Modification of Biochar to improve its functionality

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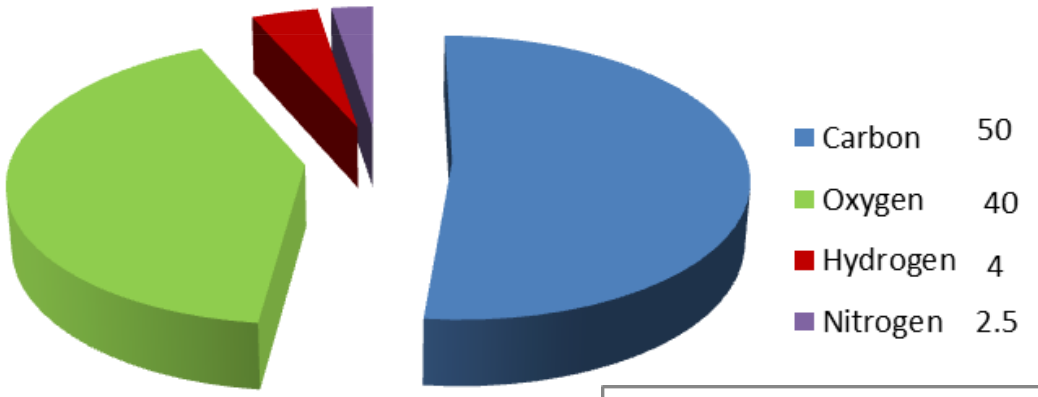
Vienna | Austria | 27 April – 02 May 2014

Biochar: To put the Genie back into the bottle?

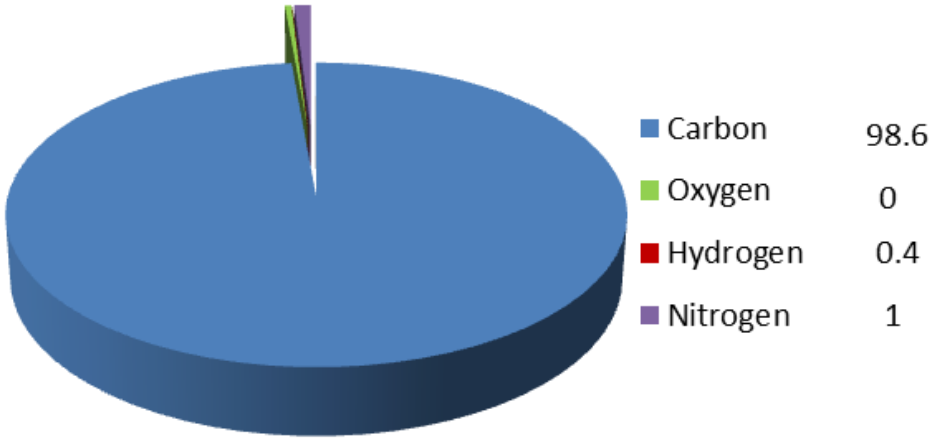
BIOCHAR is not similar to Soil Organic Matter

- Composition

Natural Organic Matter



Biochar



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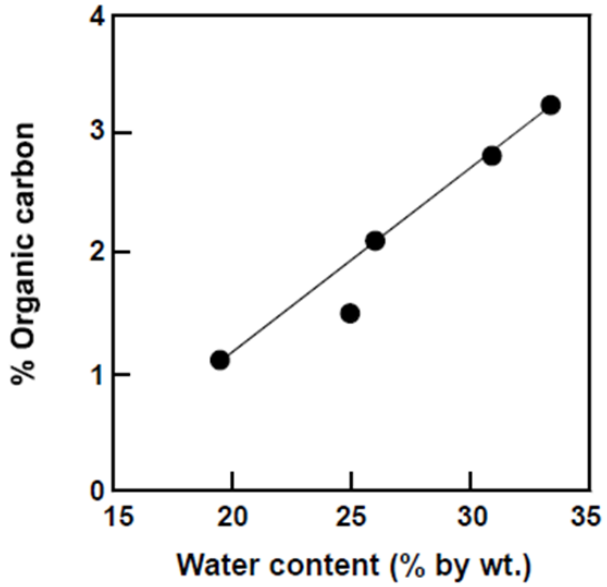
http://www.treepower.org/biochar/main.html

