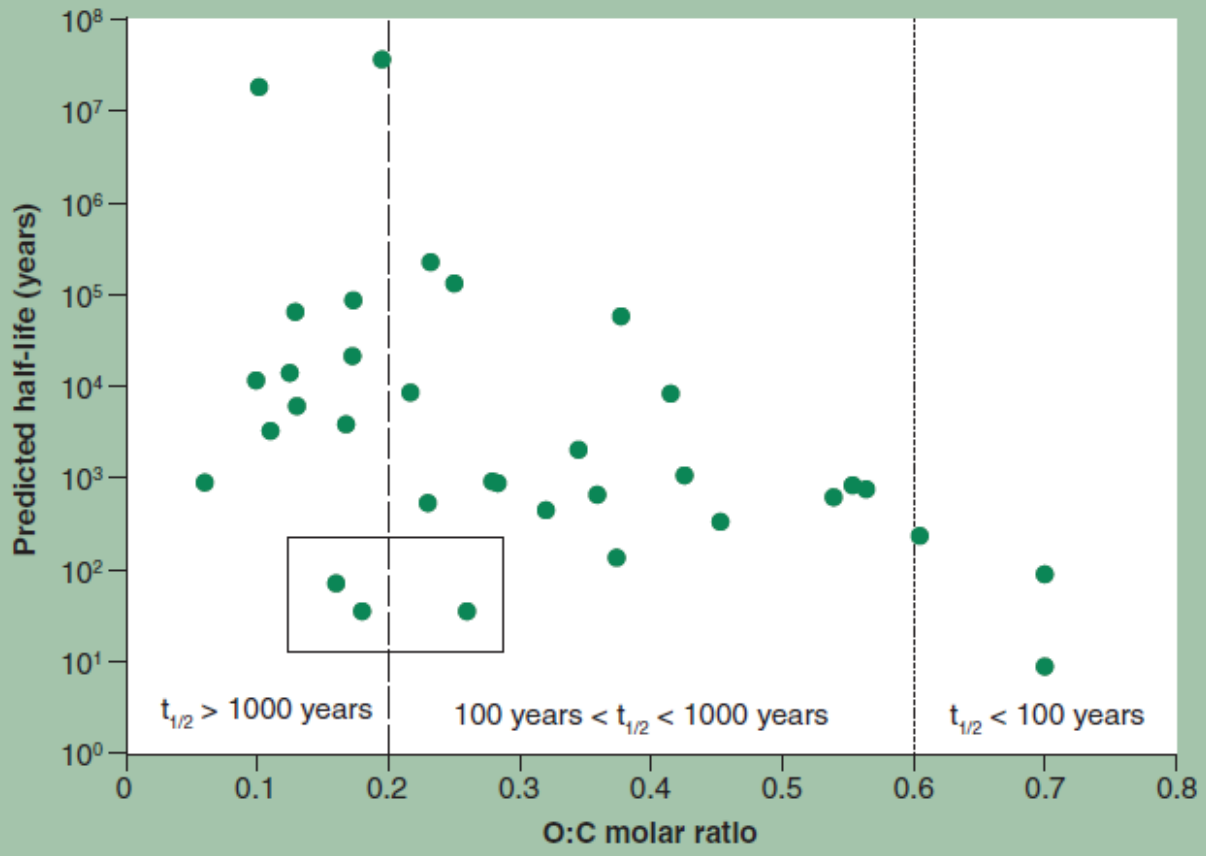
Keiluweit et al, (2010) Environ. Sci. Technol.

Biochar Carbon & Energy for micro-organisms

- Thermodynamically: No problem
- Enzymatically: ??, especially at low O:C ratio's
- CO_2 evolution: Low





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

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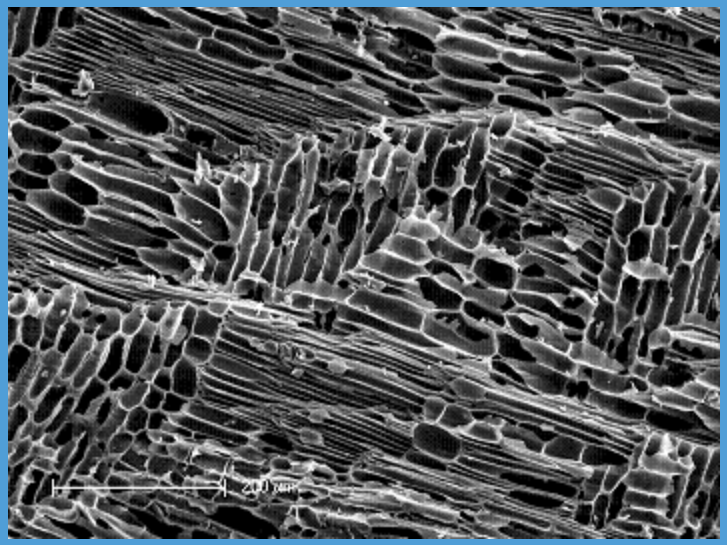
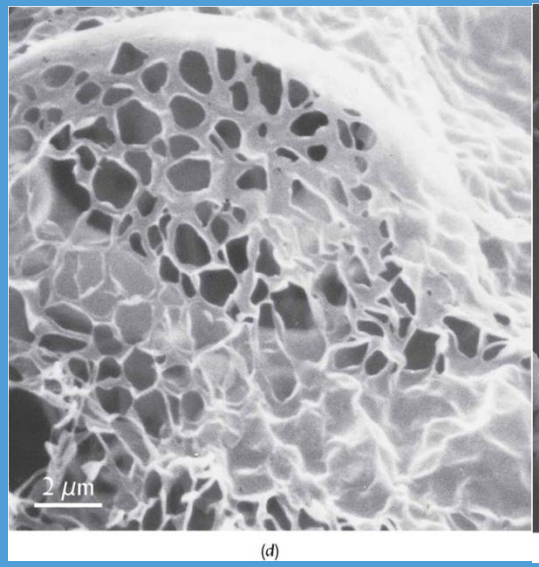
Biochar Refuge for micro-organisms

Biochar

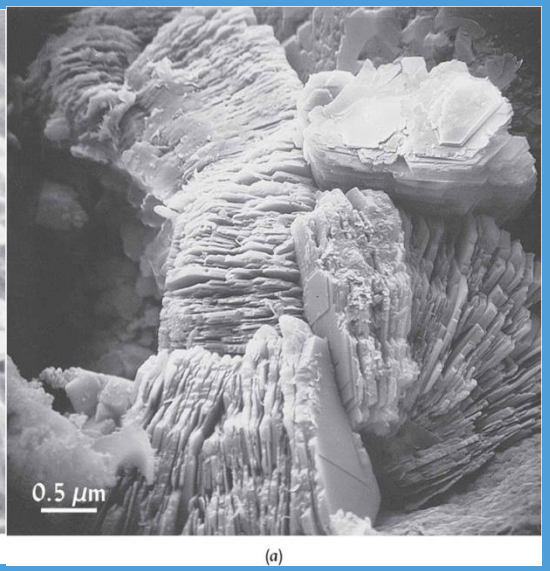


Sohi et al (2009)

