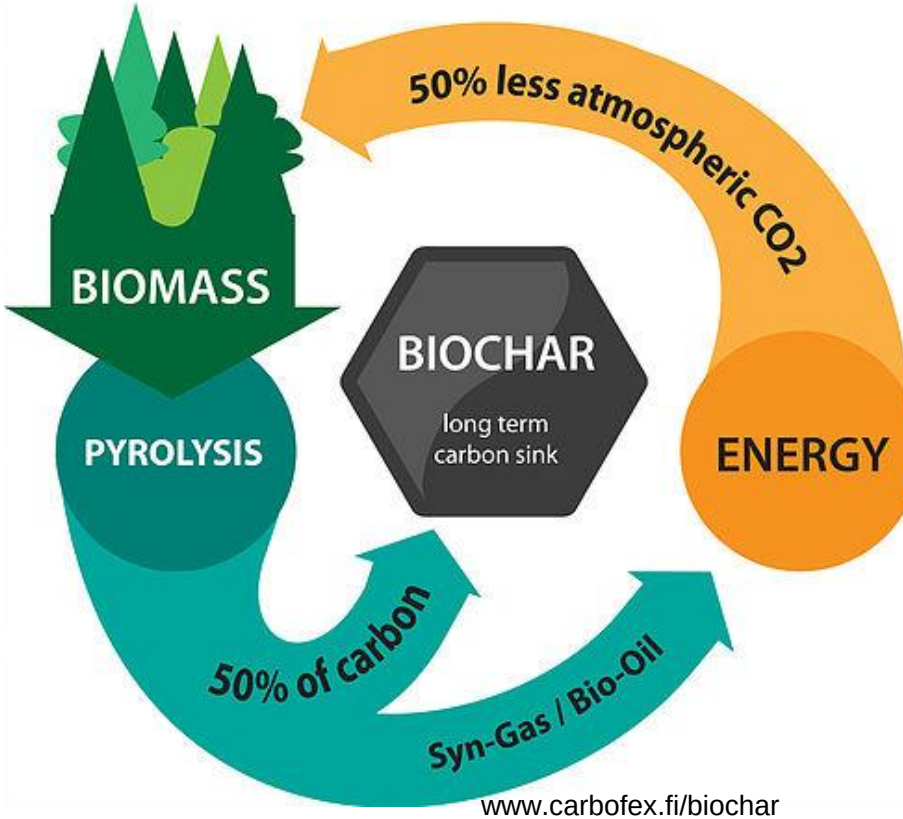
Biochars and benefits to soils and plants, Jätkäsaari demo area

Priit Tammeorg

AgriChar research group

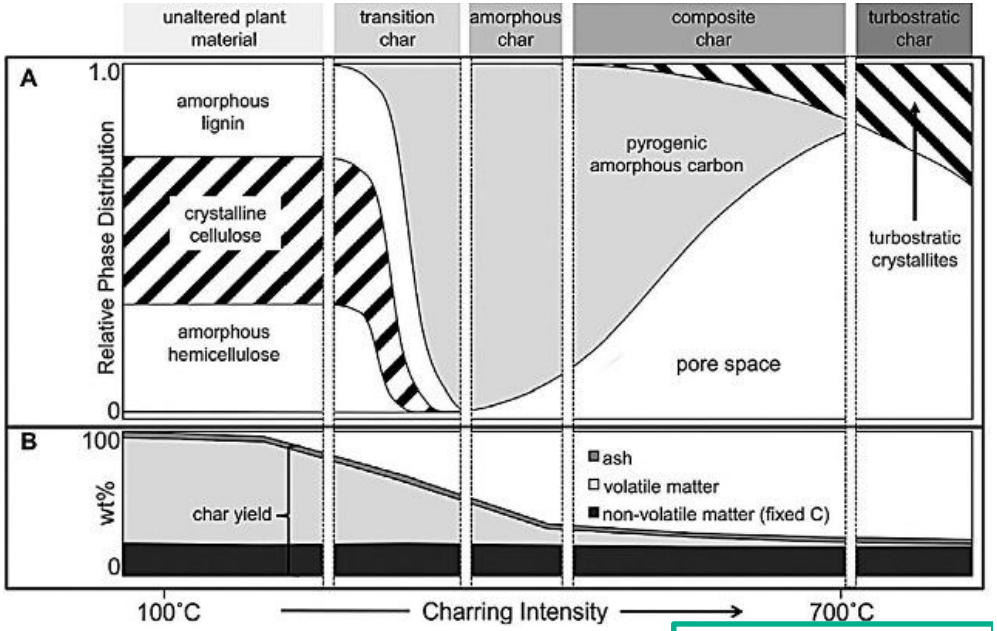
Biochars (BC): plant biomass heated without oxygen (pyrolysed) used in a way that carbon remains stored as a long-term C sink

- pyrolysis produces also bio-oil, syngas and heat energy
- Some BC properties overlap with **charcoal** as an energy carrier
  - but many types of biochars are hard to burn
  - charcoals not intended for use as a soil amendment