BIOCHAR is not similar to Soil Organic Matter

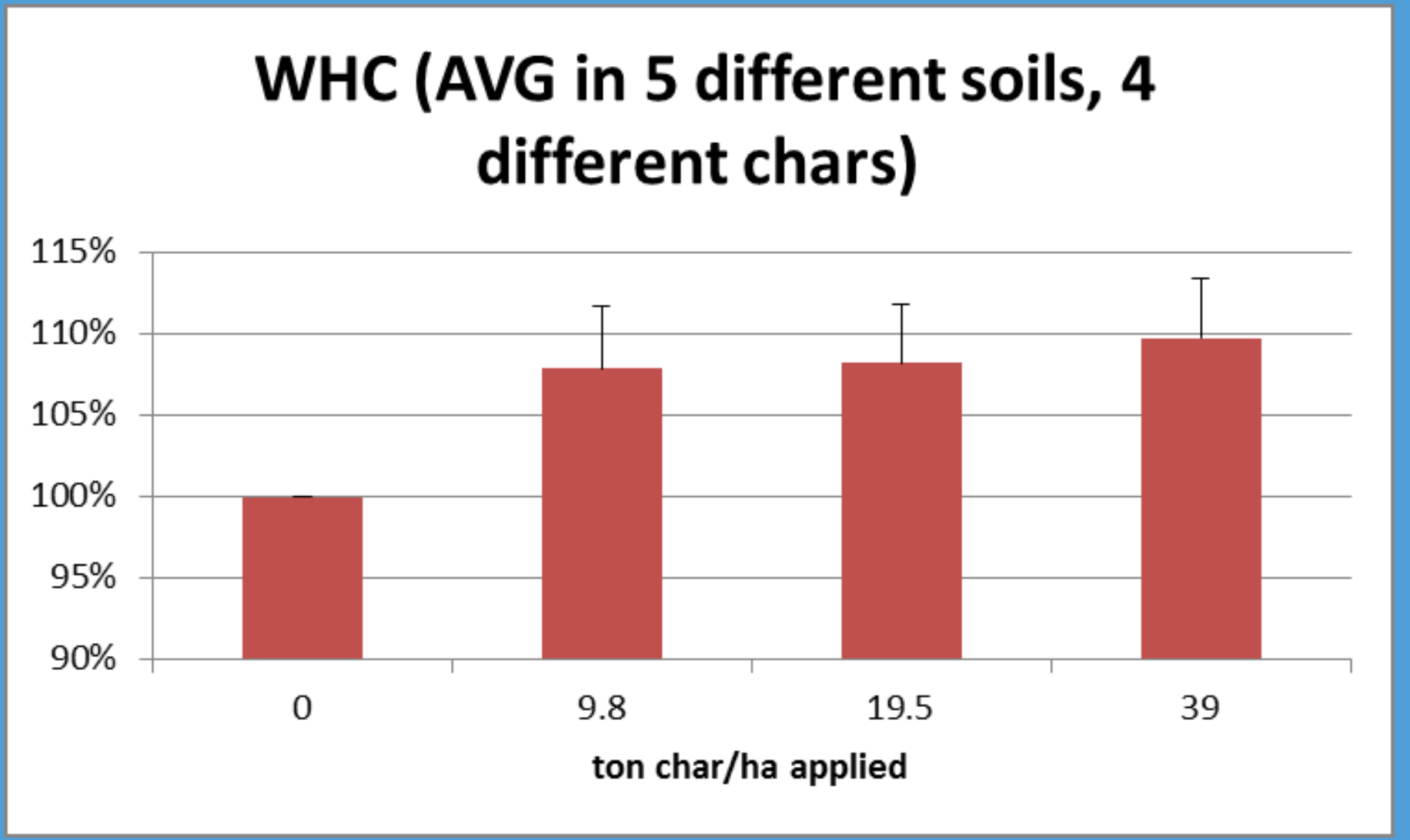
- Composition
- Water retention

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

WHC effect biochar



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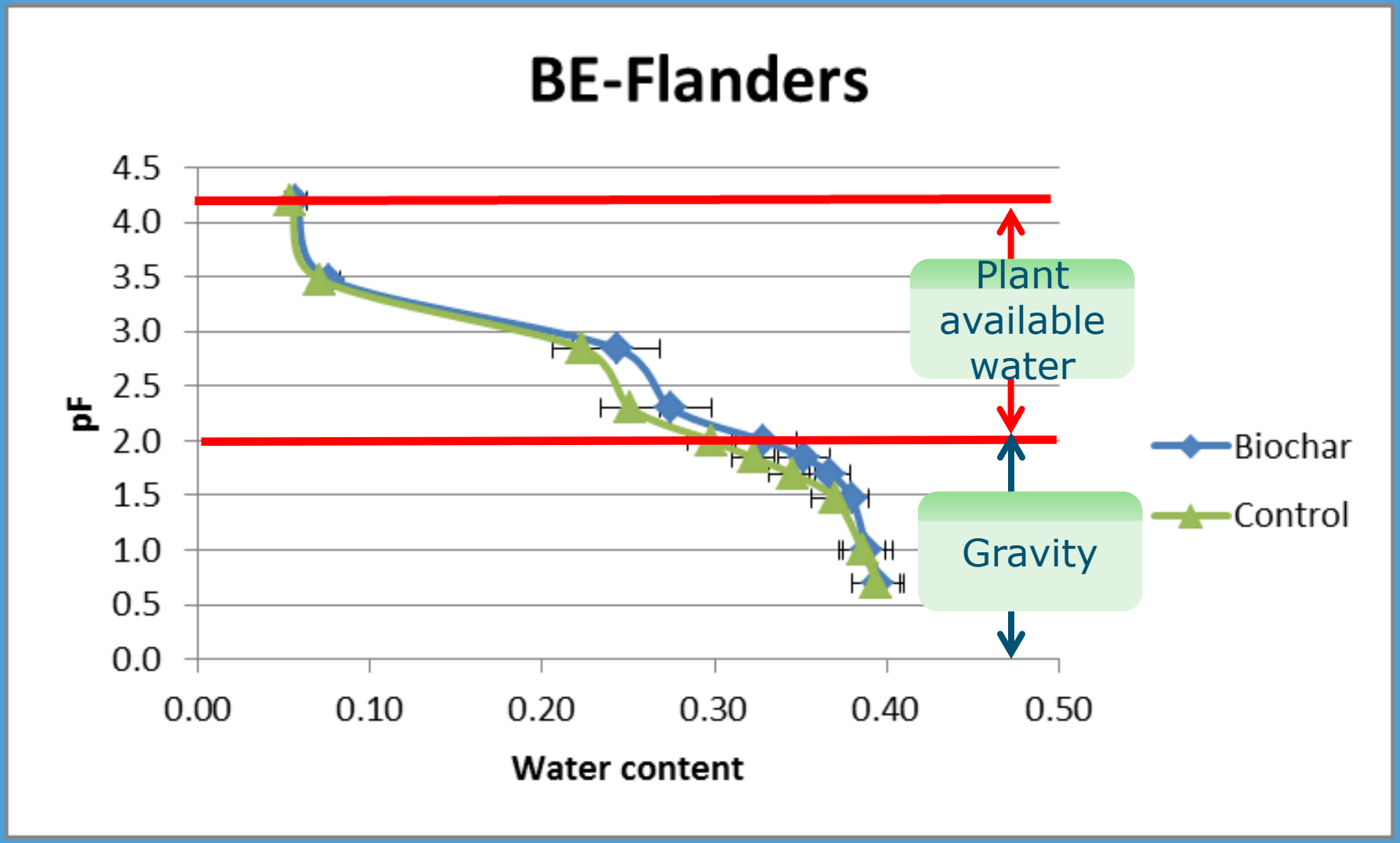
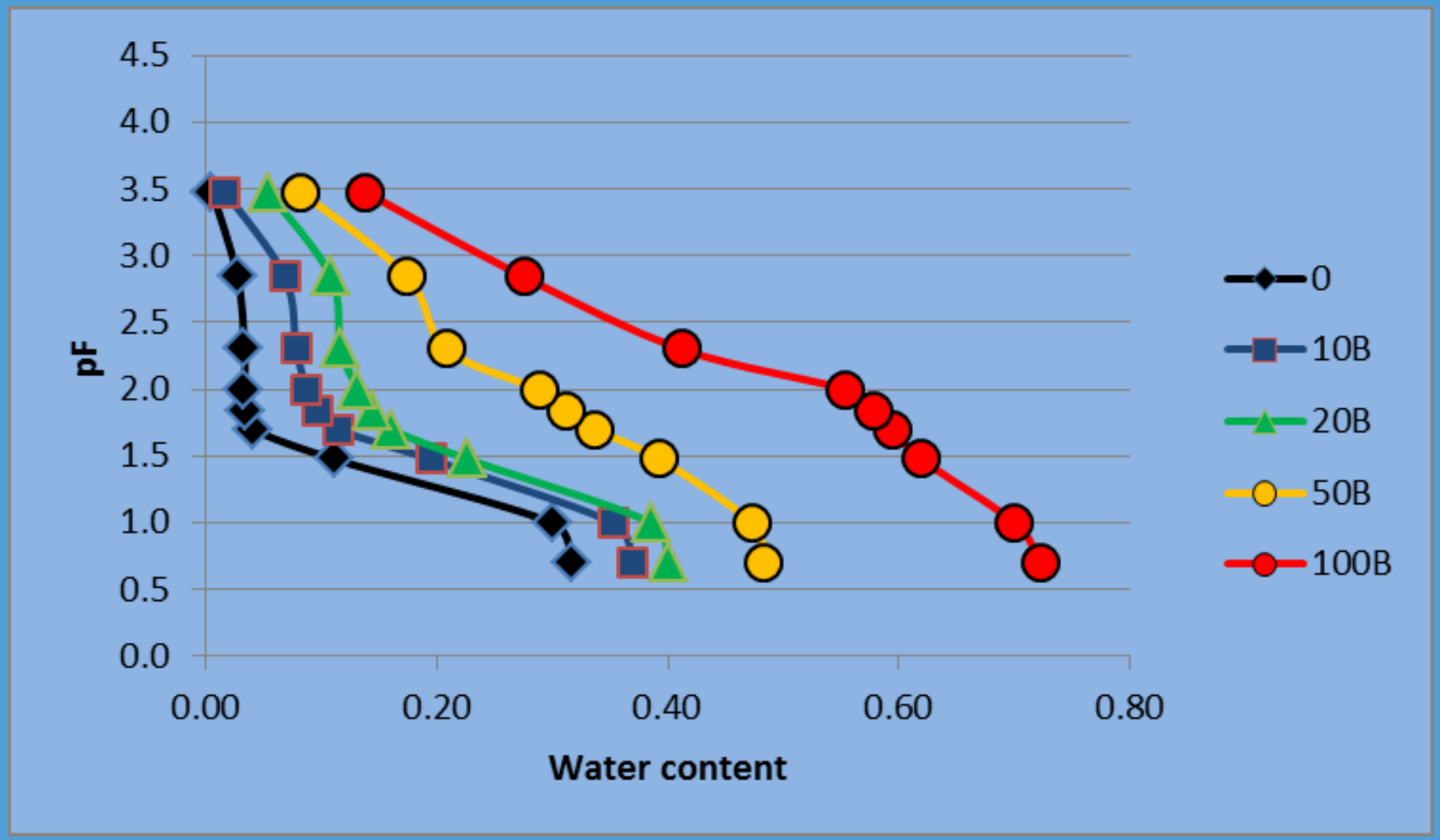
Streubel et al, 2011, JSSSA, 75:1402-1413