Humic acid



Clay



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

Hydrophobic interaction Fluidized bed reactor

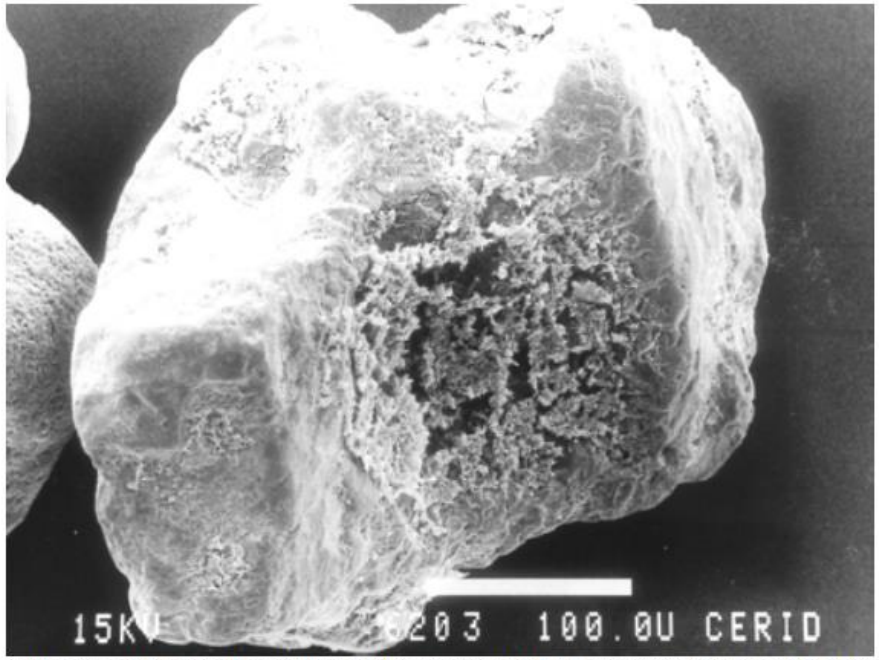


Figure 4. Representative sand particle partially covered with an anaerobic biofilm of thin thickness.

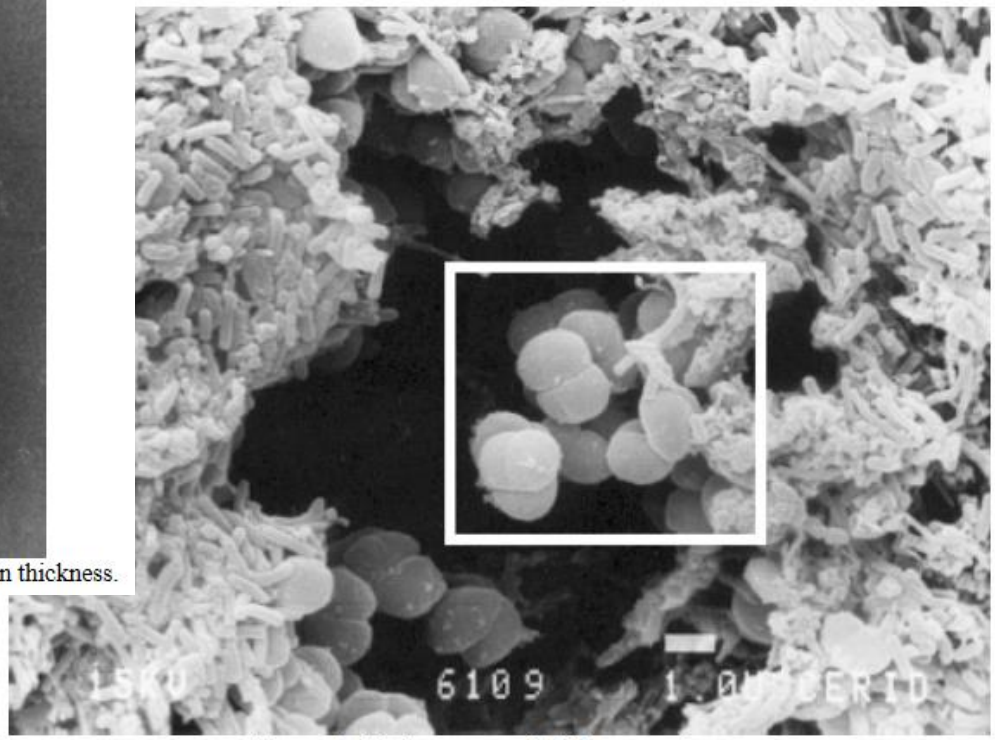
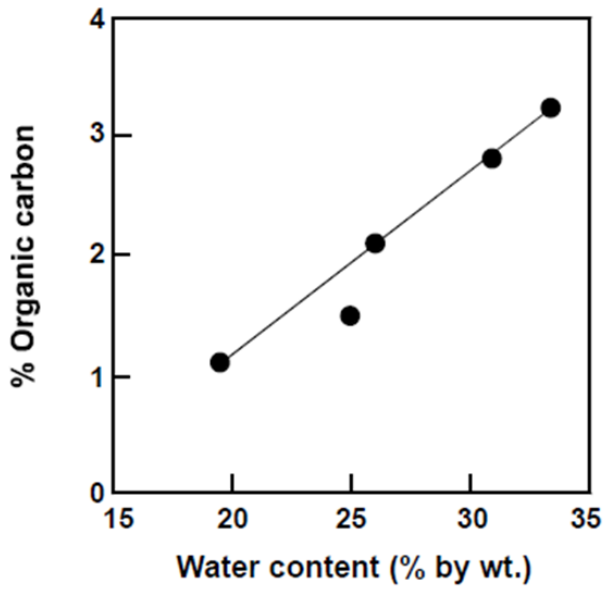


Figure 3. Methanogens: *Methanosarcina sp*

Mussati et al, 2005

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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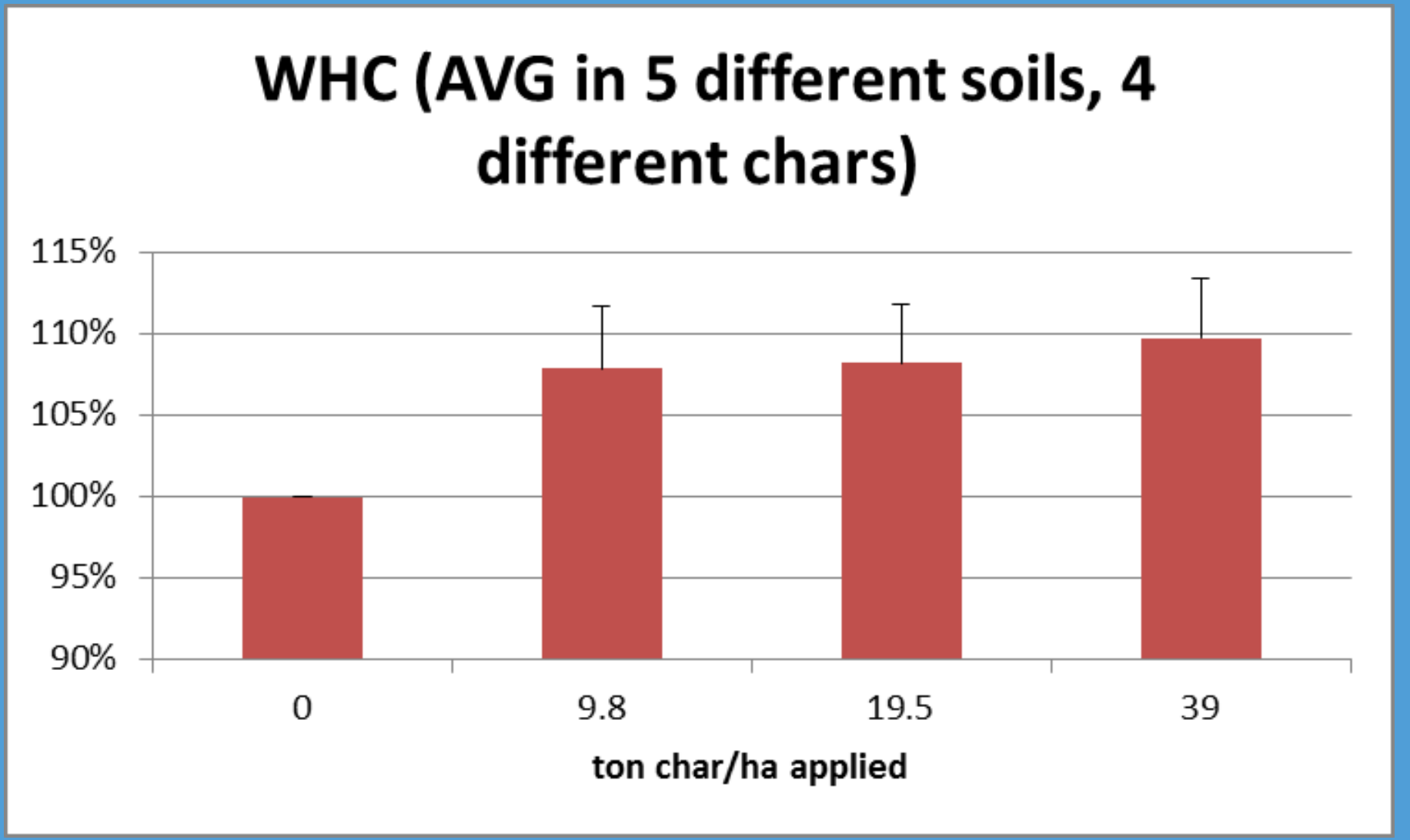
WHC effect biochar



