

Better Places, Infrastructure,Lives
Delivering Real Value with Urban Trees

Björn Embrén

Tree Officer



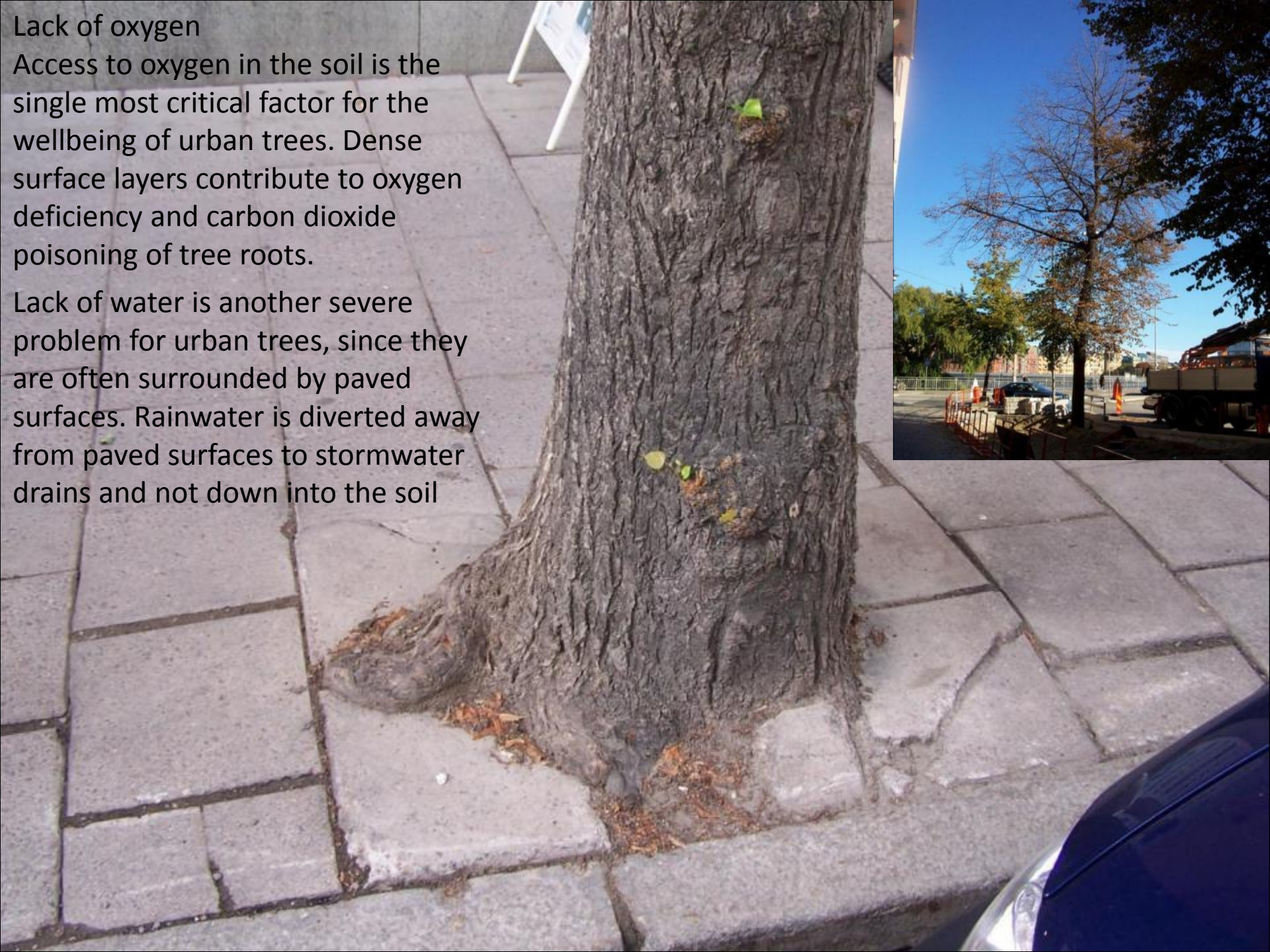
Street Department, Stockholm, Sweden

***Trees and Stormwater Management
– The Stockholm solution –***

Lack of oxygen

Access to oxygen in the soil is the single most critical factor for the wellbeing of urban trees. Dense surface layers contribute to oxygen deficiency and carbon dioxide poisoning of tree roots.