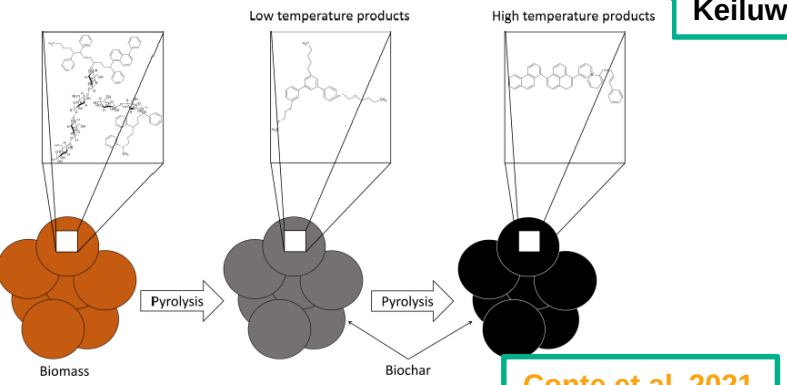


www.carbofex.fi/biochar

In high pyrolysis temperatures
C becomes aromatic, other substances removed



Keiluweit et al. 2010



Conte et al. 2021

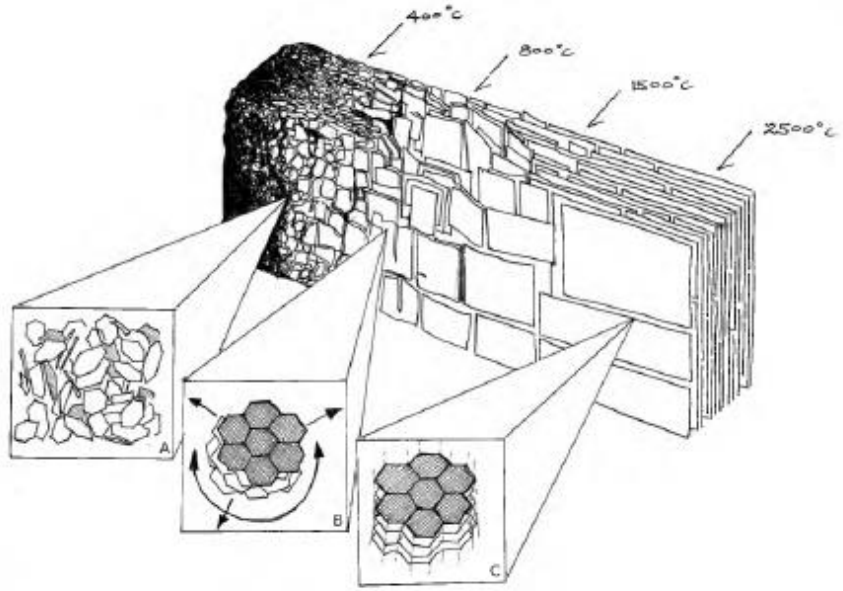


Figure 5.1 *Biochar carbon structure relative to highest treatment temperature. Inset (a): Increased degree of aromatic carbon, highly disordered in amorphous mass. Inset (b): Growing sheets of turbostratic aromatic carbon. Inset (c): Structure becomes graphitic with order in the third direction*

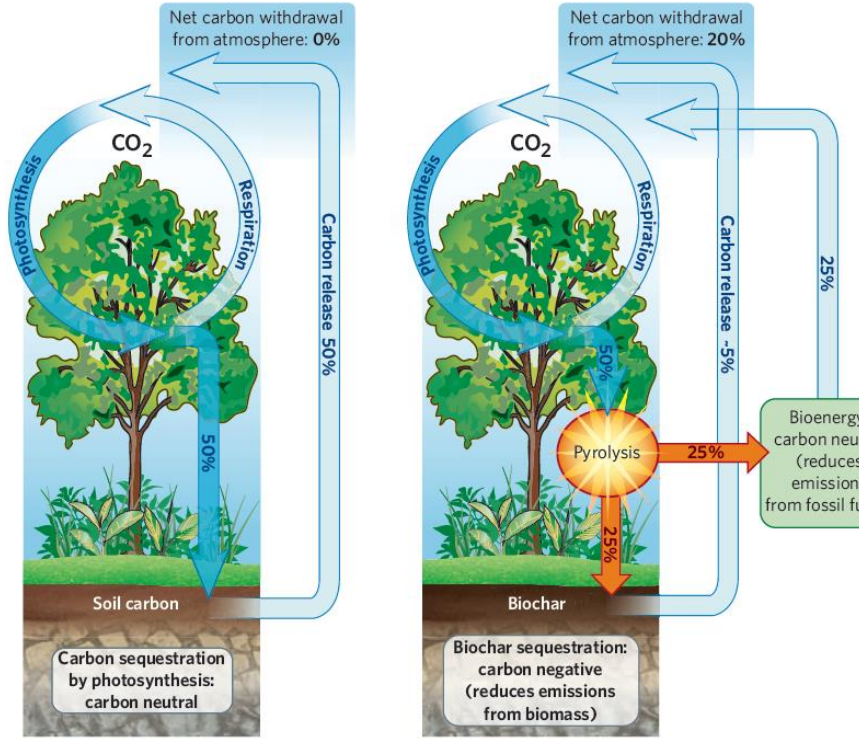
Chia et al. 2015

Aromatic biochars have high stability (… 4000 y) in soils

Kuzyakov et al. 2014

- If mixed with soil, **can draw down CO_2 from the atmosphere**
- **… 1.8 Gt C y^{-1}**
- **Alternative practices …1.5 Gt of C annually**

  reducing global warming



Lehmann 2007

(Woolf et al. 2010, 2016)

Production of biochar for urban purposes:
Flame-curtain/ Batch reactors/ Continuous