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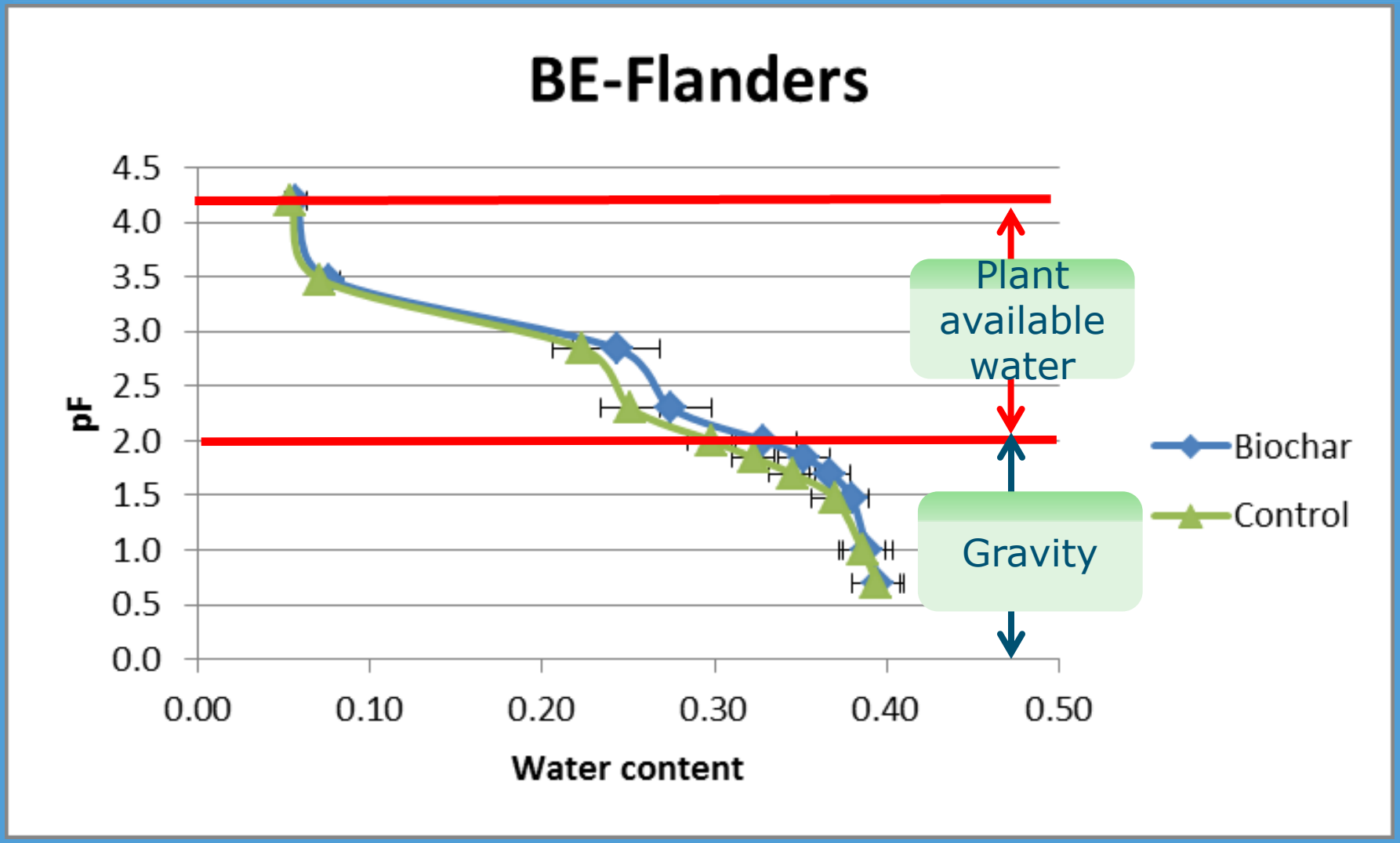
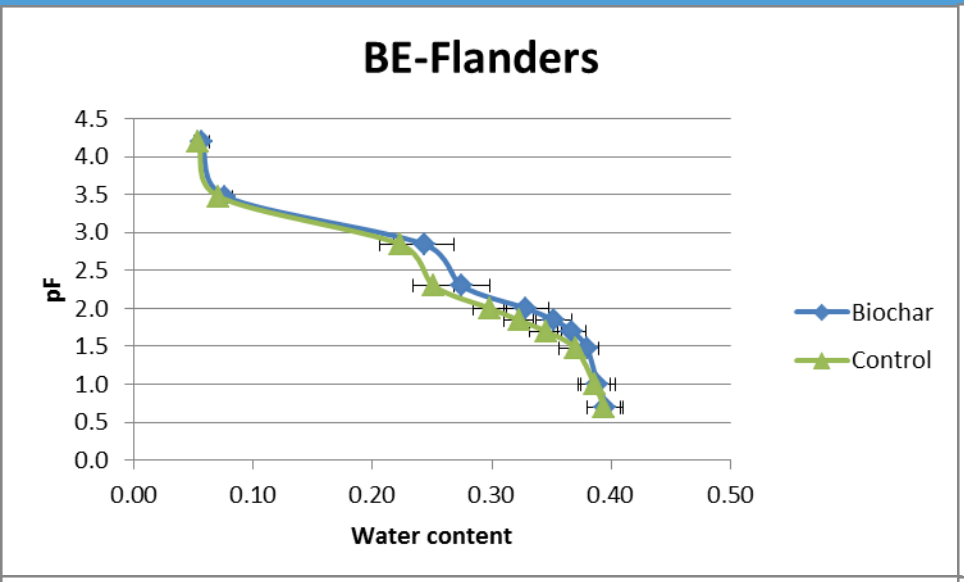
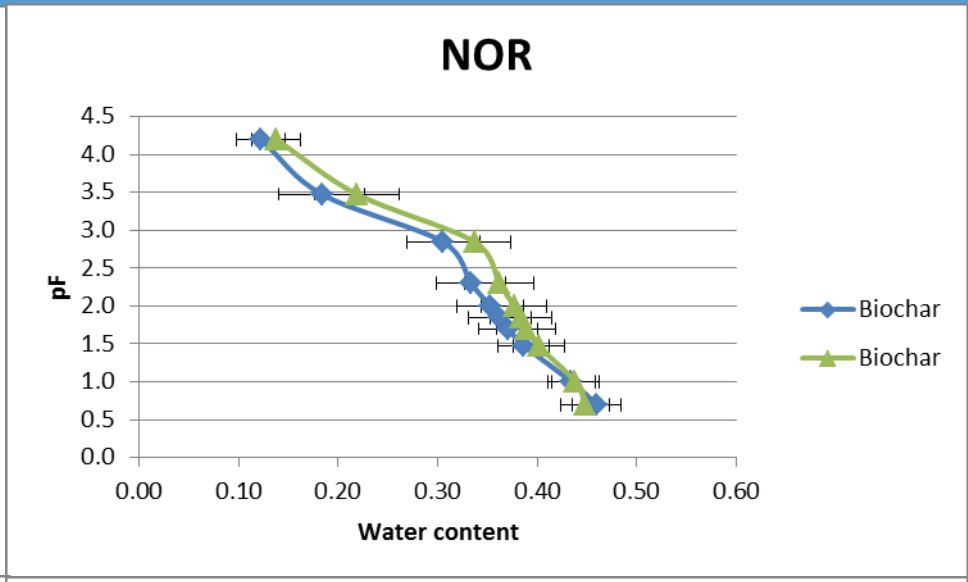
Streubel et al, 2011, JSSSA, 75:1402-1413

