Zürcher Hochschule
für Angewandte Wissenschaften

Life Sciences und
Facility Management

IUNR Institut für Umwelt und
Natürliche Ressourcen

Soil and Substrates in urban Areas

Andrea Gion Saluz

Institut für Umwelt und Natürliche Ressourcen IUNR / Pflanzenverwendung

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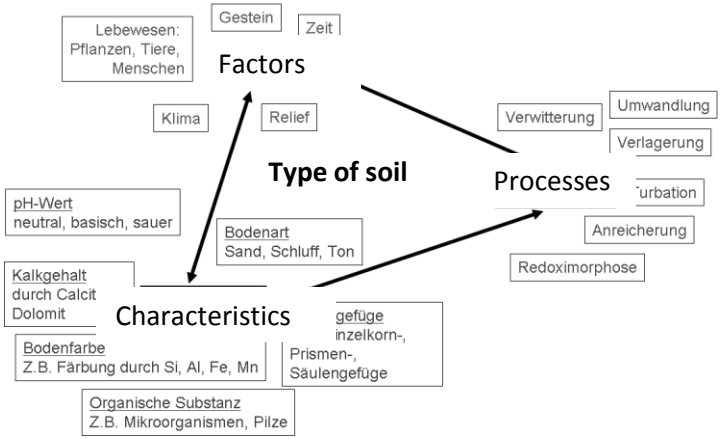
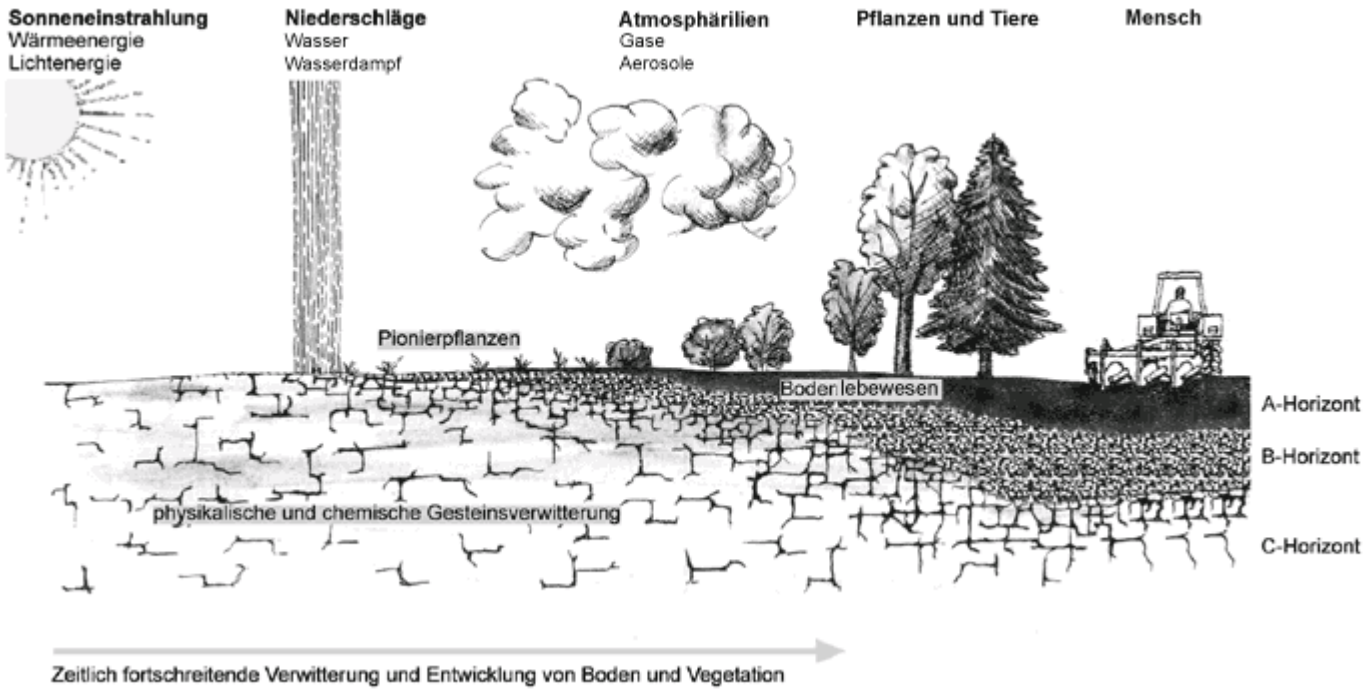
Bodenbildende Faktoren und Prozesse