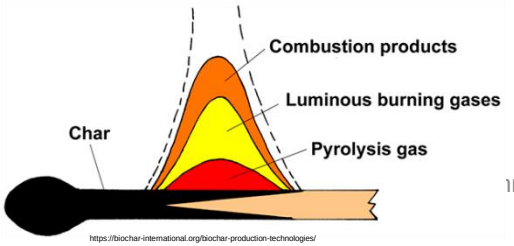
Flame-curtain pyrolysis
for green waste:

Kon-Tiki

http://terra-magica.info/index.php/willkommen/terra-magica-kontiki

Kaskinuotio

http://www.innovaatiopalvelu.fi/



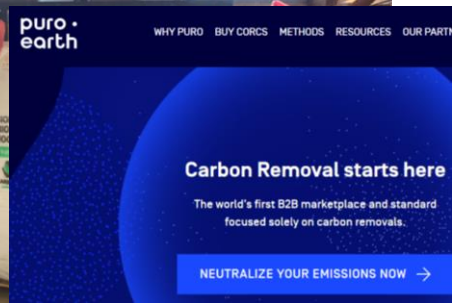
https://biochar-international.org/biochar-production-technologies/

Batch reactors


https://www.pinterest.com/pin/854759204245998880/


https://www.youtube.com/watch?app=desktop&v=6cZEPJAL8M0

Continuous: Pyreg in Stockholm
Carbofex Oy in Tampere:
largest factory in Europe



Biochars are different: EBC certification

- **Class I (Feed), II (AgroBio), III (Agro), IV (Material), V (Urban, launched soon)**
- 1. Raw materials
  - Positive list
- 2. Chemical properties
  - C 35-95%
  - O/C < 0.4
  - H/C_{org} < 0.7
- 3. Contaminants
- Heavy metals
  - PAH < 4 (I & II)/ 6 (III)/ 30 (IV) g t^{-1}
  - PCB < 0.2 g t^{-1}

Biohiilen laatutietoa hankinnoista päättäville

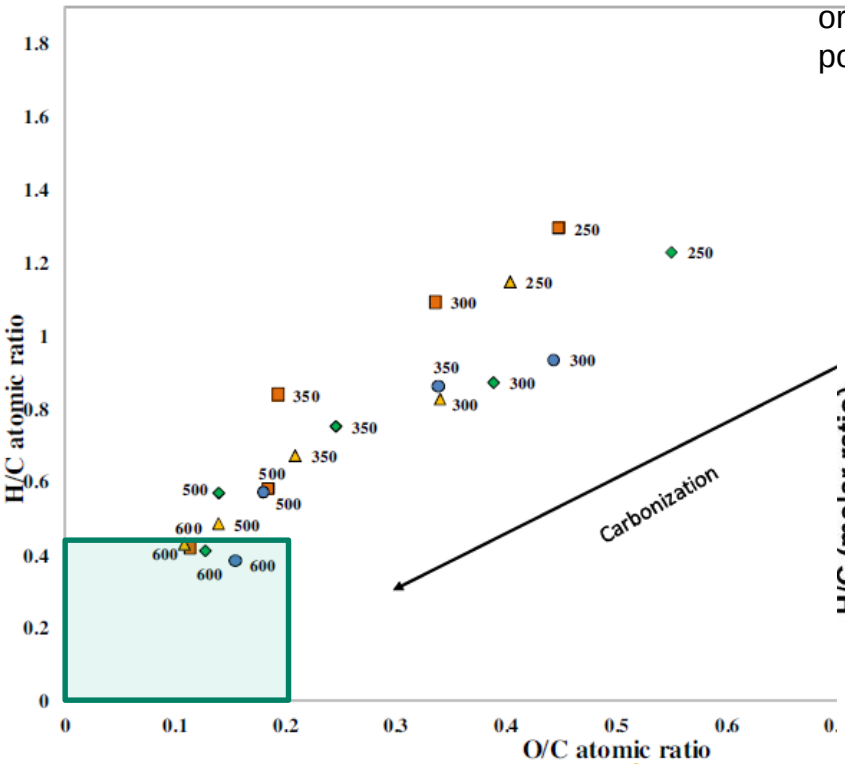
SBY hankintaohje 1.0
Julkaistu 10.2.2020

SUOMEN BIOHIILIYHDISTYS
FINNISH BIOCHAR ASSOCIATION

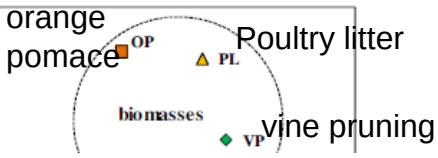
https://www.suomenbiohiili.fi/wp-content/uploads/2020/02/Hankintaohje-1.0.pdf