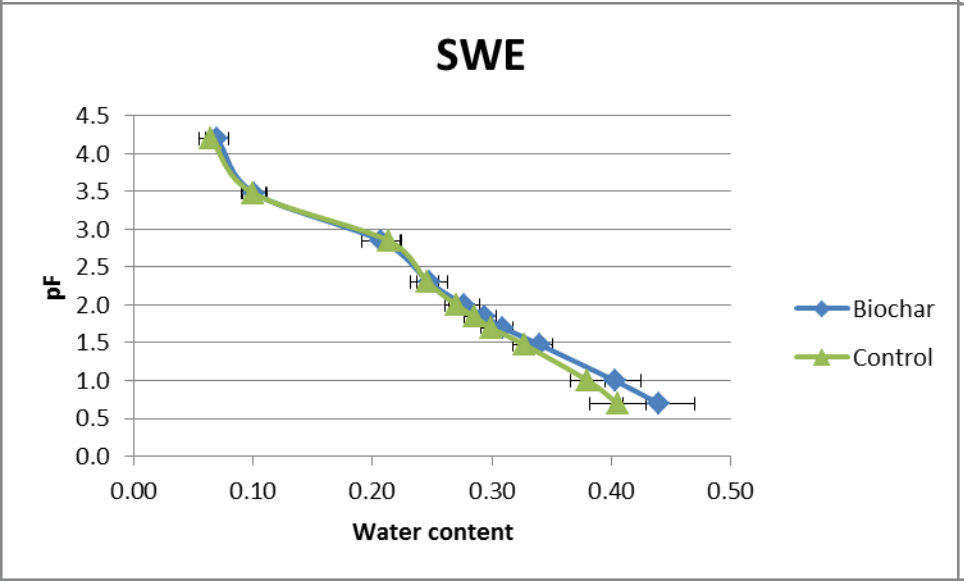
Water retention

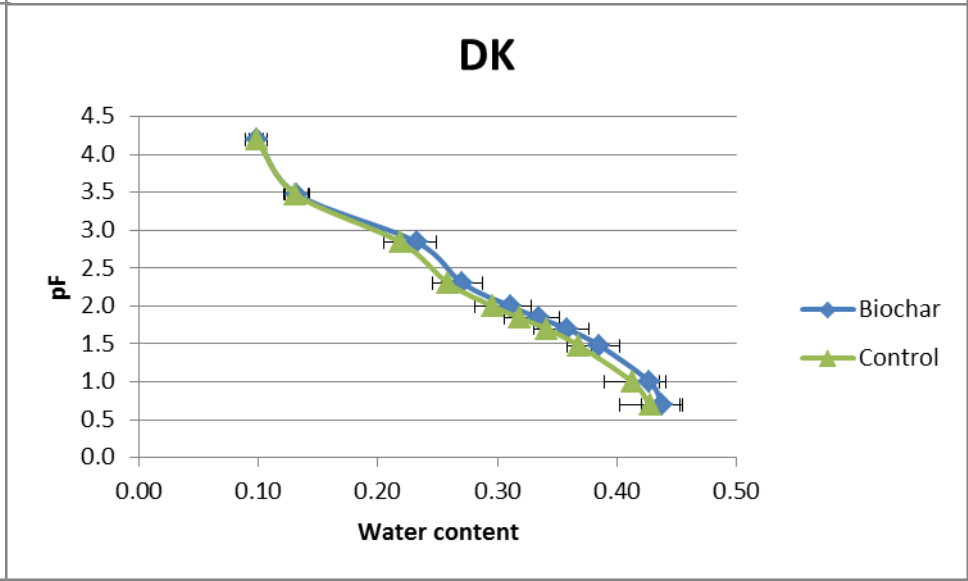


Water retention Interreg Biochar Project

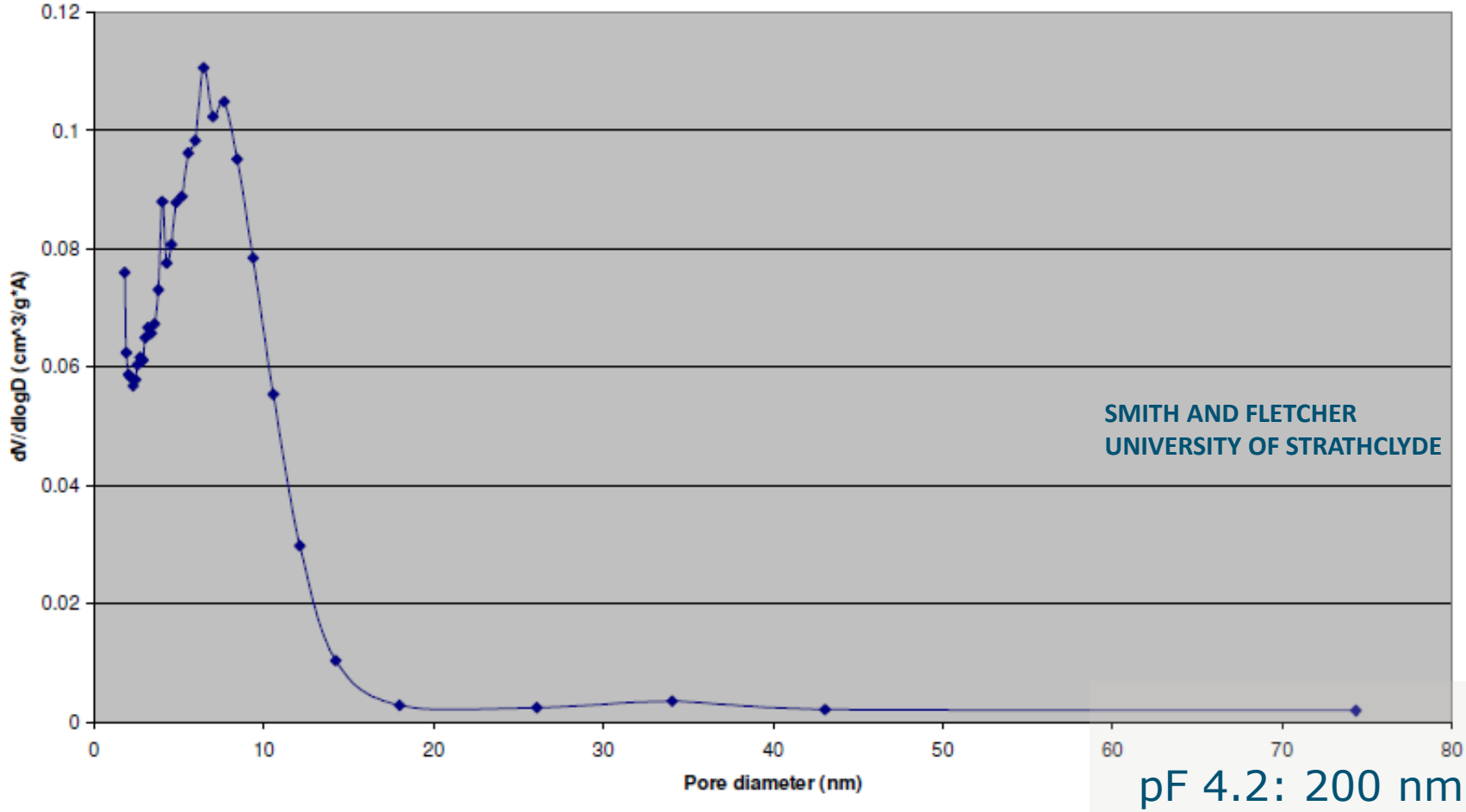








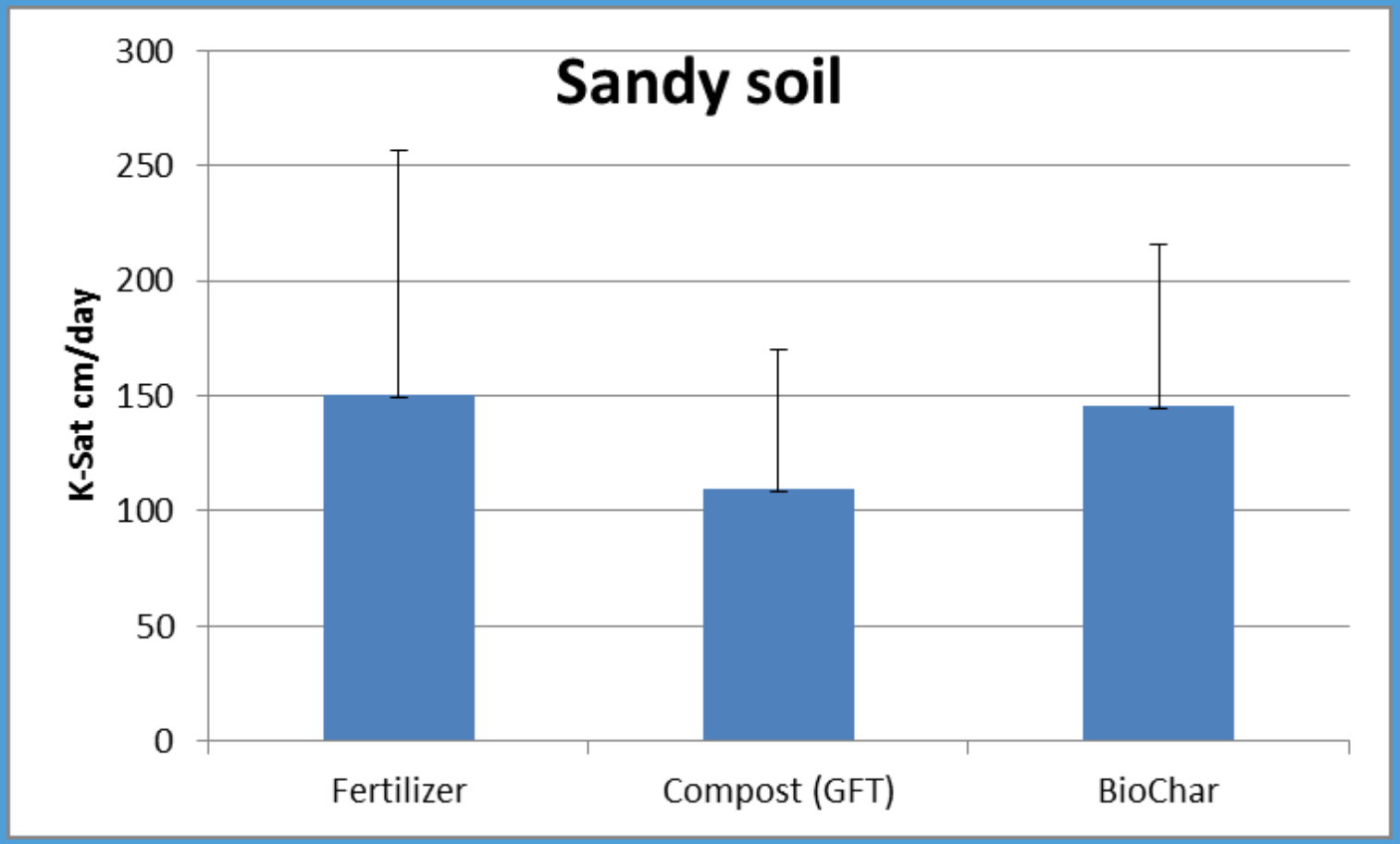
Pore size distribution