Water retention



Water retention Sand-Biochar mixtures



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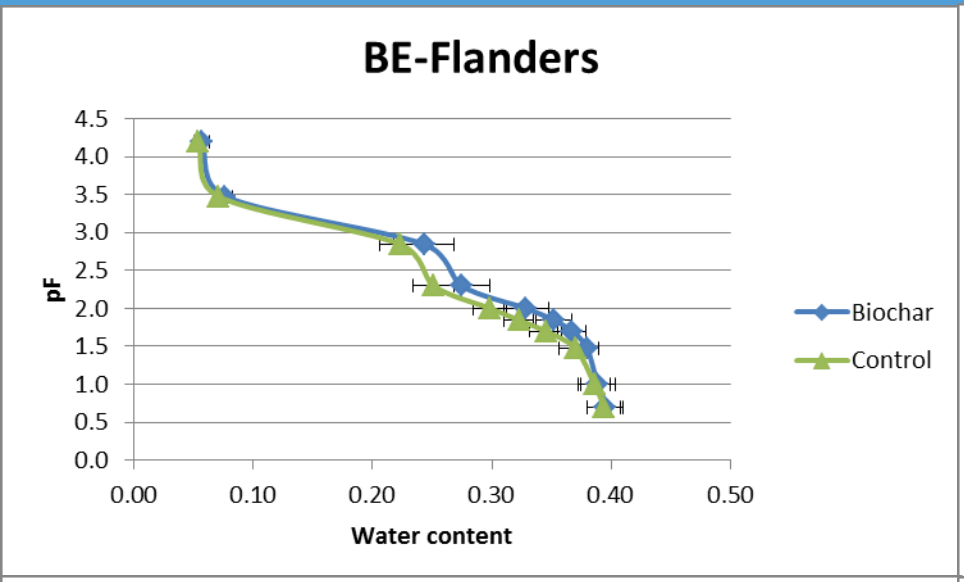
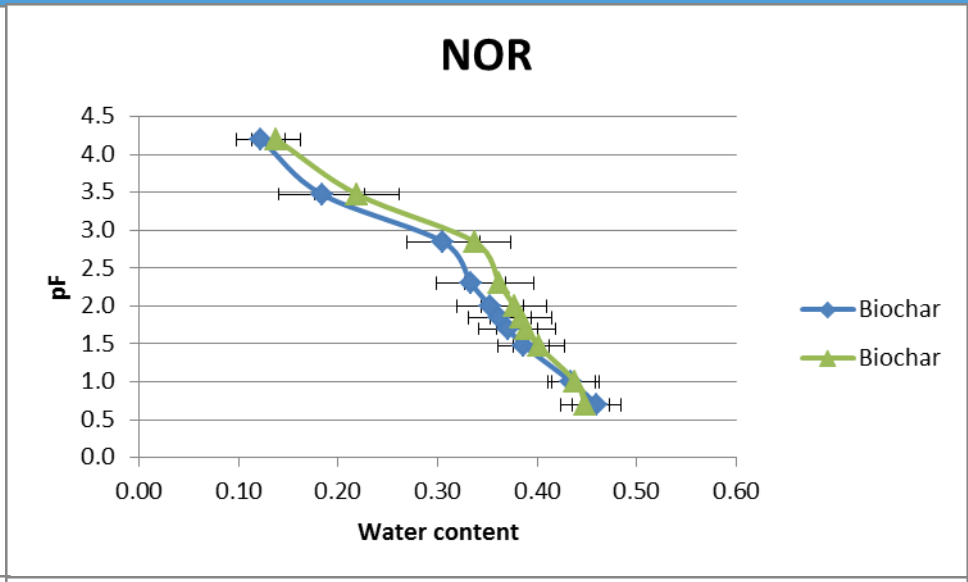
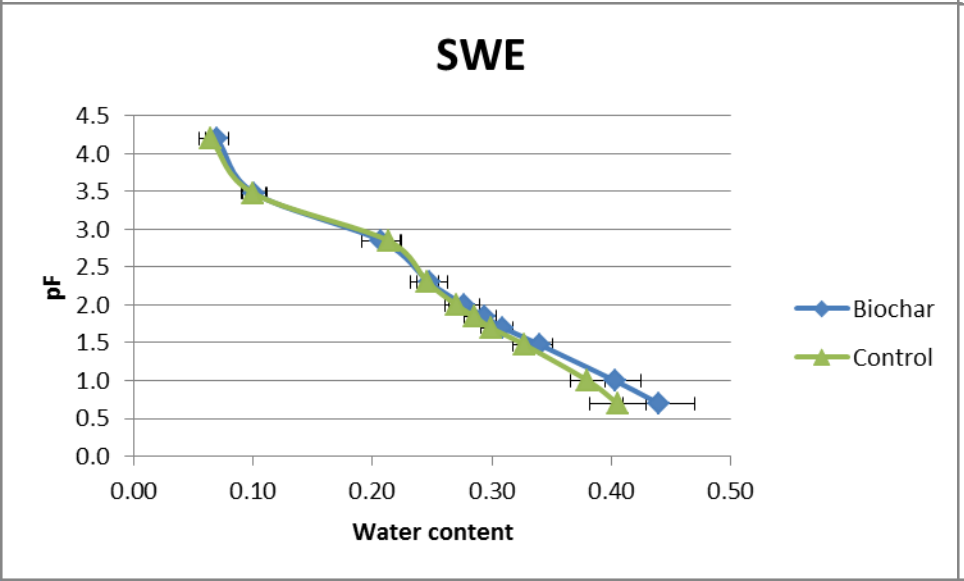
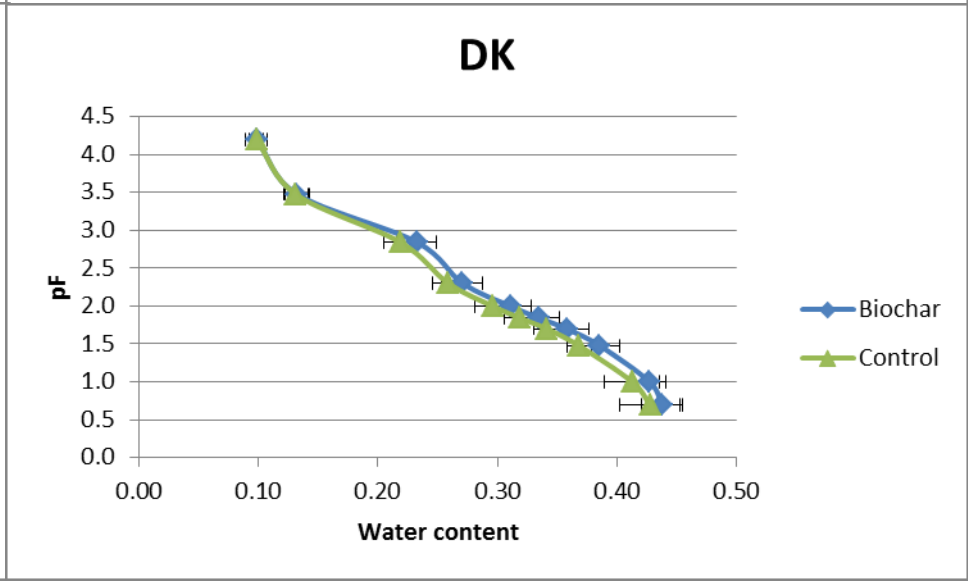
Water retention Interreg Biochar Project