Pyrolysis temperature >500 ºC: high aromaticity

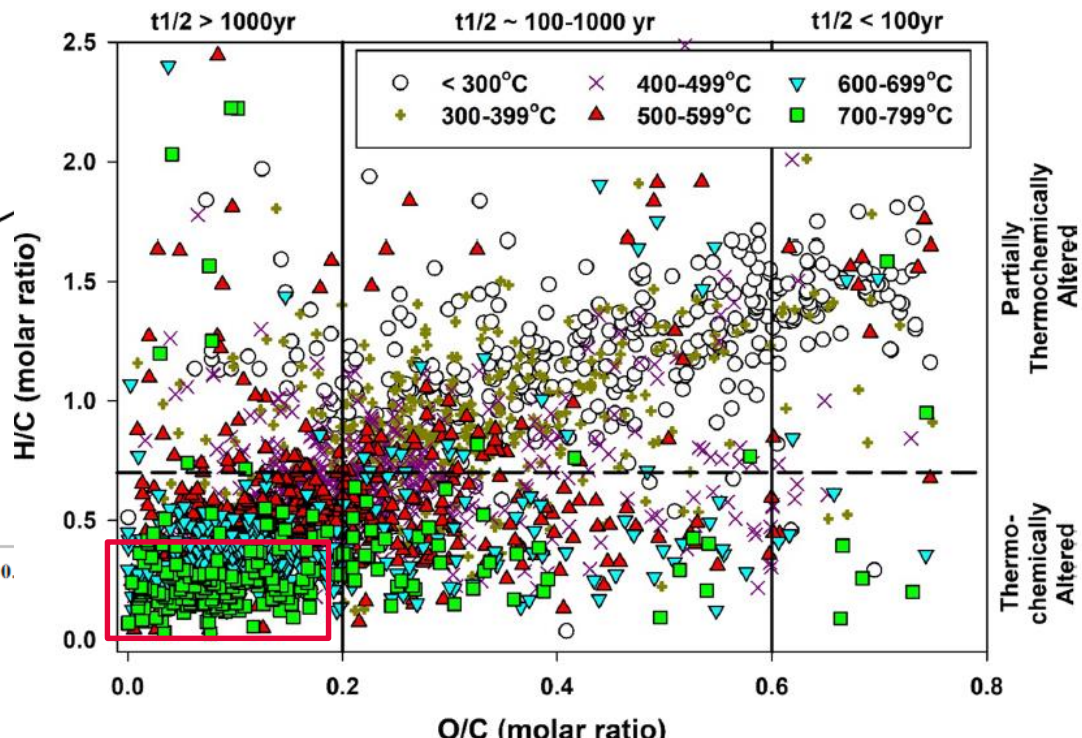
raw material affects less



Tag et al. 2016

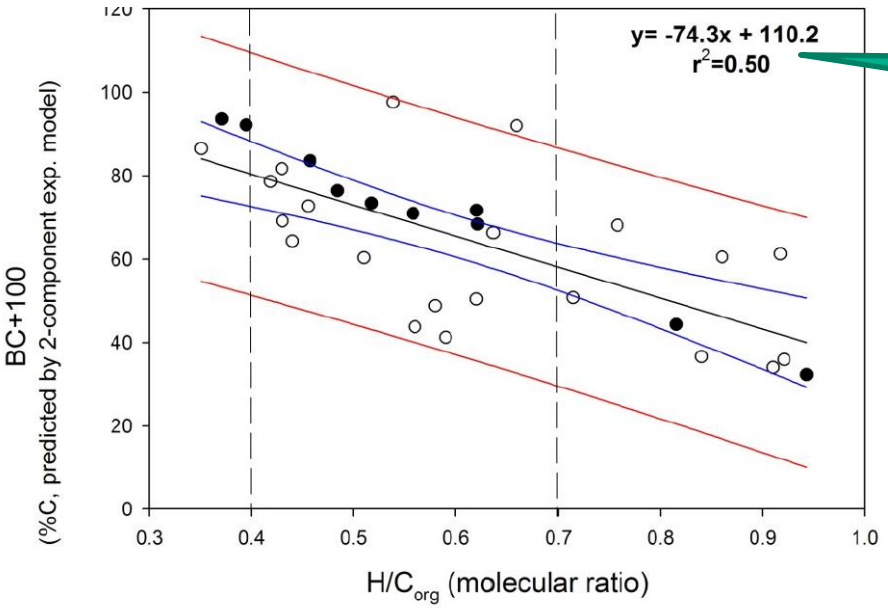


Ippolito et al. 2020



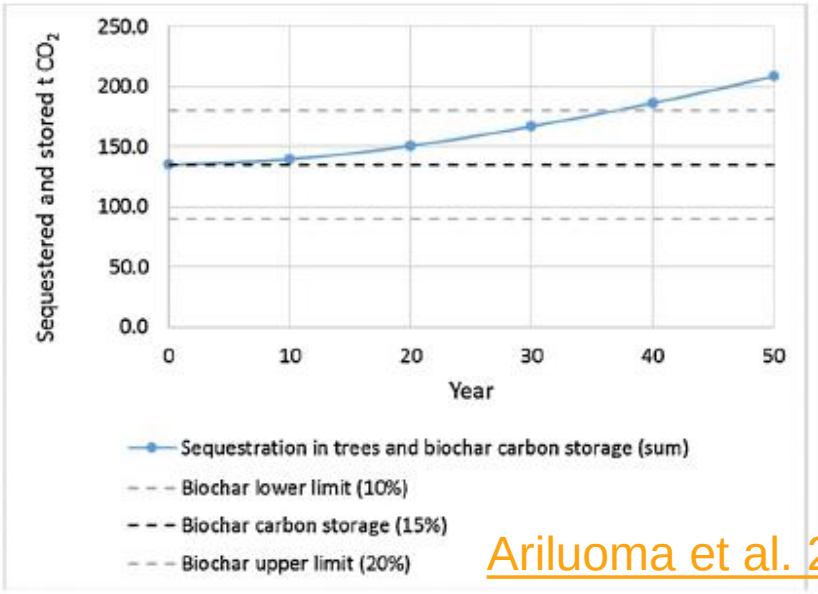
C stability affected by BC properties and environmental conditions

- H/C_{org} ratio easy to measure, correlates well with aromaticity



If one knows H/Corg ratio of a biochar, can use formulas to calculate the stability