Lack of water is another severe problem for urban trees, since they are often surrounded by paved surfaces. Rainwater is diverted away from paved surfaces to stormwater drains and not down into the soil



conventional construction
for sidewalks in
Stockholm
a completely sealed
surface where no water
can be infiltrated or gas
exchange can take place



Concrete tile

Sand

Asphalt

Roadbed crushed granite fraction 0-63 compacted

After 40 years





Our goal

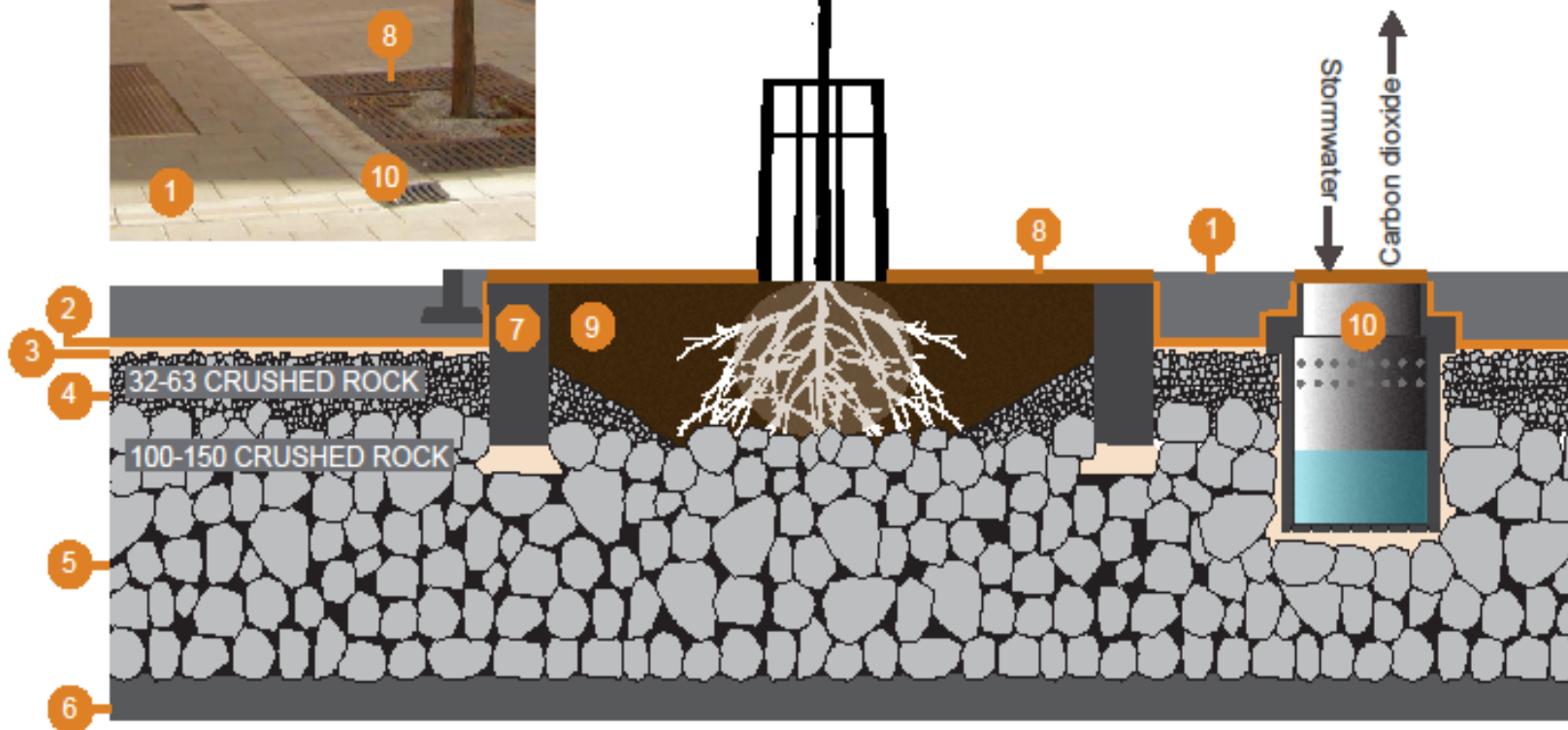
is plant beds that are sustainable and has minimal environmental impact on the basis of material and design,
simple design for secure results,
low operating costs,
a final product where trees and plant beds is part of the city's environmental efforts