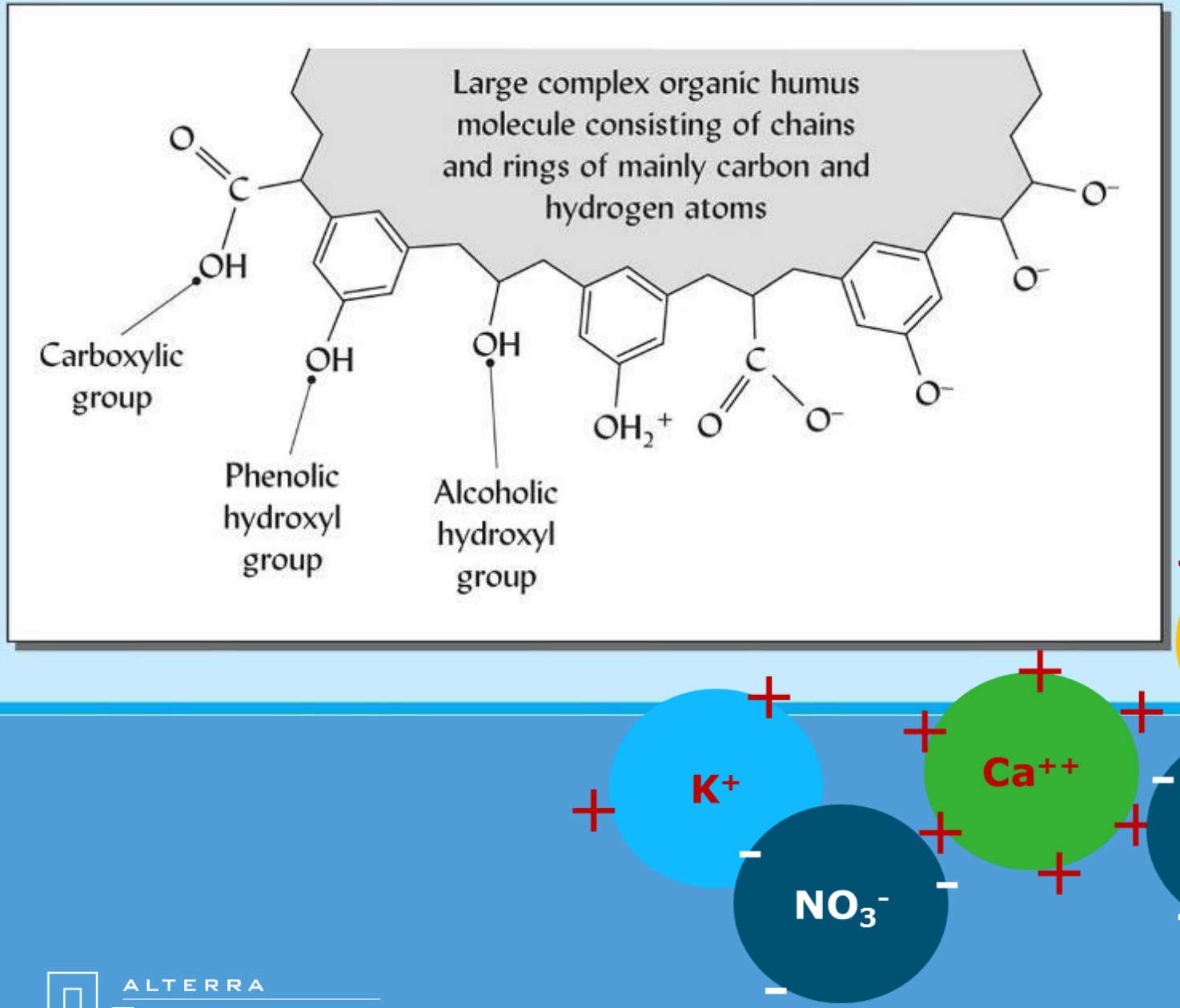






BIOCHAR is not similar to Soil Organic Matter

- Composition
- Water retention
- CEC