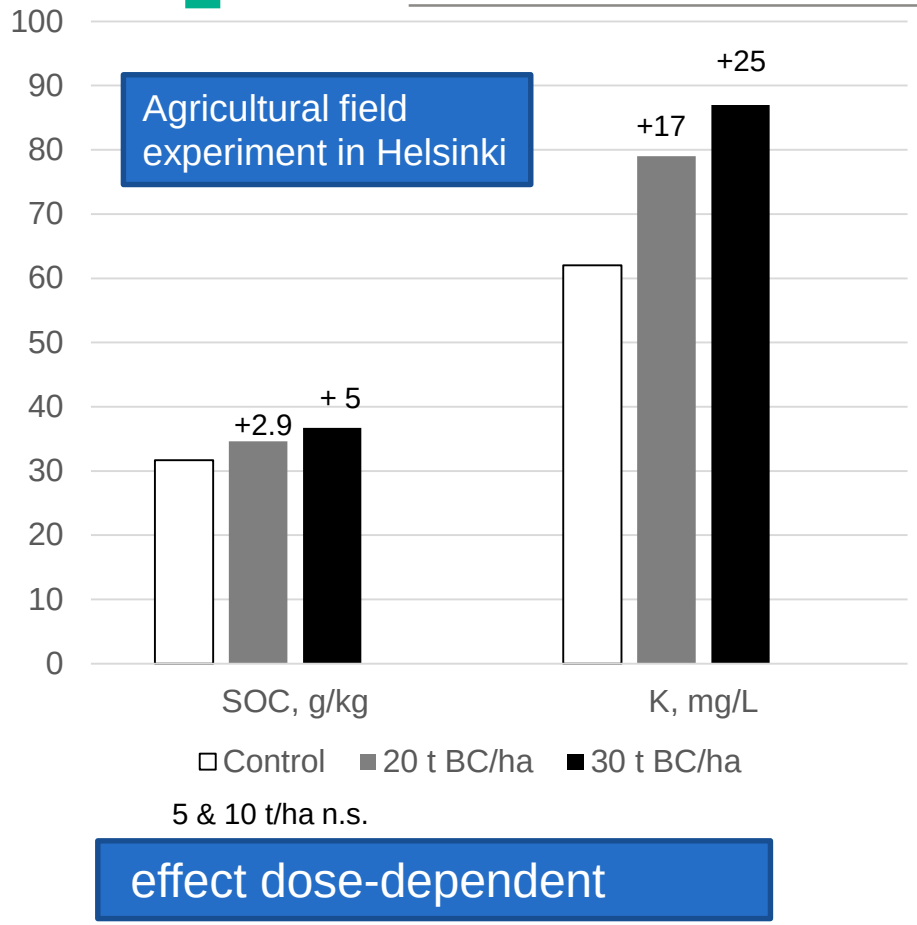
Budai et al. 2013



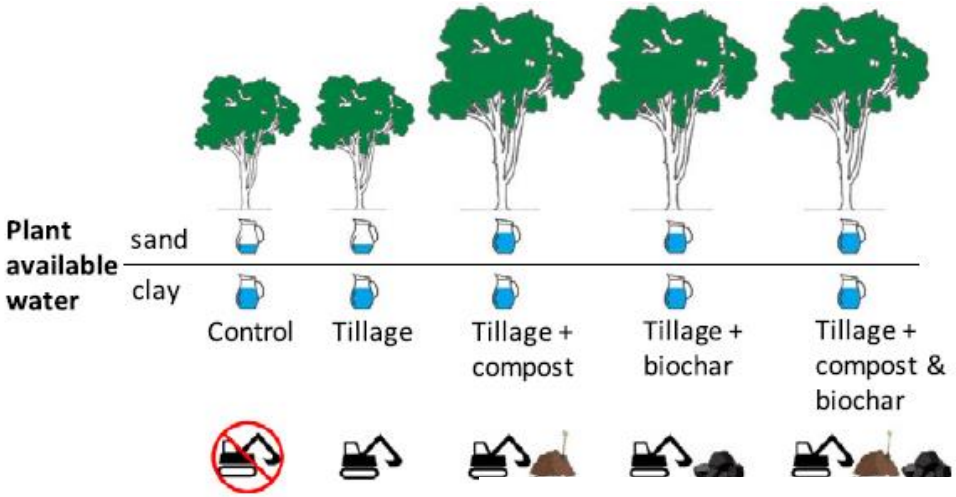
Ariluoma et al. 2021

Fig. 9. The cumulative CSS (t CO_2) of the case area during 50 years in the optimal test scenario.

Higher water retention capacity and nutrients (especially K)



- Similar results from urban study from Australia
- Greenwaste compost and eucalypt biochar
- Lower bulk density, higher available water content
- Less water stress for trees, better growth