- Verschiedene Ausgangsprodukte
- Zeitraum und Zusammensetzung
  - Verschiedene Böden
  - Verschiedene pflanzenverfügbare Nährstoffe
  - pH-Wert



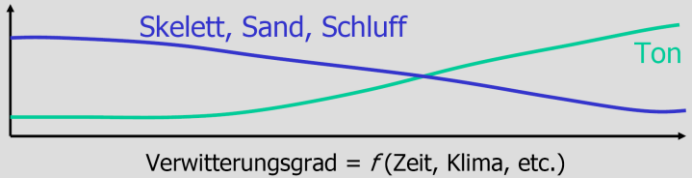
Skript Bodenkunde IUNR

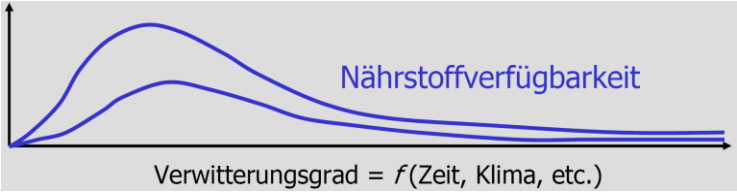
Soil development / Pedogenesis



Bodenbildung (Abb. verändert nach: MAYER, J. 1996)

Soils over time





Boden pH	Einstufung	Vorkommen (Beispiele)
9.1 – 10.0	stark alkalisch	Solonchaks, Solonetze
8.1 – 9.0	mässig alkalisch	Solochaks
7.1 – 8.0	schwach alkalisch	Rendzinen
7.0	neutral	Rendzinen, Schwarzerden
6.0 – 6.9	schwach sauer	basenreiche Braunerden
5.0 – 5.9	mässig sauer	Braunerden, Parabraunerden
4.0 – 4.9	stark sauer	saure Braunerden, Pseudogleye
3.0 – 3.9	sehr stark sauer	Podsole, Hochmoore

Essential Plant nutrients

Organic basic elements C, O, H

- Macro Nutrients
  - 6 Elements
  - N, P, K, Mg, Ca, S

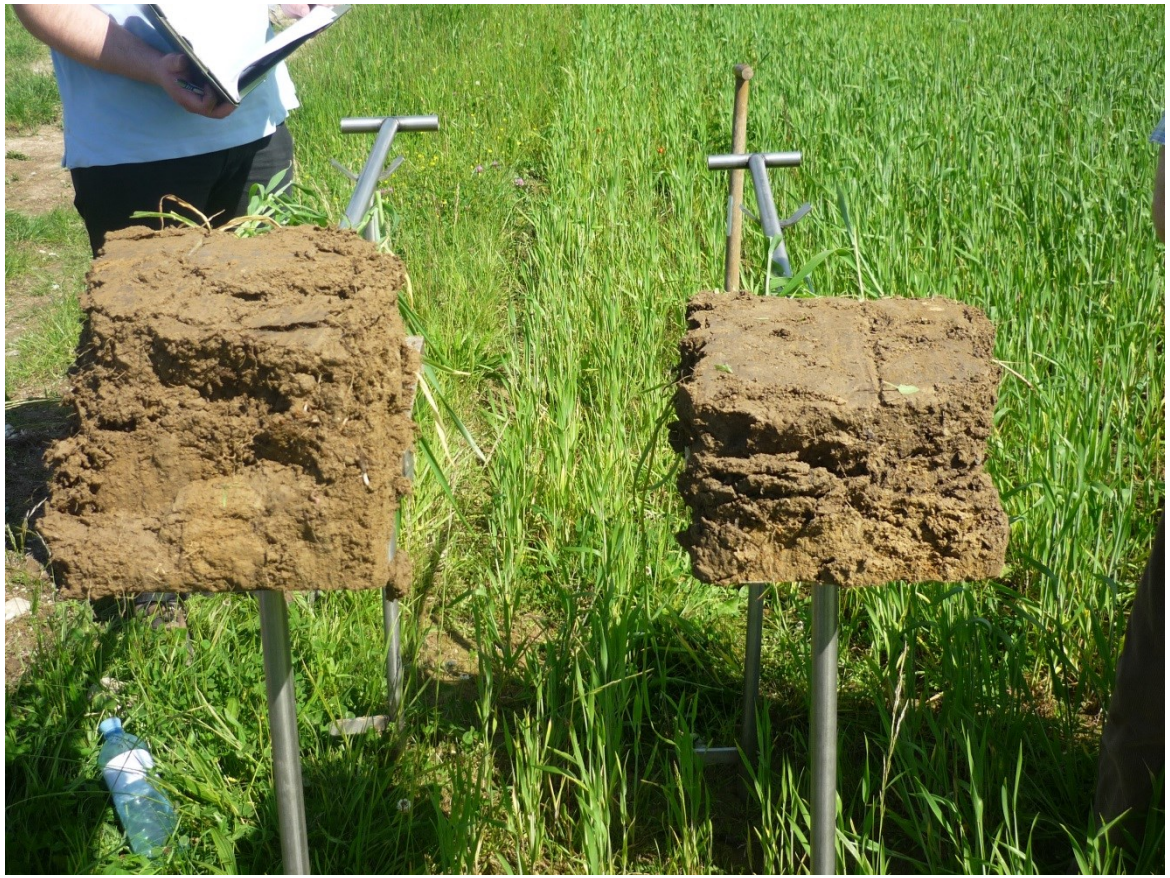
- Micro Nutrients
  - 8 Elements
  - Cl, B, Fe, Mn, Zn, Cu, Ni, Mo