pF 4.2: 200 nm

FIGURE 2.4: PORE SIZE DISTRIBUTION FOR COARSE CHAR

Water infiltration Interreg Biochar Project



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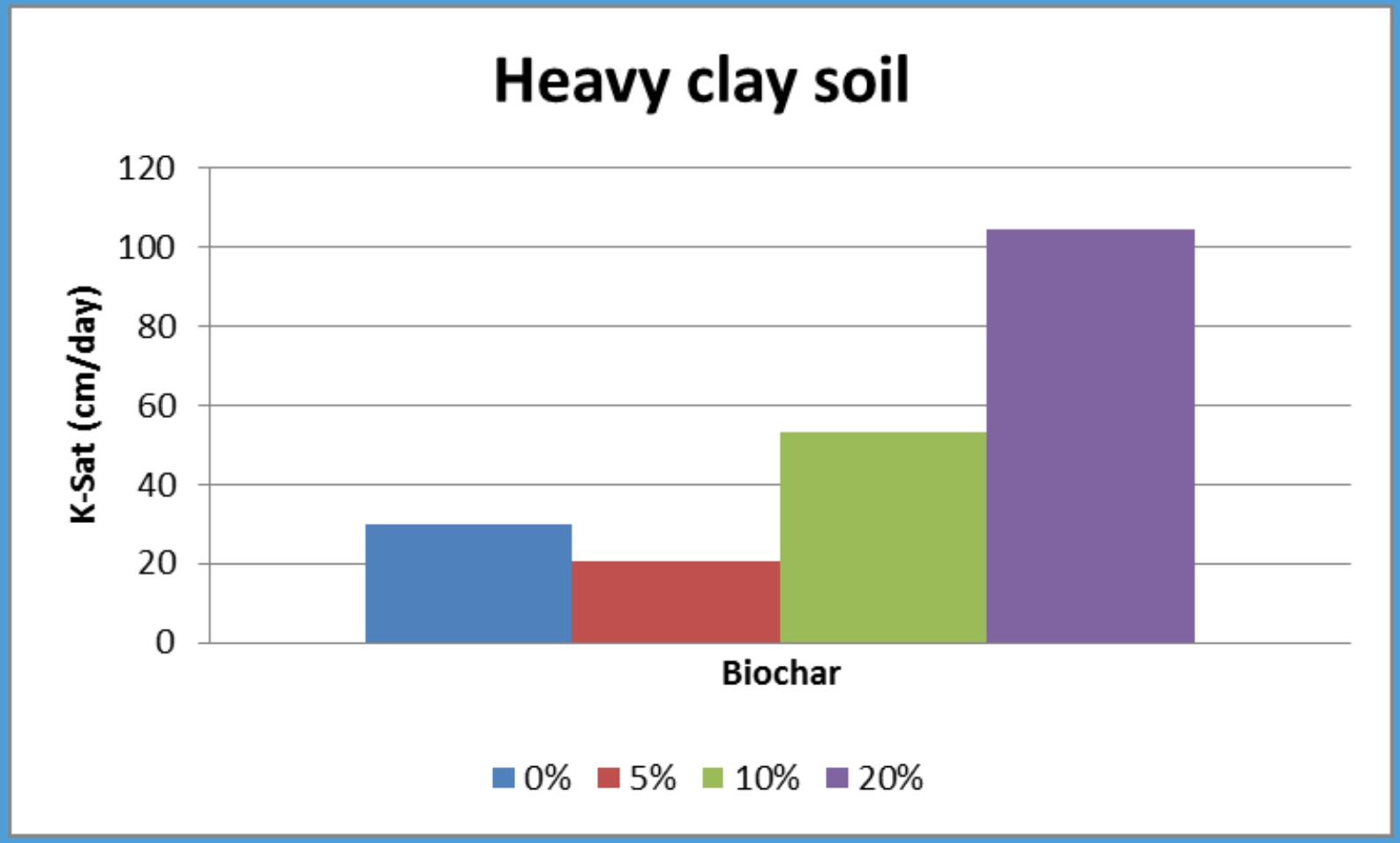
Water infiltration Interreg Biochar Project