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Tammeorg et al. 2014

Somerville et al. 2020

Long-term fertilization effect for P, K, S, Cu & Fe

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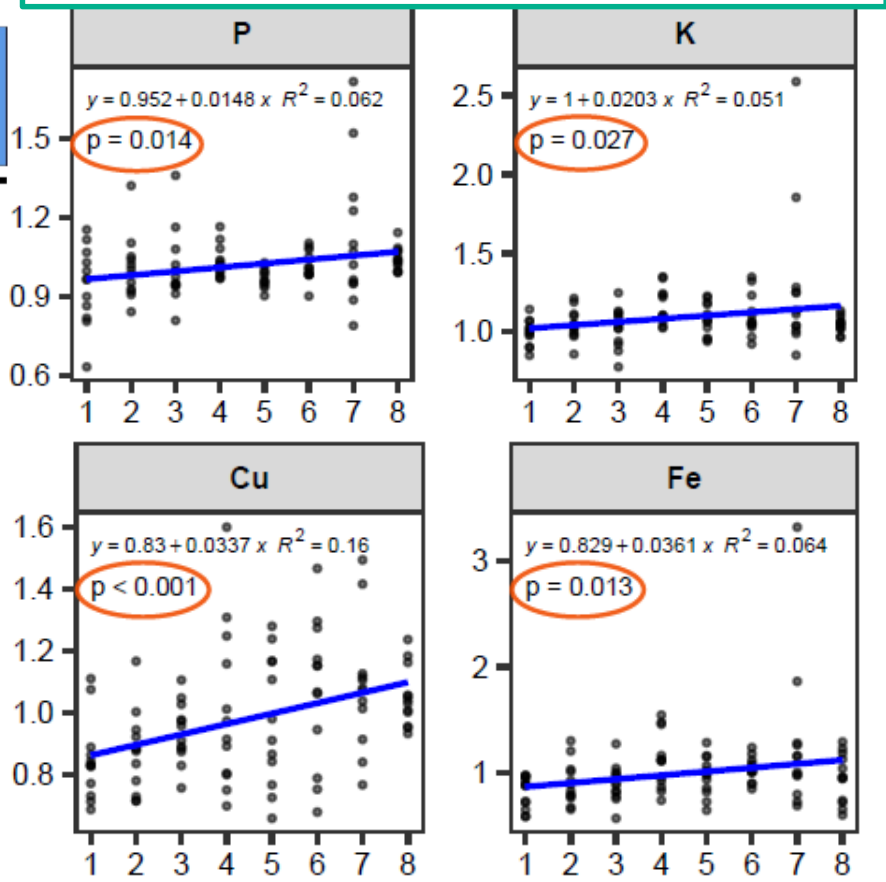
journal homepage: www.elsevier.com/locate/agee

Long-term effects of softwood biochar on soil physical properties, greenhouse gas emissions and crop nutrient uptake in two contrasting boreal soils

Subin Kalu [a,b,*], Asko Simojoki [c], Kristiina Karhu [b], Priit Tammeorg [a]

- BC own nutrients
- Interactions with soil nutrients

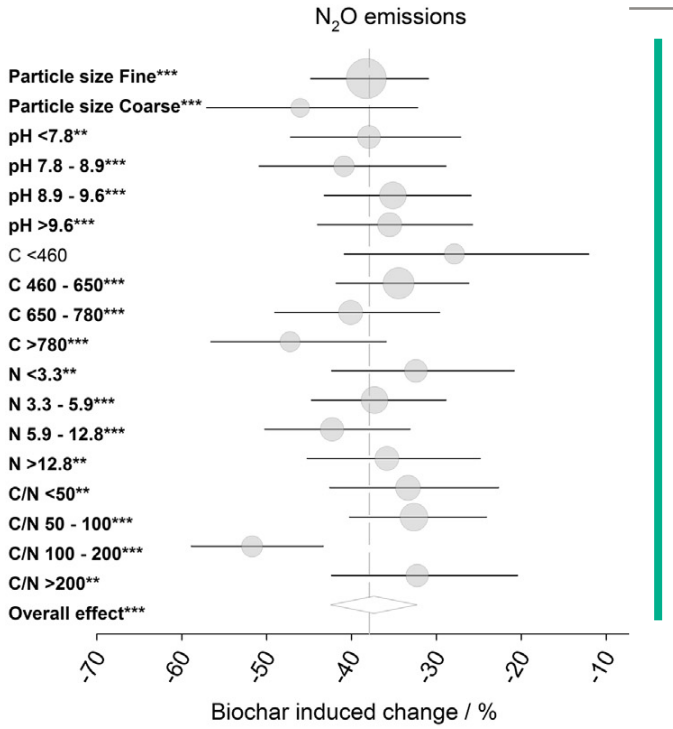
BC effect to crop biomass nutrient concentration over 8 years, Stagnosol