  - Nutrients as ionic get absorbed by tender roots→ Ion-exchange

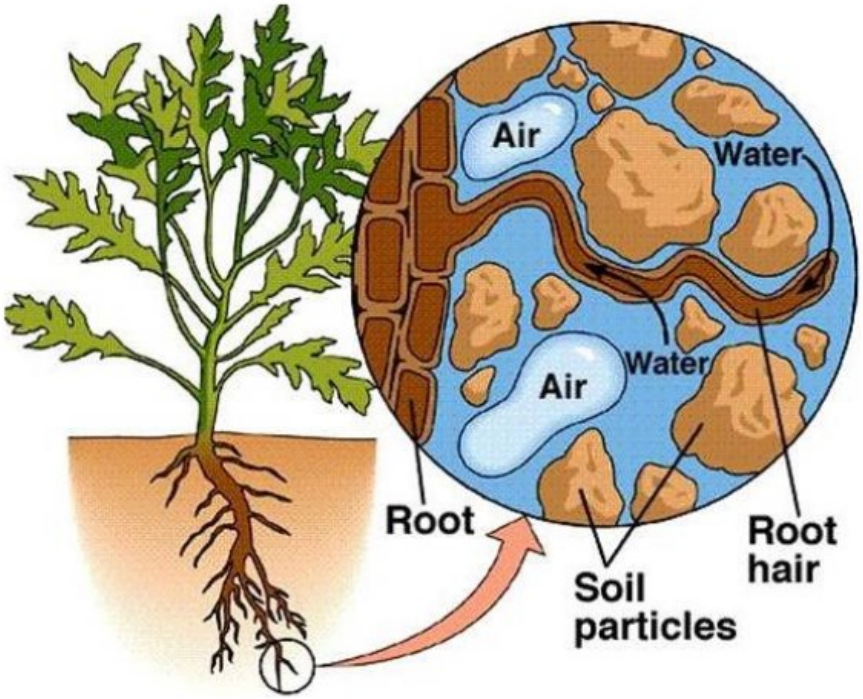
Disturbed soils in urban areas

- Air and water are the most important elements for plant nutrition
  - Soil compaction leads into decrease of macropores
  - Less air, more micro pores
  - Increase of death water (plants can't absorbe)
  - low Nutrient availability
  - Anaerobic conditions (Redoxpotential)