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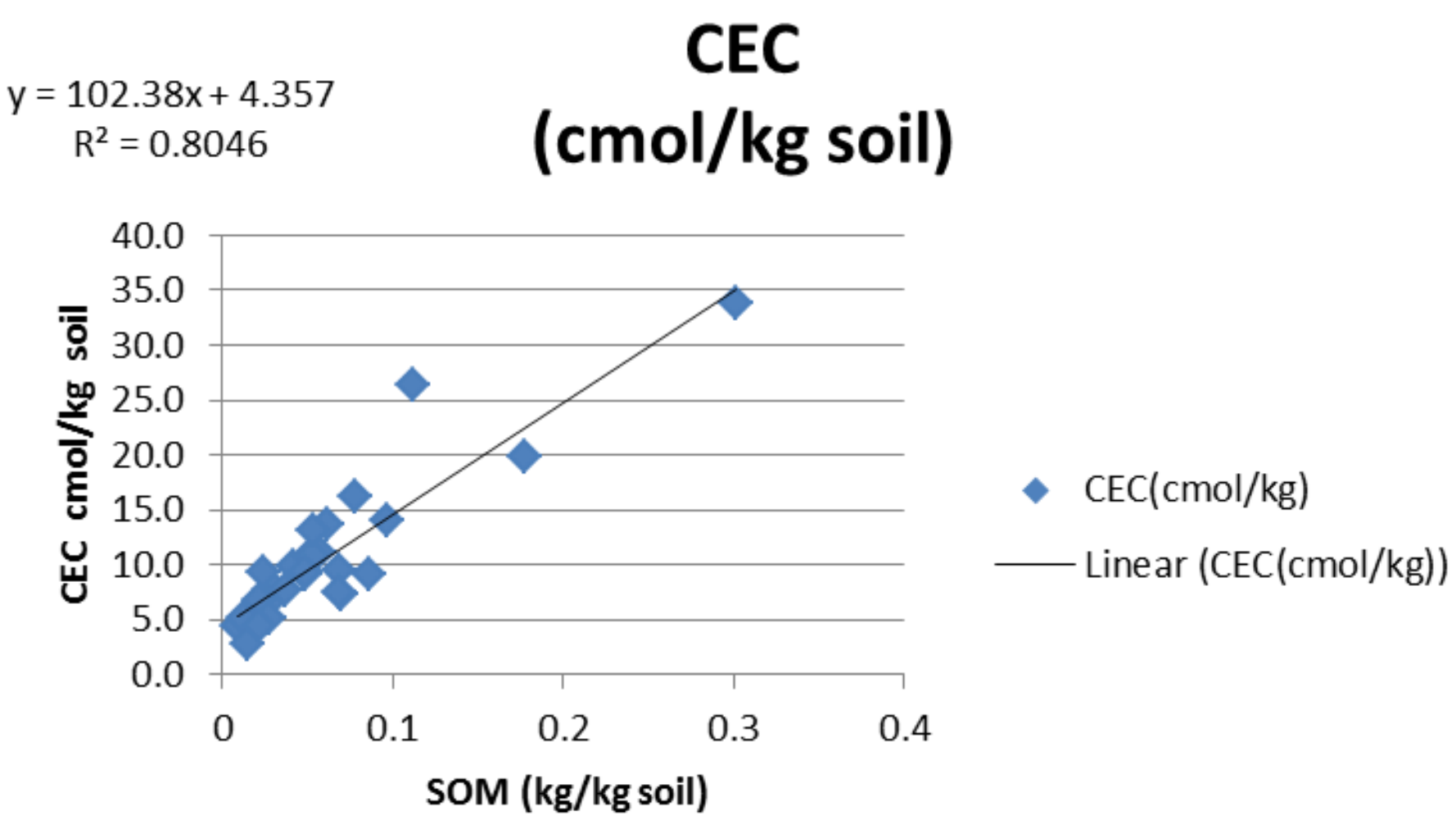
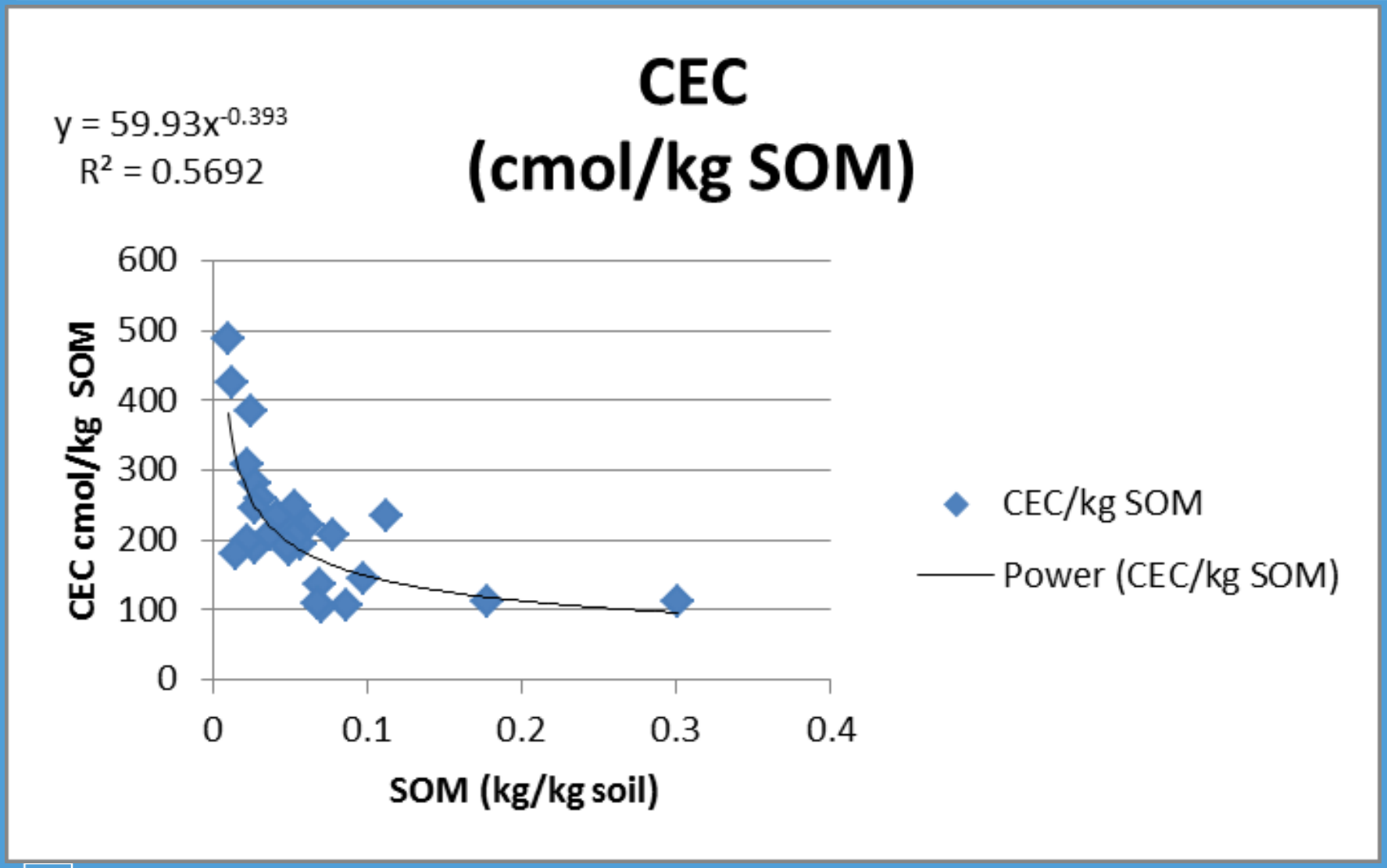
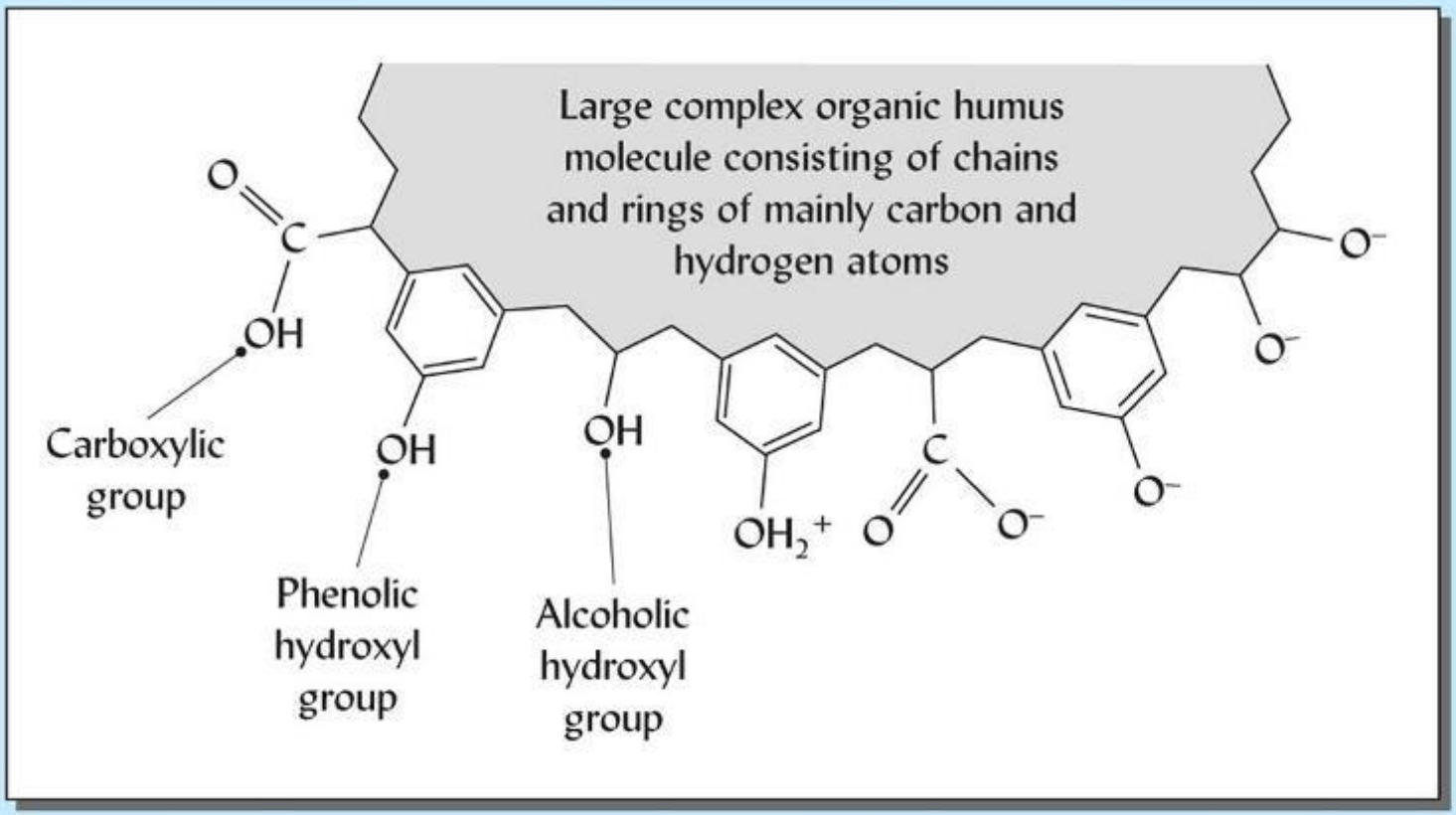
CEC reclaimed peat soils