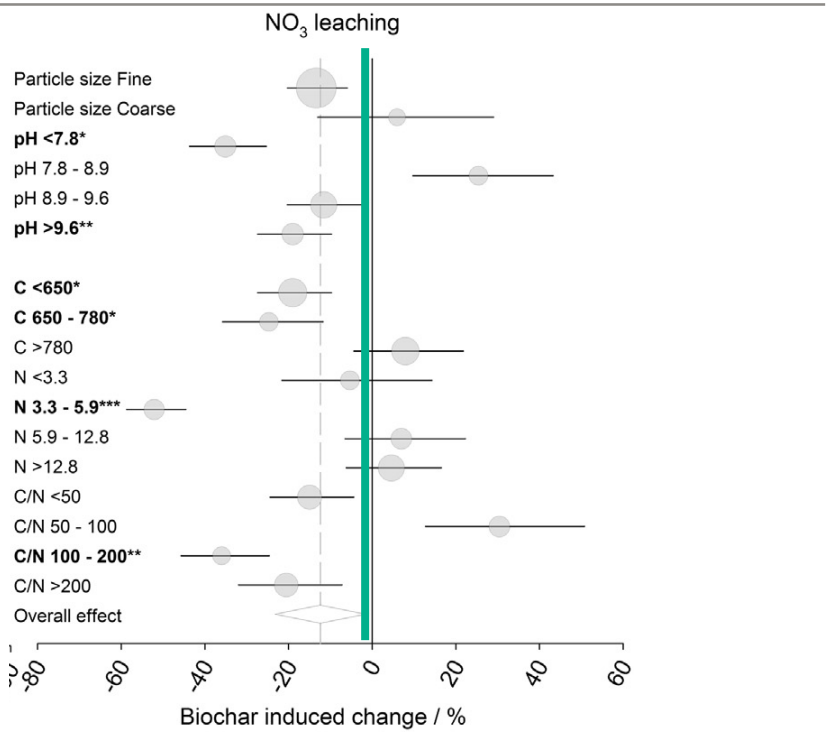


Kalu et al. 2021

Porous biochars can reduce nutrient losses from soils

Meta-analysis by Borchard et al. 2019





Impact of various biochar properties (particle size, pH, carbon [C; g kg−1], nitrogen [N; g kg−1], and C/Nmass ratio) on soil N2O emissions, NO3 − concentration in soil after study, and NO3 − -leaching during study. Data are shown as estimated mean effects and their lower and upper confidence intervals (95%). Circle size indicates number of observations. Solid vertical line indicates mean of control treatments and dashed vertical line indicates mean of overall effect. Probability levels are indicated by asterisks (*** for P < 0.001; ** for P < 0.01, and * for P < 0.05).

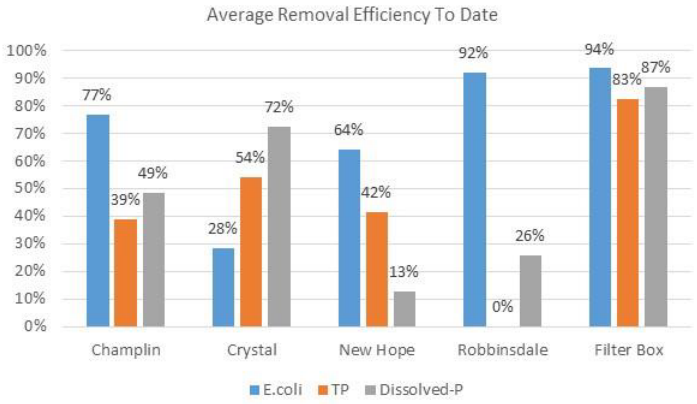
Overall, N_2O emissions **-38%,** NO_3^- leaching **-13%.**

Cleaning stormwater in filters

example of streams in Minnesota, US

Matthiesen et al. 2019

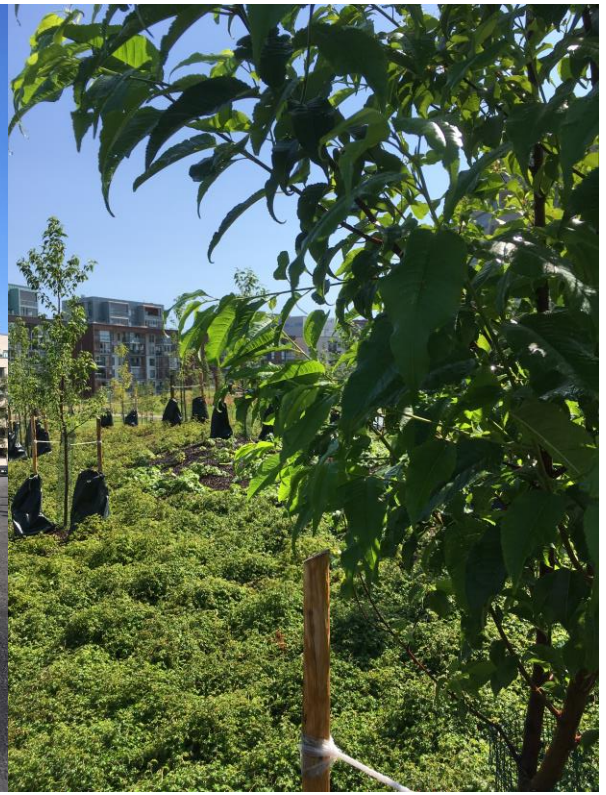
Iron and biochar sand filters



Suitable BC has

- **High SSA and porosity**
  - **Wood, 500-700 ºC**
- **treatment of BC with Mg**
  - **improves P adsorption**
  - **less with Fe**
    - **(Riddle et al. 2019)**

Jätkäsaaren Hyväntoivonpuisto



Photos: Minja Koivunen

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eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

Deliverable 2 of Carbon Lane project

Design support for the carbon drawdown demonstration area in Jätkäsaari, Helsinki

Report on principles of urban demonstration areas for carbon sequestration

Päivi Soronen, Anu Riikonen, Esko Salo, Minja Koivunen, Suvi Tikka, Sushant Passi, Anna-Reetta Salonen, Mikko Jalas, Priit Tammeorg