Disturbed soils



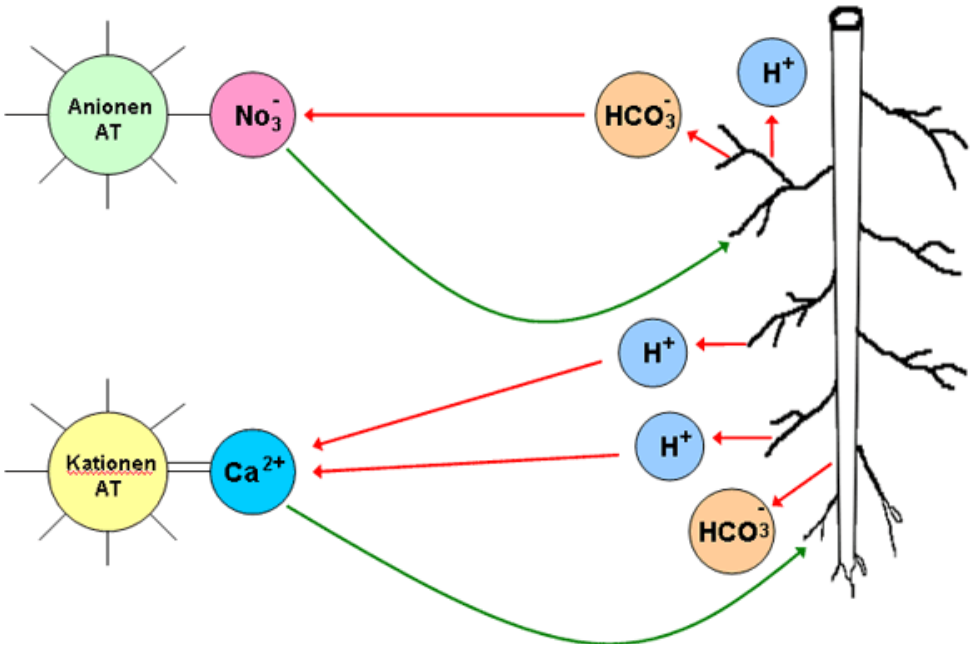
Soil and roots



- Air
- Accurate temperature
- Availability of nutrients
- No harmful substances

http://preuniversity.grkraj.org

Ionic exchange



Exchanger

Liquid soil phase

Roots

(HyperSoil, 2012)

Definition of substrates

Artificial mixtures that are adapted to the needs

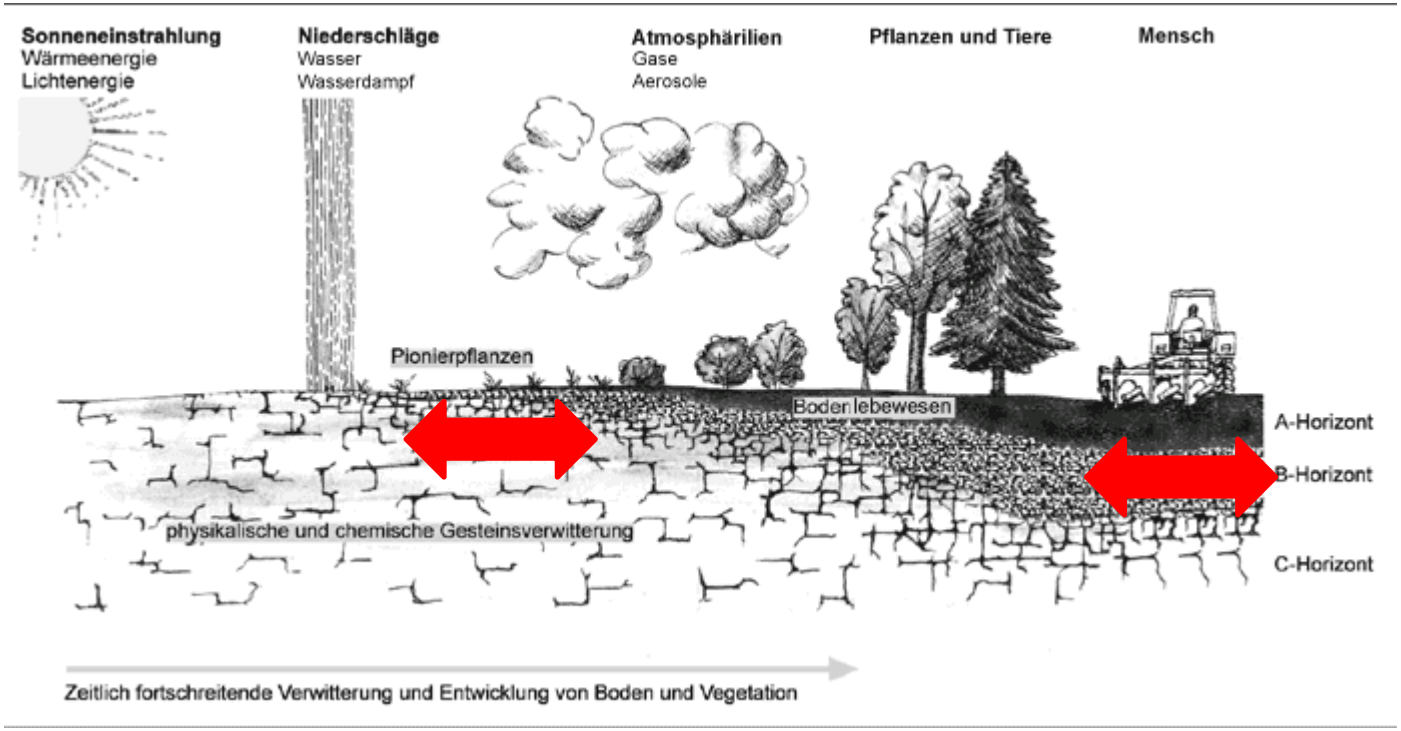
- of plants
- anthropogenic use

Substrates are used where natural soils can no longer fulfill their natural function due to:

- Damage
- Through anthropogenic needs

Substrates are not soils!