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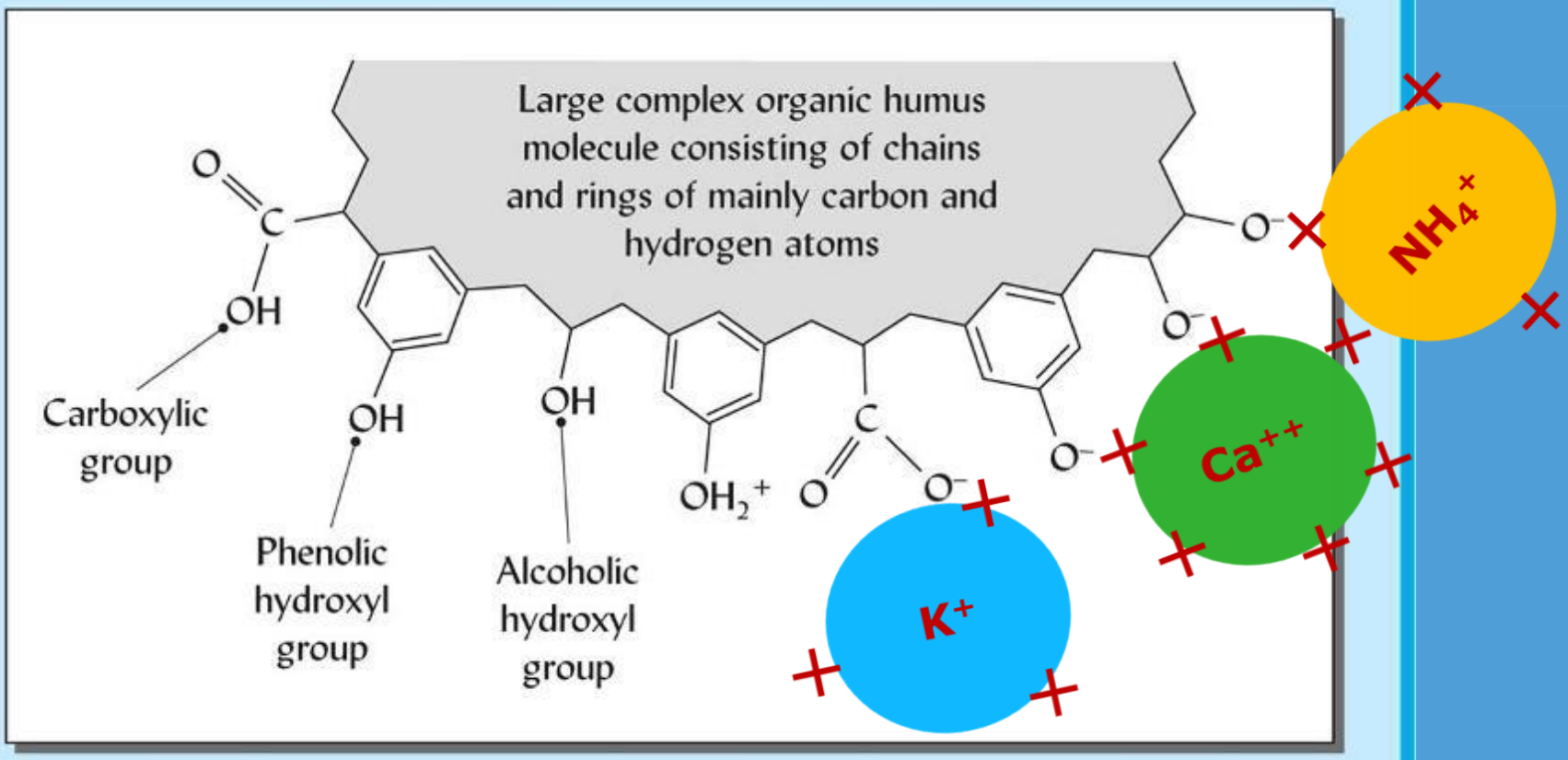
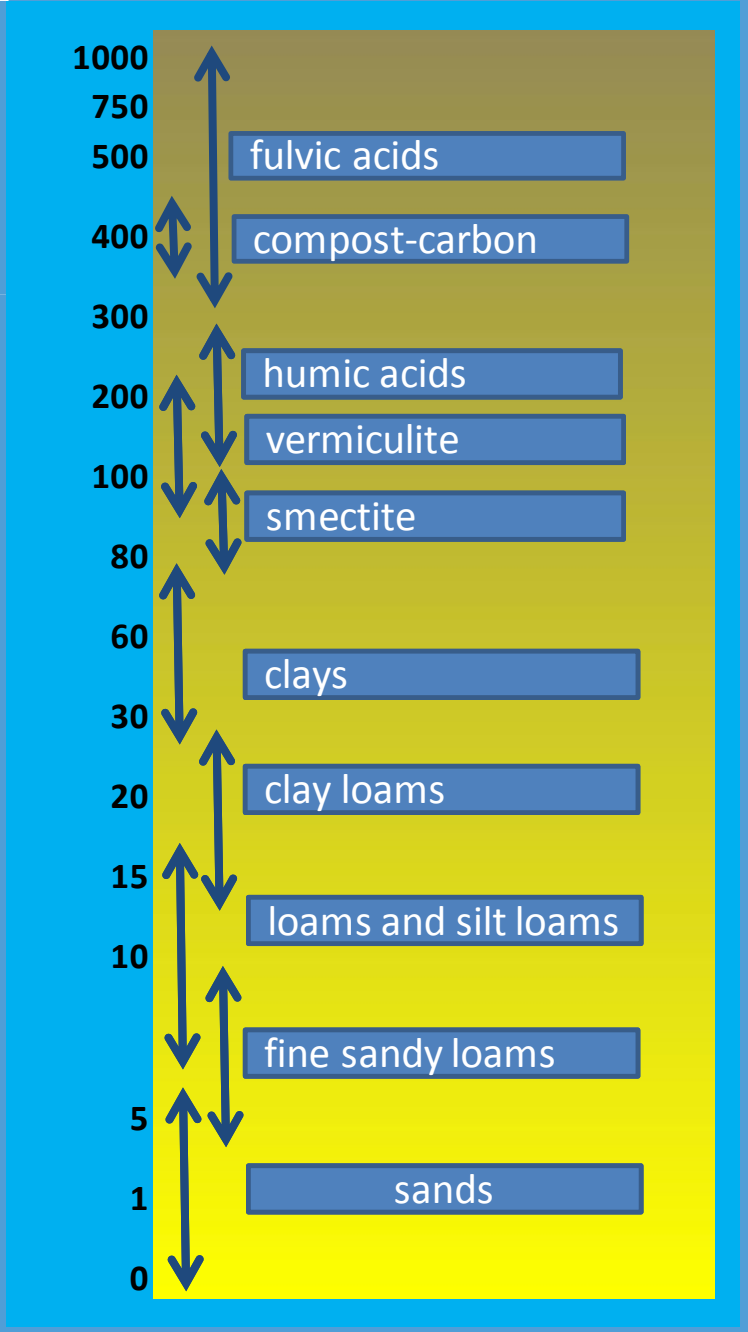
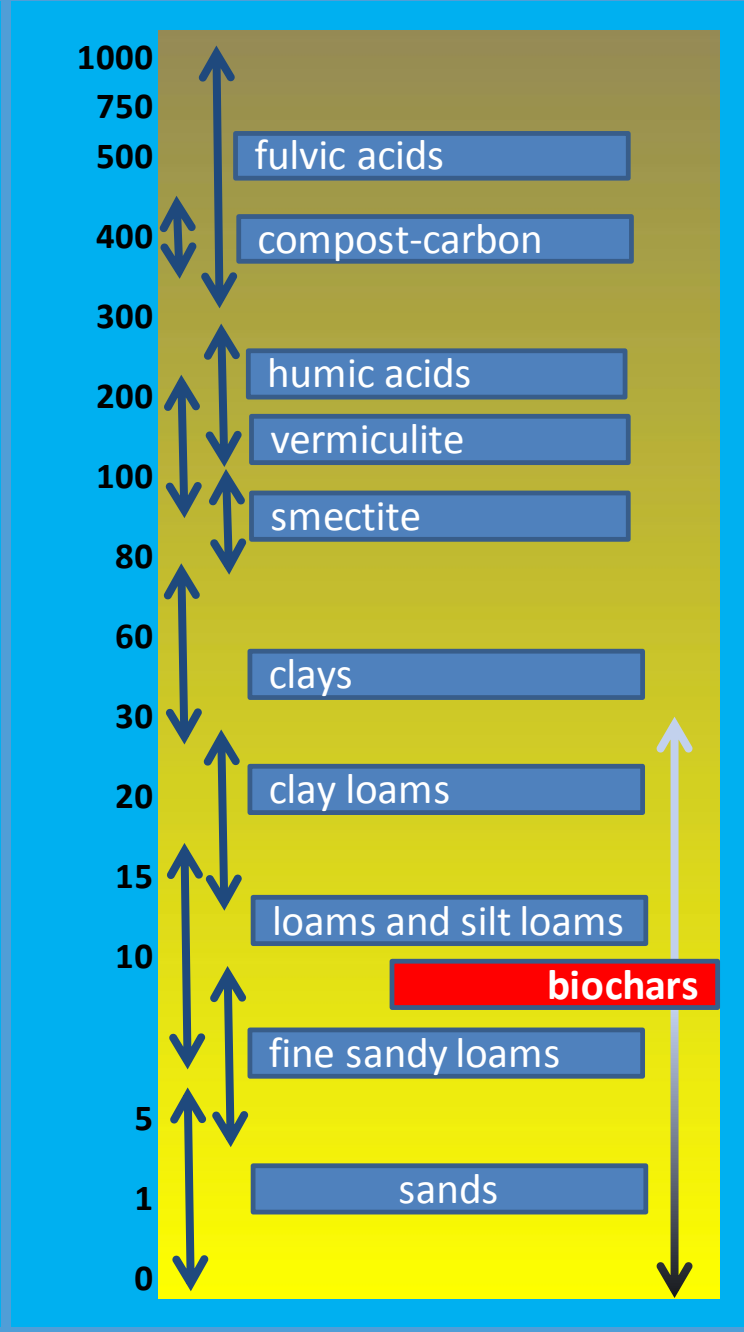