December 2019

Helsinki

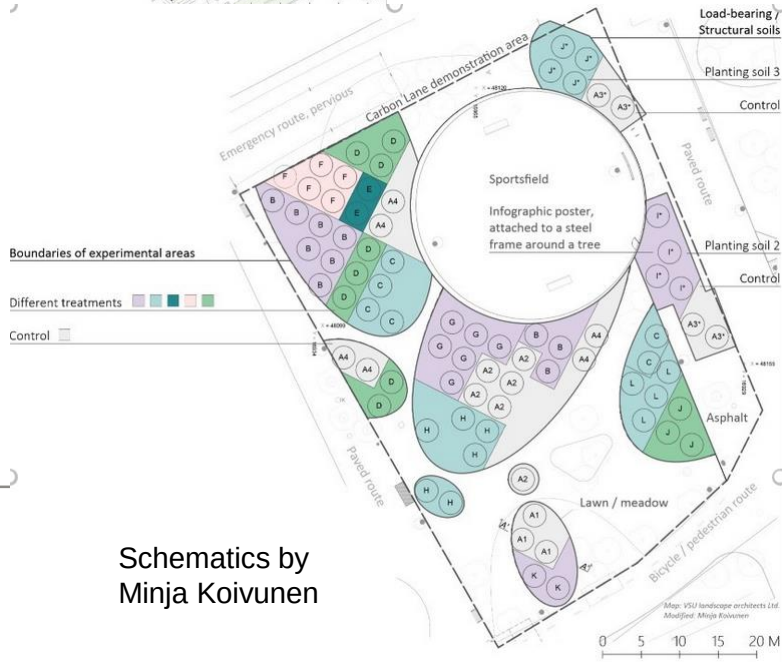
UNIVERSITY OF HELSINKI

eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

Demo area in Jätkäsaari, Helsinki since 2019

- **Started within Carbon Lane project**
- **80 trees (partly in structural soils)**
- **Treatments randomized and replicated (compromises)**
- **6 growing media inc. 5…25% biochar**
- **BiHii, Biolan, Carbofex, Kekkilä, Tieluiska, HSY control**



Schematics by Minja Koivunen

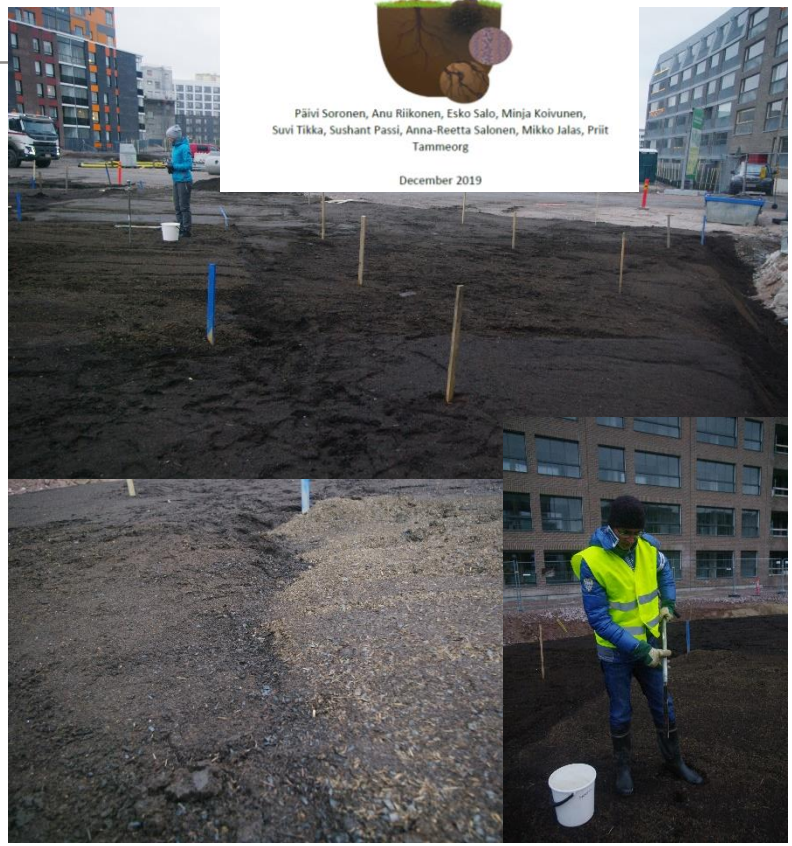

Jätkäsaaren Hyväntoivonpuistossa tehdään kaupungin viheralueiden hiilensidontaa edistävää tutkimusta

Jätkäsaari
20. marraskuuta 2019

We will follow-up the demo park

2019-2021 baseline establishment

Hiilipuisto-project



2019

- Planting soils applied, first samples

2020

- Trees planted, measured twice
- Soil samples, C fractions

2021

- 8 trees replaced (poor tree quality)
- Tree measurements
- Water Retention Capacity
- Report in 2022

Maiju ja Yrjö Rikalan PUUTARHASÄÄTIÖ

Helsinki

So far, trees doing good in all soils

- Differences about to appear
- Some fluffier soils shrinked
- Heavy metal contents below limits

- Lessons learned:
  - Compromises due to resources
  - Common criteria for testing materials (e.g. nutrients)
  - Good documentation!

See soon:
Tammeorg et al. **Co-creating urban carbon sink parks: case Carbon Lane in Helsinki.** In review.

The work continues: We will follow-up the demo park also in coming years

- **Continuing monitoring of**
  - Soil carbon
  - Soil nutrients
  - Tree health, growth

Wood biochars safe for C sequestration

H/C_{org} < 0,4 leads to stability 500+ y

- BCs typically increase soil nutrient and water availability
- Reduce nutrient losses
- Hyväntoivonpuisto demo area baseline measurements 2019-2021 promising
- Long-term follow-up and reporting needed

AgriChar research group **biochar-hy.blogspot.com**

aalto.fi/fi/arkkitehtuurin-laitos/hiilipuisto

aalto.fi/fi/carla

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Thanks!