Pedogenesis – where are substrates located?



Bodenbildung (Abb. verändert nach: MAYER, J. 1996, S. 13

Substrates in Practice

Relevant standarts in the topic of structural substrates

FLL - Recommendations for tree planting
Part 2 (yellow print) Site preparation for new plantations; Plant pits and root space extension; Construction methods and substrates (2017)

ZTV Vegtra-Mu
Additional technical regulations for the production and installation of improved vegetation strata in Munich (2016)

Substrates in Practice– urban trees

Structural stable substrates must not contain more than 5% organic material

Often these substrates do not provide enough nutrients for the tree

the missing organic substance leads to a lack of retention of nutrients

How can we face these challenge?

Use of biochar

What is biochar?

- Carbonated biomass (carbonized under exclusion of oxygen)
- Stable carbon (C) in soil from biomass
- Fixed CO^2 bound from the atmosphere

What can biochar do?

- Increase the fertility of the soil
- Increases pH, sorbent property and CAC in soils
- Habitat for MO's

Use of biochar

What is biochar made of?

- **Biomass from plant parts**
- **kitchen waste**
- **Excrement**

Where can I use it?

- **In composting**
- **For soil improvement in horticulture**
- **For soil improvement in agriculture**
- **In modern urban planning (rainwater management, tree substrates)**

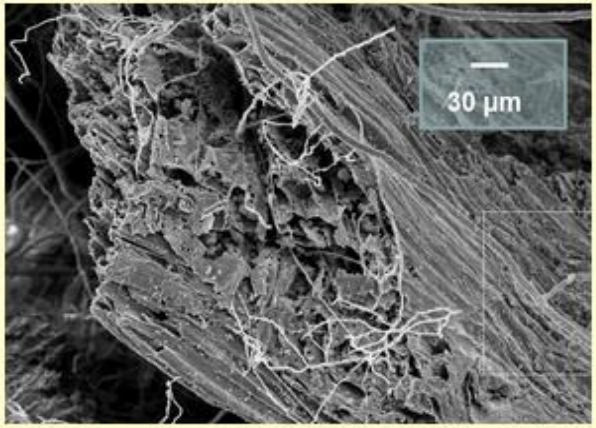
Great potential for neutral or even negative CO2 energy production from biomass

biochar

- Aktivkohleherstellung

Aktivierung mit Wasserdampf

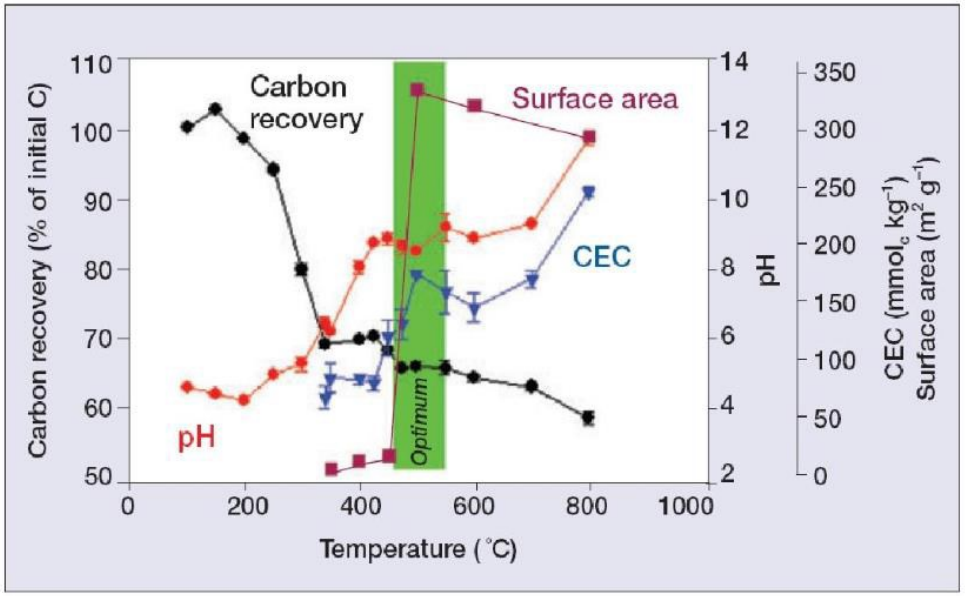
bei 800 °C - 1000 °C



Above: Mycorrhizal hyphae (*Glomus clarum*) growing on biochar in a sample taken from a greenhouse experiment. (photo: S. Vanek)