Large complex organic humus molecule consisting of chains and rings of mainly carbon and hydrogen atoms
Carboxylic group
Phenolic hydroxyl group
Alcoholic hydroxyl group
NH4+
Ca++
K+
NO3-
NO3-

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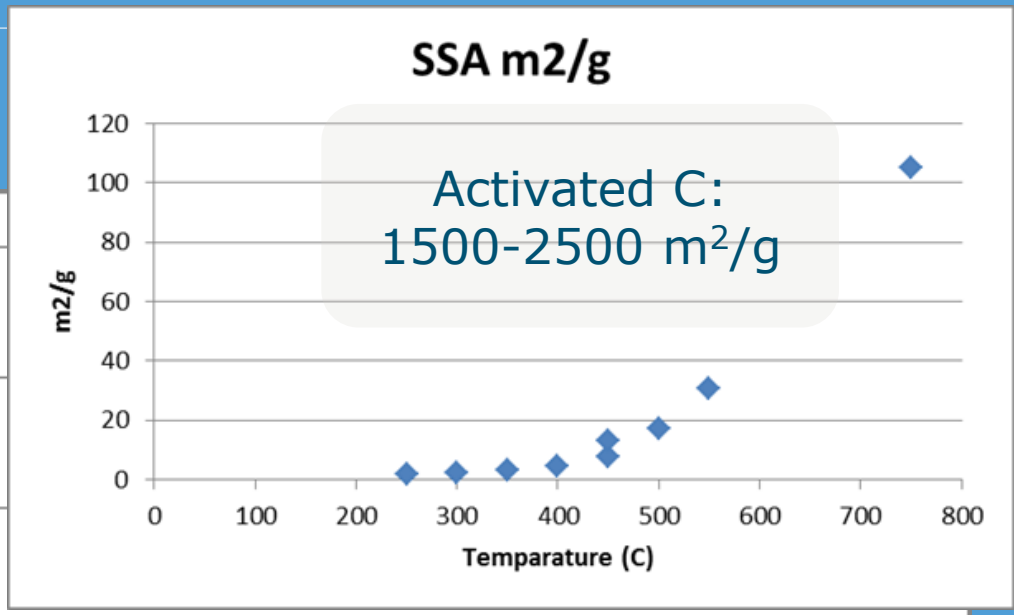
100
80
60
30
20
15
10
5
1
0
fulvic acids
compost-carbon
humic acids
vermiculite
smectite
clays
clay loams
loams and silt loams
biochars
fine sandy loams
sands

Pyrolysis conditions



Activated C:
1500-2500 m^2/g

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

Modification of Biochar

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

Modification of Graphene
Functional Group increase

Selective Chemical Modification of Graphene surfaces: Distinction between Single and Bilayer Graphene **

Fabian M. Koehler, Arnhild Jacobsen, Klaus Ensslin, Christoph Stampfer and Wendelin J. Stark *

APS physics

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Phys. Rev. B **82**, 125403 – Published 2 September 2010

Jia-An Yan and M. Y. Chou

Modification of Biochar within FERTIPLUS

- Two types of raw biochar
  - Oak wood-based, 450 and 650 ^{o}C
    - SME PROININSO (ES)
  - Green House Waste (GHW) 400, 600 and 750 ^{o}C;