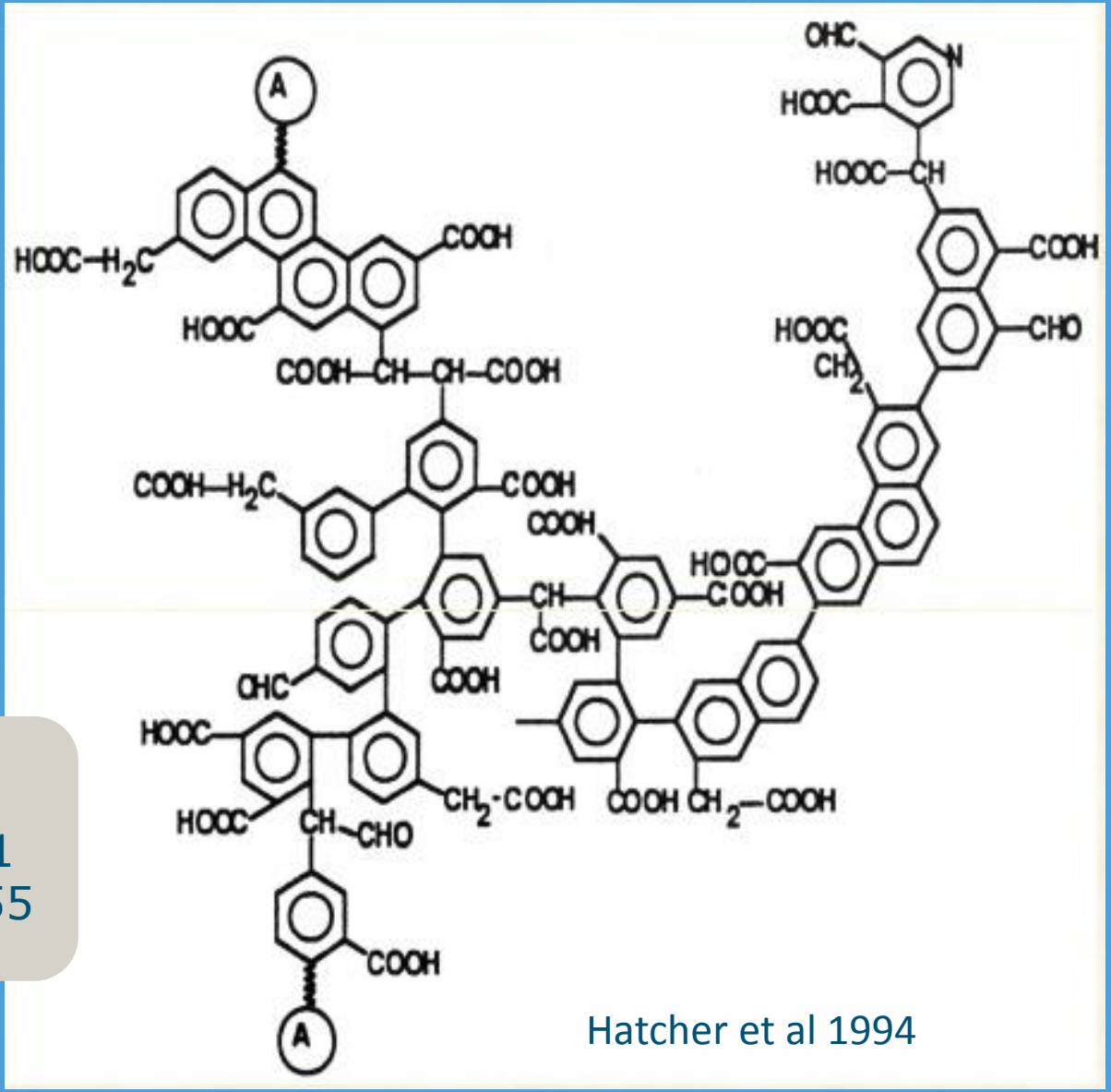


CEC reclaimed peat soils




Large complex organic humus molecule consisting of chains and rings of mainly carbon and hydrogen atoms
O
C
OH
Carboxylic group
OH
Phenolic hydroxyl group
OH
Alcoholic hydroxyl group
OH_2^+
C
O
O⁻
O⁻
O⁻
O⁻