Biochar manufacturing process

Varianz Oberfläche, KAK



[LEHMANN 2007]

It is an old principle

„Terra Preta“ – Forschung = Wiederentdeckung von altem Wissen

Delinat-Institut für Biodiversität und Klimafarming
Hochschule Wädenswil ZHAW
Justus Liebig Uni Giessen DE, Uni Bayreuth DE

Biochar – Pflanzenkohle ein neues Element für die Humuswirtschaft?

Normaler Urwaldboden

Bodenprofile im Amazonas-gebiet Brasilien

Funde von fruchtbaren Böden mit Biochar

„Terra-Preta do Indio“

How can we use biochar in Substrates

- Important! The Biochar needs to be charged with nutrients. (ECB, Certificate)

How much biochar per m2?

- Terra Preta has around 100t / ha
- Annual application vs. total quantity
- 100gr (500ml) / m2 is around one tonne / ha

How to spread

- Root application in planting holes or trenches
- Conventional milling / plowing coal

How can we use biochar in Substrates

- **Root application in combination with deep-rooted species!**

Mixture of substrates – research in Wädenswil

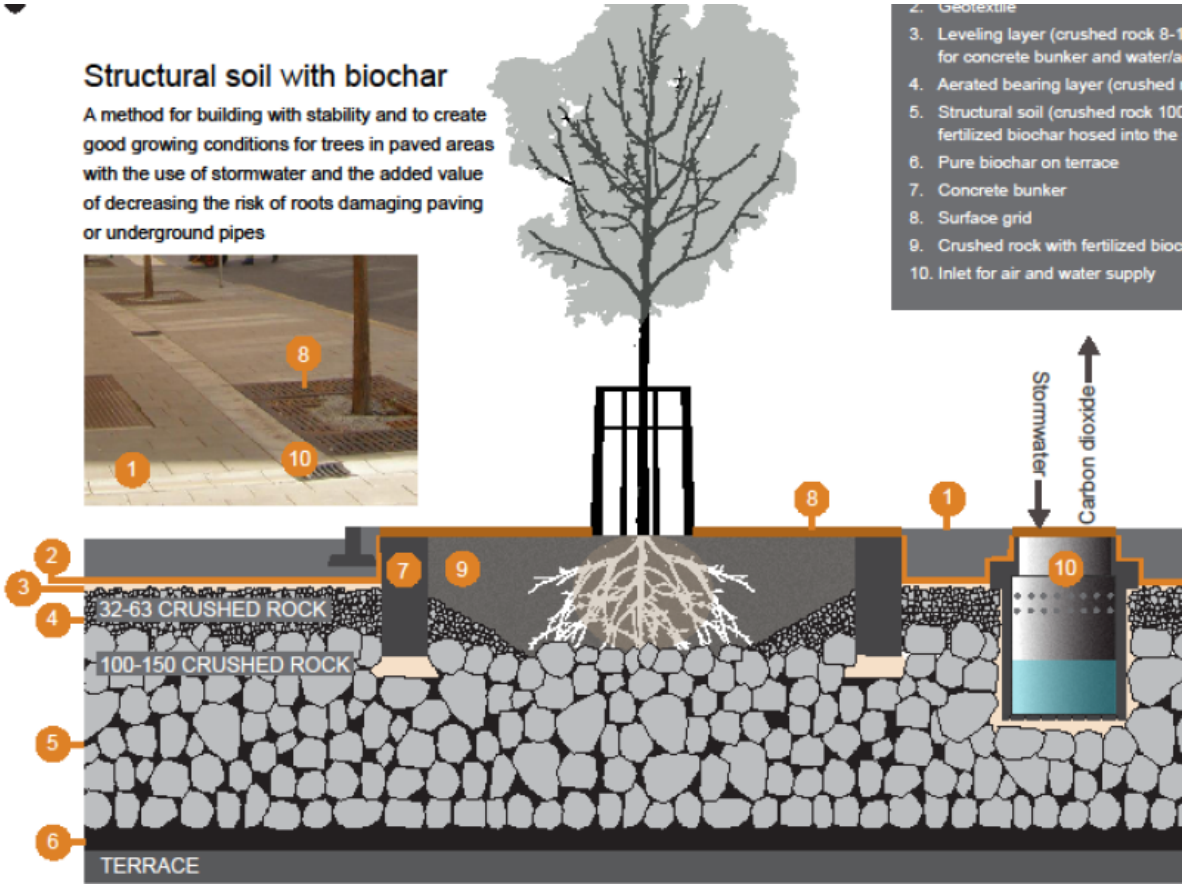
- Highly compactable tree substrate (macadam construction)
  Good price / performance ratio
  Easy to install