Modification of biochar

- Chemical modification
- Process condition modification

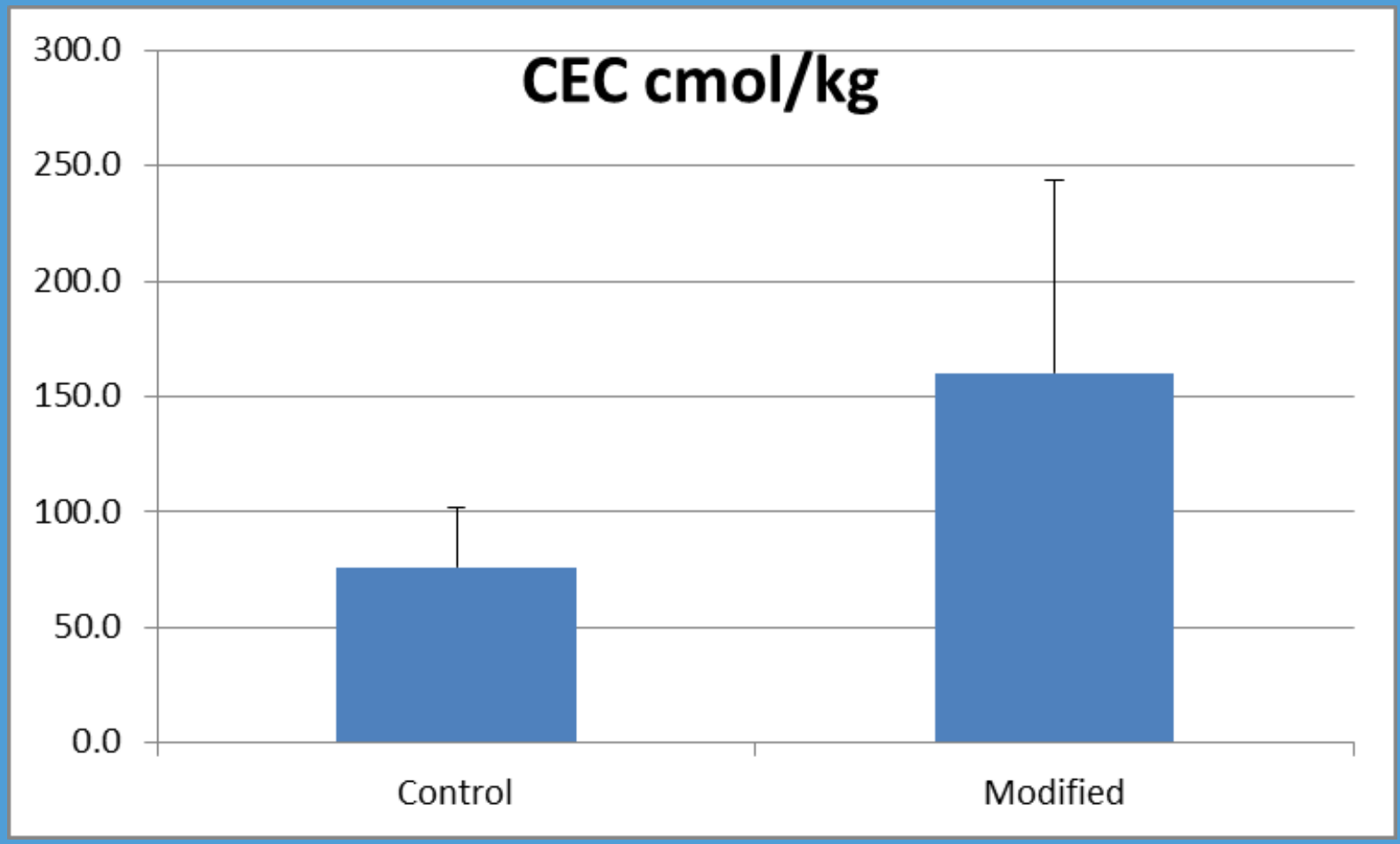
Modification of biochar

- Chemical modification
  - **KOH** (2 and) **5M**
  - **H_2O_2** **30%**
  - **$FE(NO_3)_3$** **2M**
  - (H_3PO_4 0.1 and 0.3M)
  - (H_2SO_4 0.1 and 1M)

Modification of biochar

- Process condition modification
  - 400 ^{o}C
  - 600 ^{o}C and
    - 1% Oxygen
    - Air
    - N_2
    - Steam
  - 750 ^{o}C
    - Air
    - N_2

Results chemical modification



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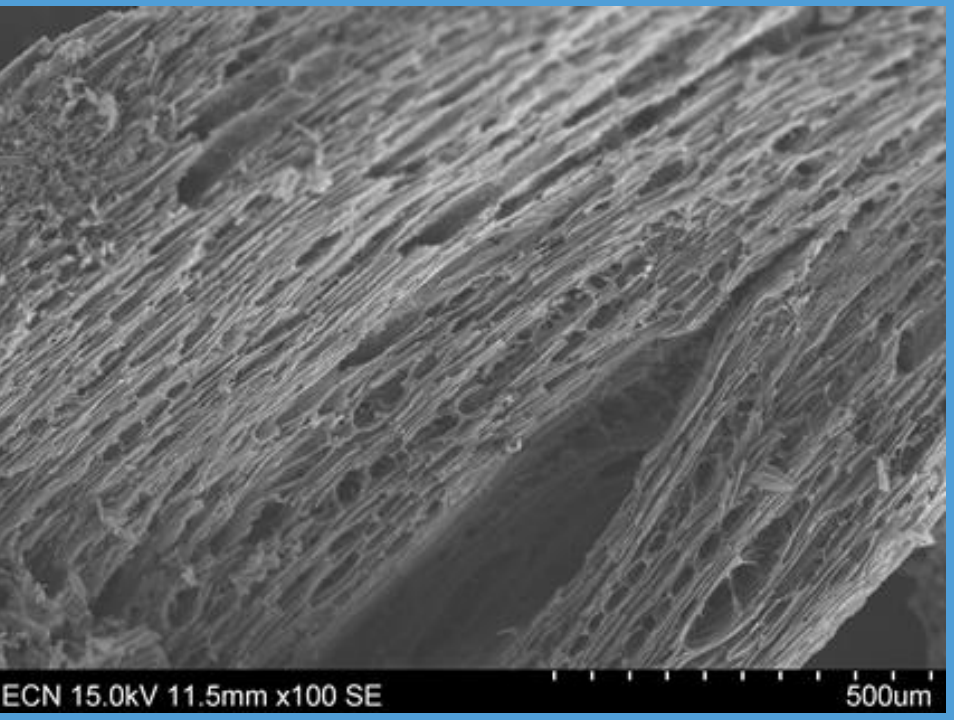
Results chemical modification (CEC, cmol/kg)

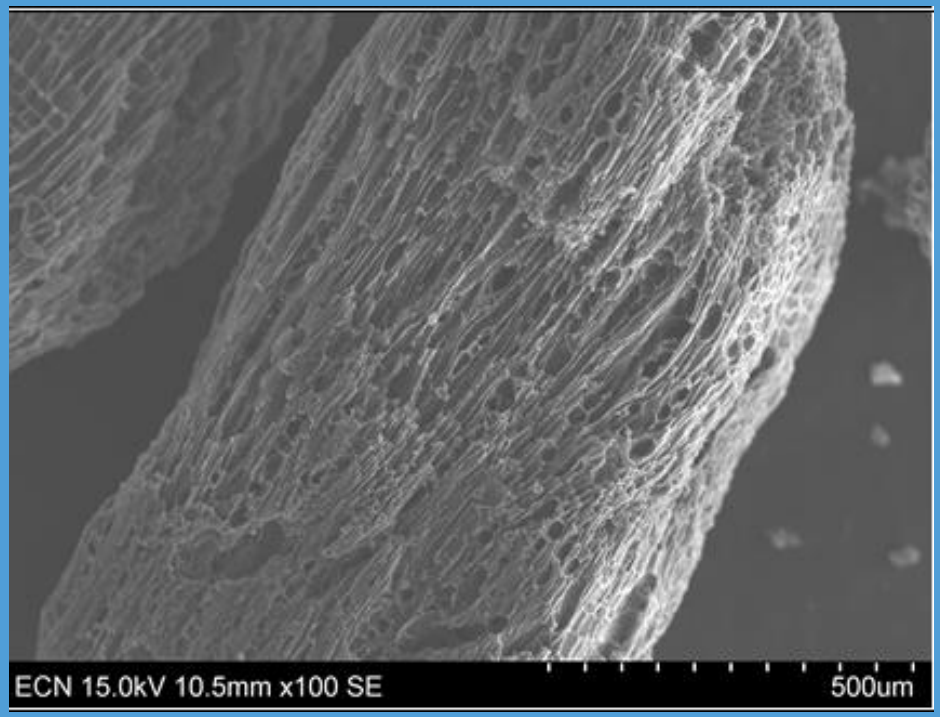
	Control	KOH	H2O2 10%	Fe(NO3)3
Biochar		5M	80 °C	
Wood 450	58.3	153	147	101
Wood 650	64.4	132	69	155
GHW 400	144.0	366	157	162
GHW HTC 250	55.0	162.3	83.9	159.9