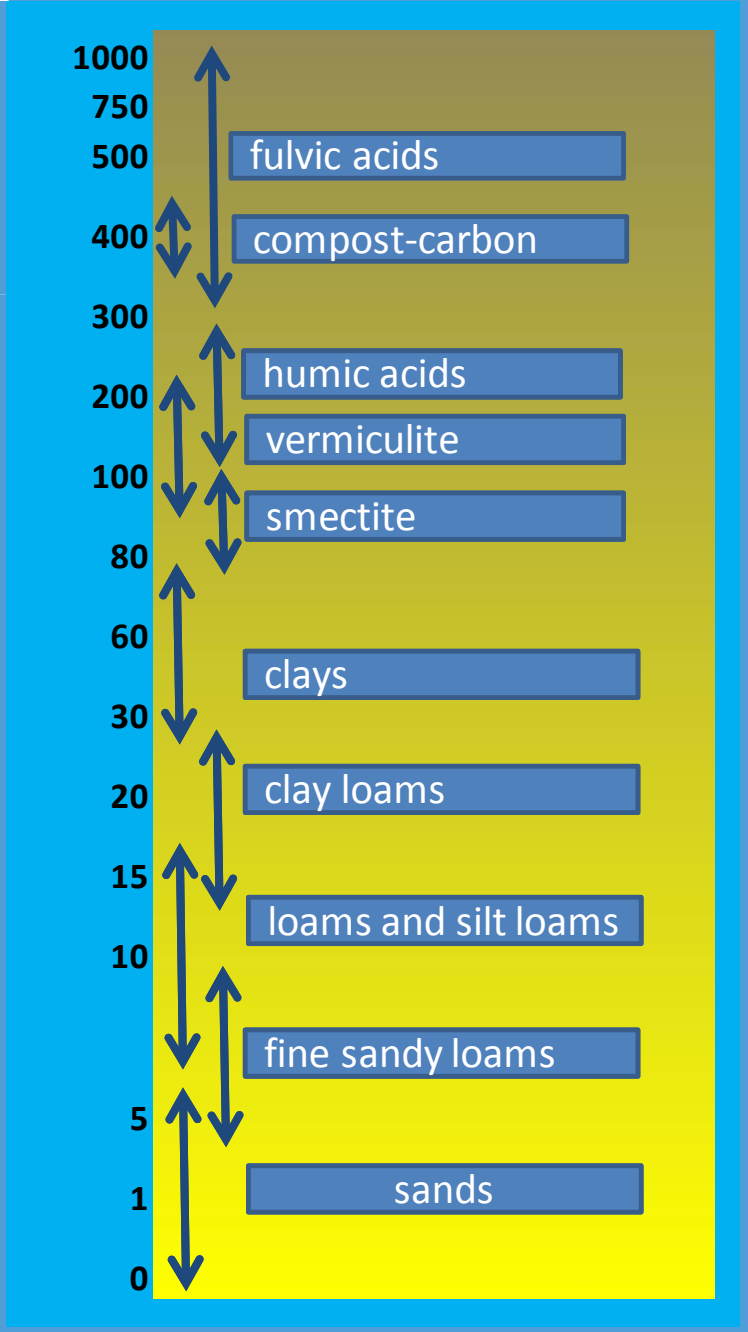
Humic Acid structure

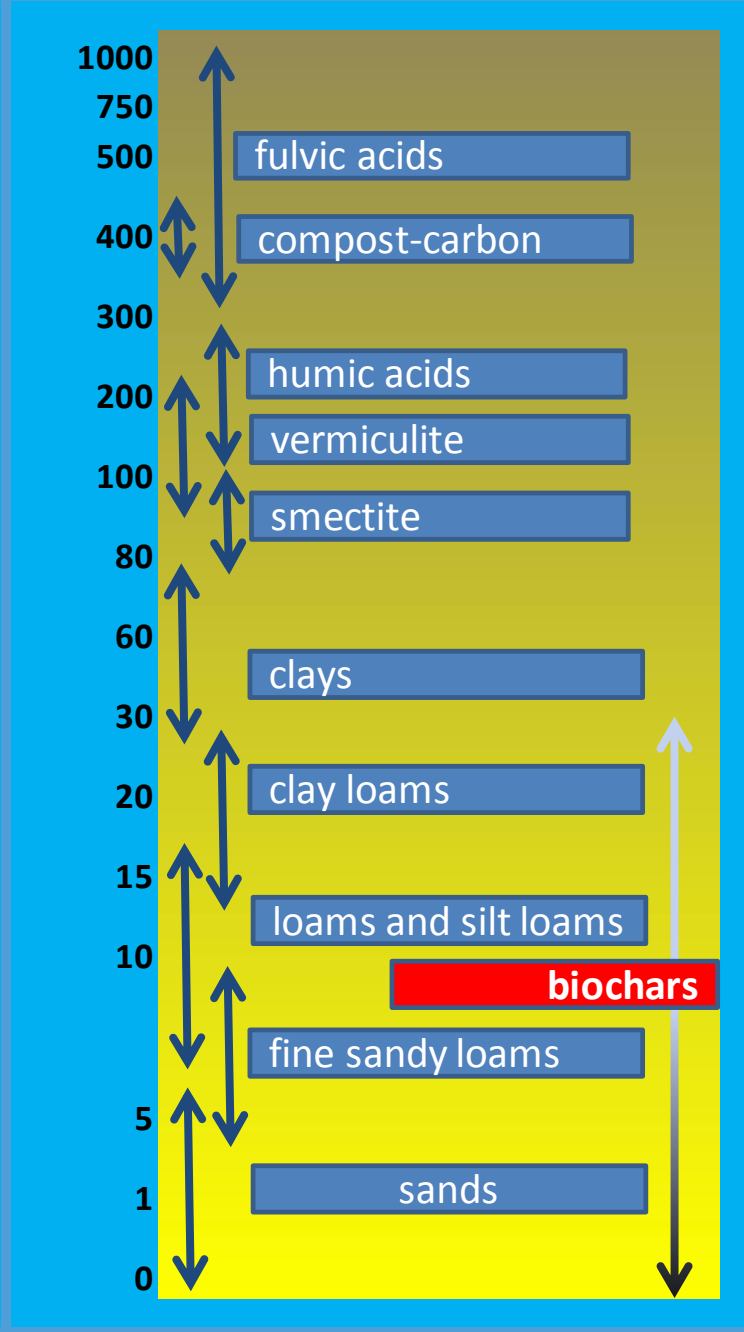


Hatcher et al 1994

C:O
Fulvic acids: 1
Humic acids : 0.55

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
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
biochars
fine sandy loams
sands

Modification of Biochar

- Activation (?)
- Adsorption of SOM
- Biological modification (?)
- Chemical modification
    - Functional groups CEC
    - Functional groups AEC (NR_4^+)

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