  Organic substance is supplemented / enriched by PK

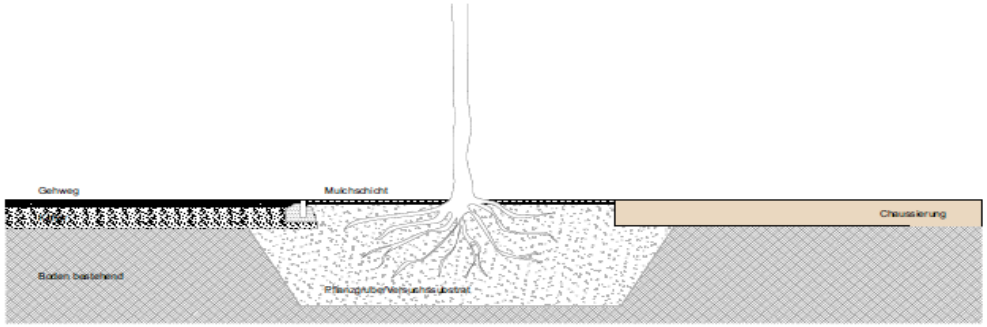
  Growth behavior, phenotype and substrate properties are tested in a preliminary experiment

- According to substrates in Stockholm

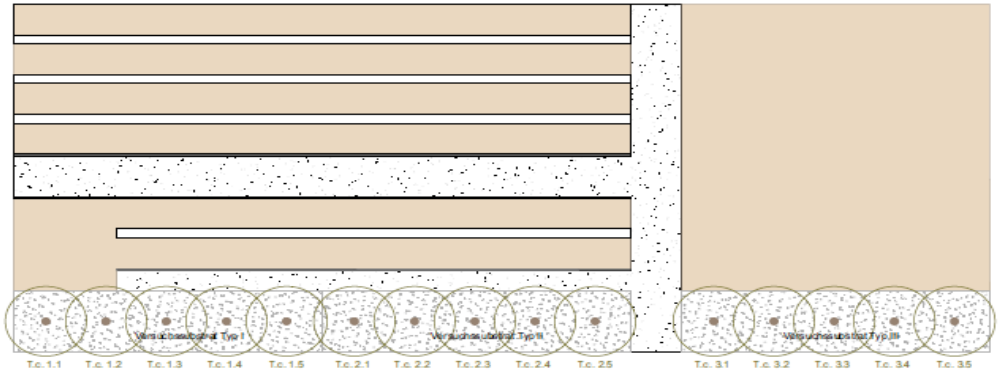
Substrates with biochar



Substrates with biochar

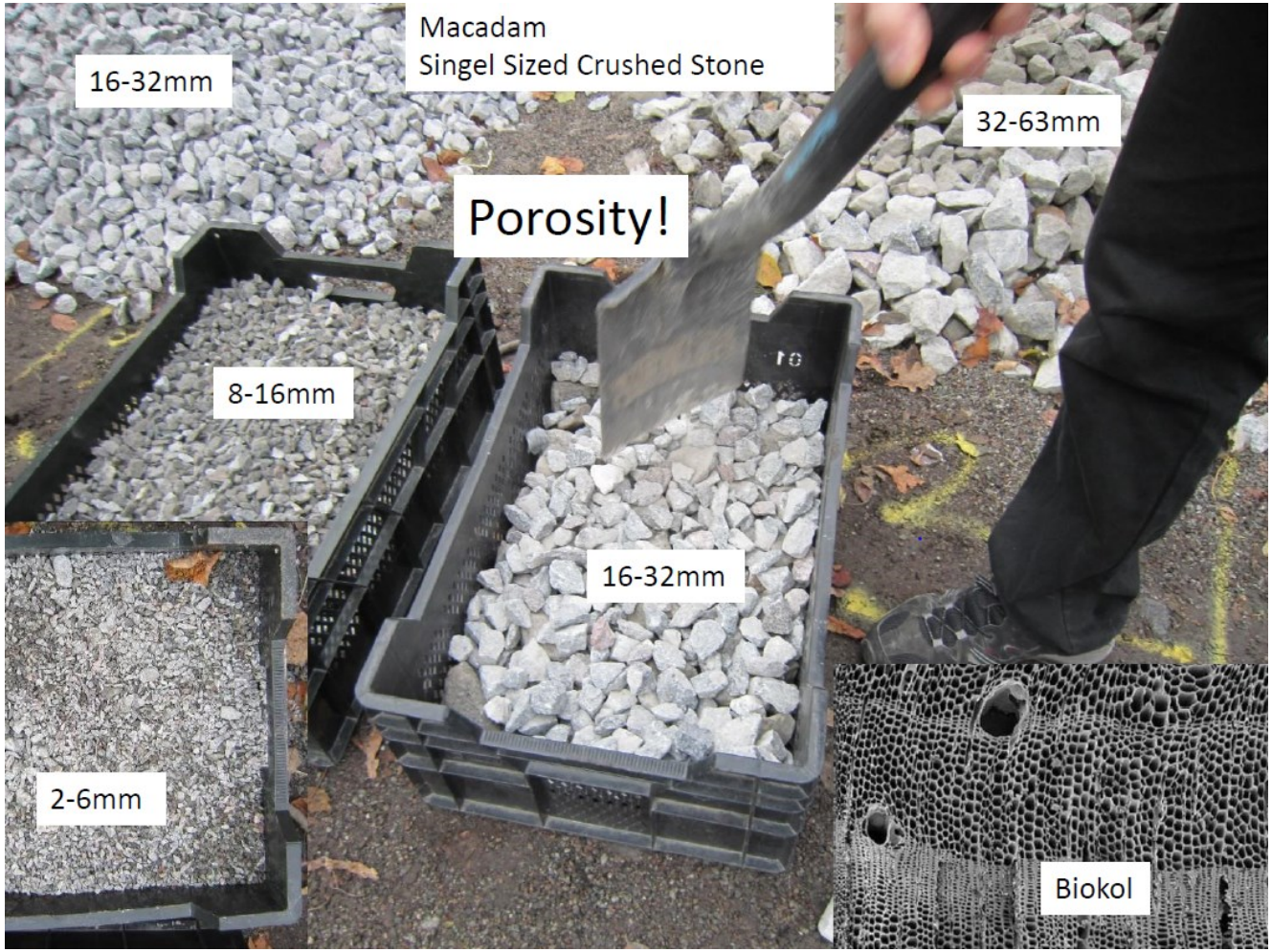


Schnitt 1:25



Grundriss 1:200

Substrates with biochar



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Substrates with biochar

Substrates with biochar

Substrates with biochar

Jahr	pH	P_2O_5	K_2O	NO_3-N	Mg	Salzgehalt	KAK pot.
		(mg/100g)				mg KCl/100g	mmol/100g
Substrat 1							
2016	8.1	0.75	32.3	0.41	21.5	29	4.83
2017	7.6	0.95	34.5	0.65	23.5	32	4.65
2018	7.5	0.99	33.2	0.64	24.6	36	4.52
Substrat 2							
2016	9.7	0.25	30.8	0.5	36.9	47.3	7.03
2017	8.1	0.54	31.2	0.65	37.2	47.2	7
2018	8.0	0.56	31.3	0.63	37.0	47.5	7.2
Substrat 3							
2016	8.8	0.55	39.7	1	39.9	52.5	10.35
2017	7.6	1.2	48.4	13.4	52.3	67.5	8.5
2018	7.3	1.4	55.2	14.1	54.1	71.3	7.9

Biochar and roots

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Biochar and roots

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Biochar substrate in zurich

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Seepage surface – Variety of substrates

Seepage surface (No fibermats!!)

Seepage surface

Using substrates with biochar

Gives healthy trees with all the positive effects it provides

Planting beds become part of the circular economy

Stops the use of finite resources

Reduce the heat island effect

Locks down carbon dioxide into the ground with the use of biochar in the planting beds

Reduce the presence of particles and carbon dioxide in the air

Reduce the load on the storm water systems, thereby reducing pollution in Lake Mälaren and the Baltic Sea

Reduce the risk of flooding

Summary and future prospects

- Urban substrates are subject to highly dynamic environment, standardized substrates are not effective
- Biochar for degraded, marginal, barren soils has a great potential
- Biochar can be used as a soil improver in agriculture or in urban areas
- It provides a Pedogenesis
- Very high dynamics in research
- Substrate research shows great promise
- Good first results and further research questions with Trichoderma and Mykorhiza
- First assignments in practice

Do something that put down roots!