Results process modification

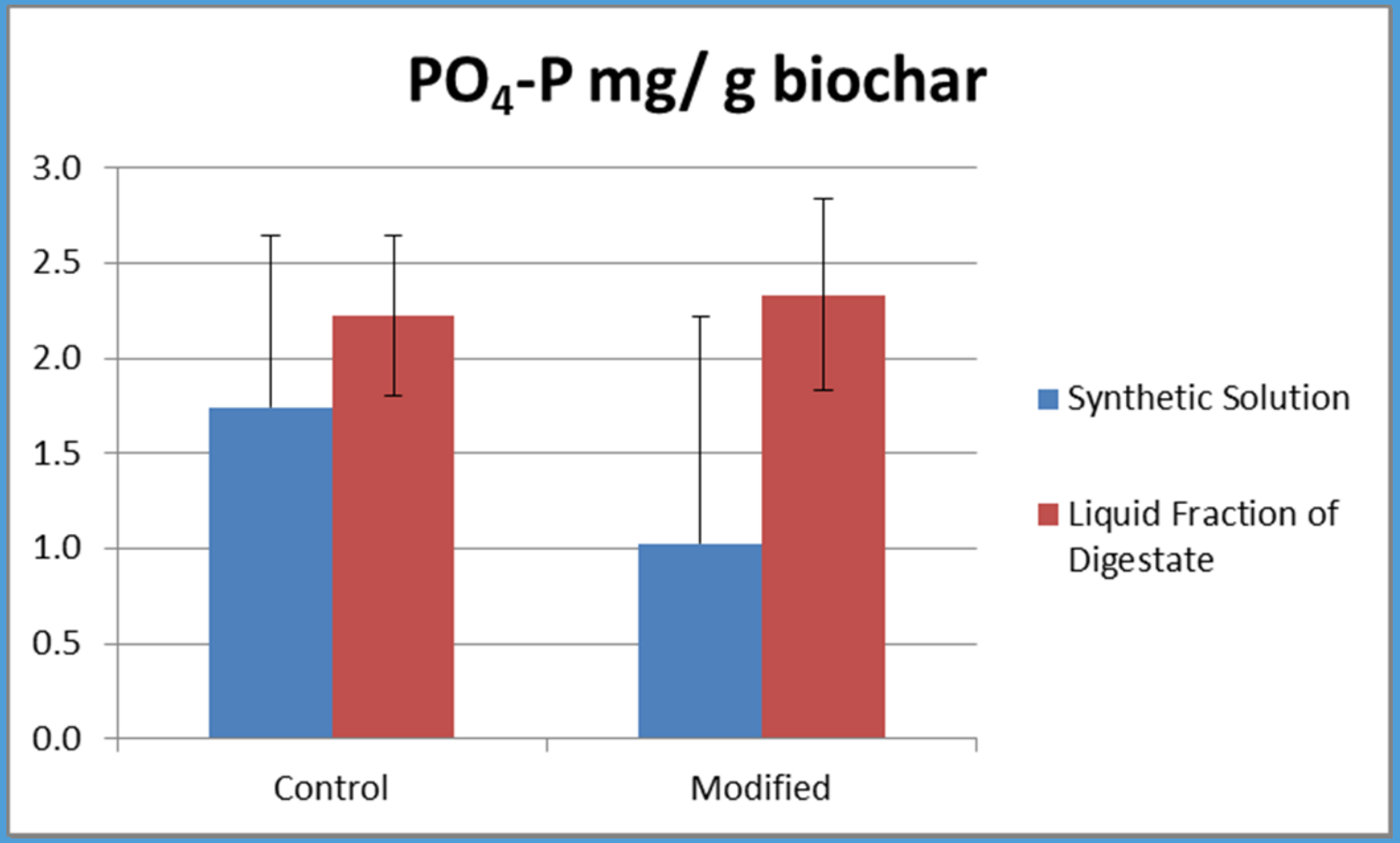
Biochar / process condition	CEC (cmol/kg)	SSA (BET) M2/g
GHW 400 °C	144.0	1.3
GHW 600 °C	82.8	2.0
GHW 600 °C; 1% O2	78.1	1.9
FB-GHW 600 °C; Steam	113.6	139
FB-GHW 750 °C; Air	156.5	249
FB-GHW 750 °C; N2	68.0	53.4

BET Surface area





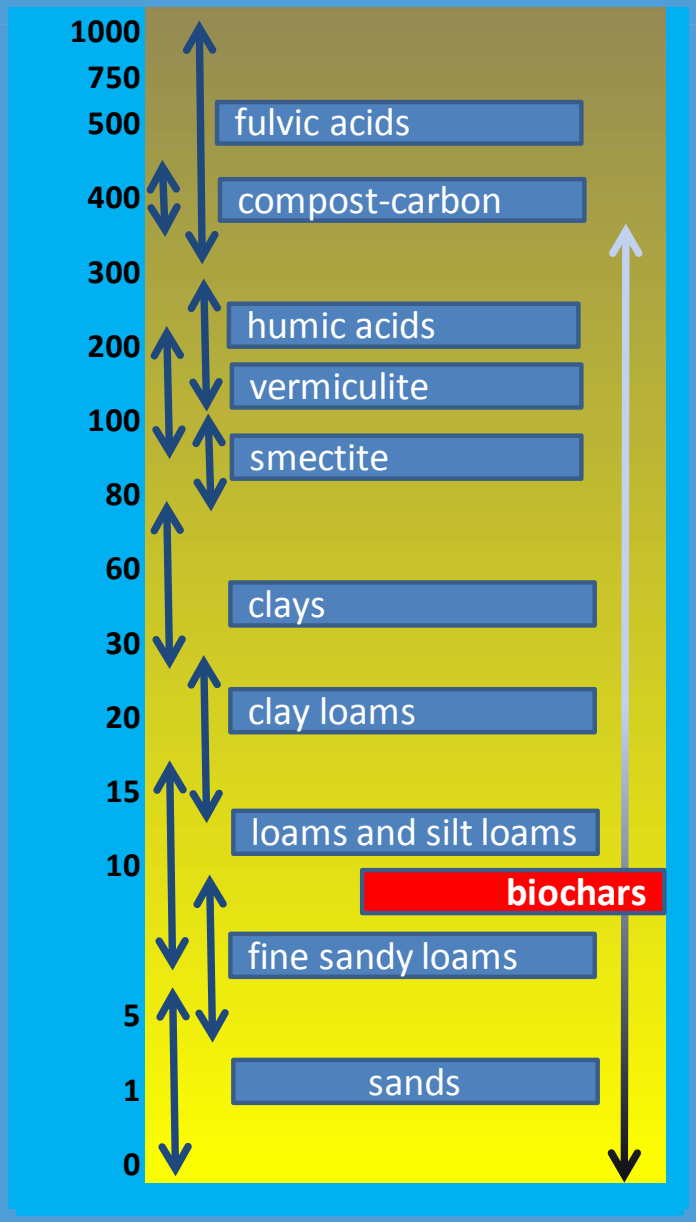
Effect modification on Nutrient adsorption



Conclusions CEC modification

- Yes modification is possible
- Highest CEC raw biochar: GHW, 400 ^{o}C
- Best chemical modification method: 5M KOH
- Variable results for same treatment with different biochars
- CEC and SSA can be increased using proper pyrolysis conditions

Biochar CEC after modification



Conclusion nutrient adsorption capacity

- No effect of modification

Biochar: To put the Genie back into the bottle?