Structural soil

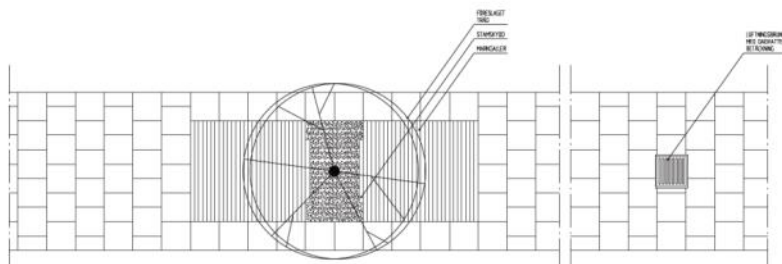
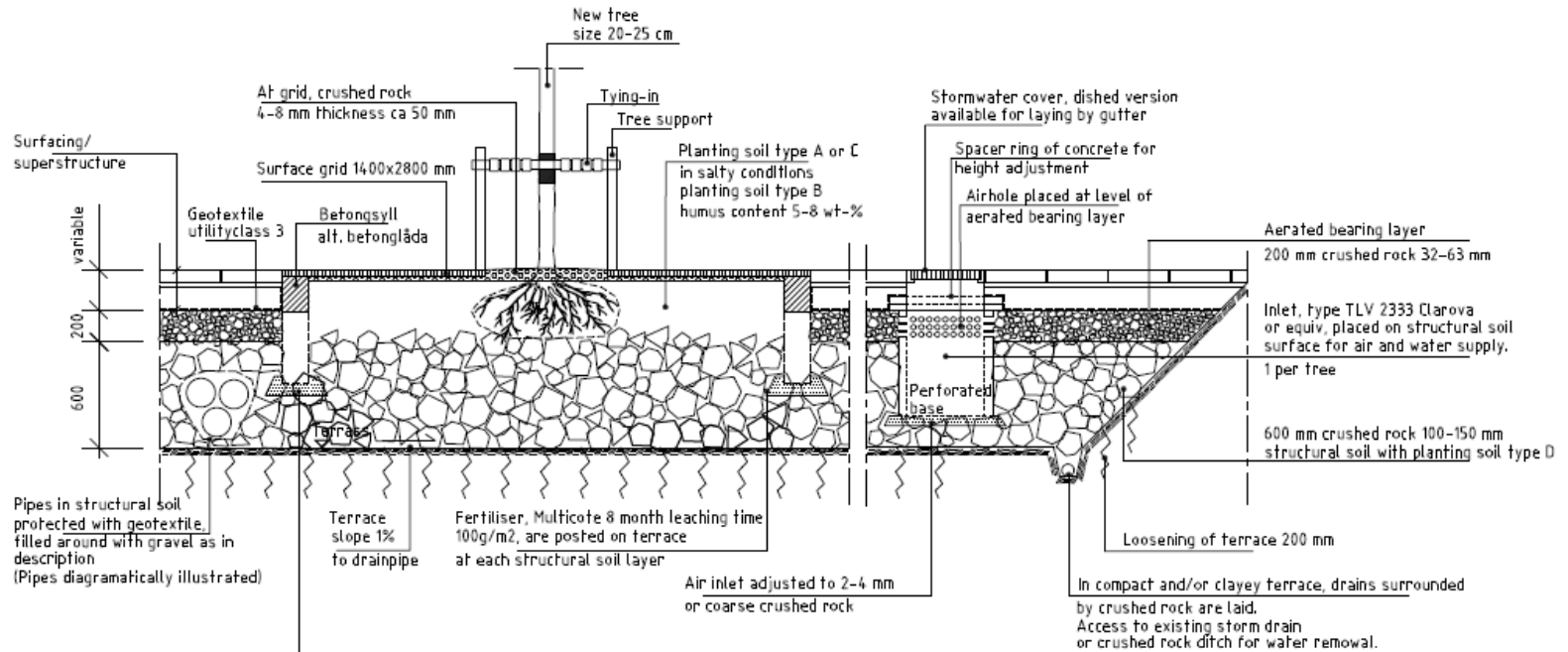
A method for building with stability and to create good growing conditions for trees in paved areas with the use of stormwater and the added value of decreasing the risk of roots damaging paving or underground pipes



1. Paved surface with dished stormwater gutters
2. Geotextile
3. Leveling layer (crushed rock 8-16 mm) – also used for concrete bunker and water/air inlet.
4. Aerated bearing layer (crushed rock 32-63 mm)
5. Structural soil (crushed rock 100-150 mm) with planting soil holed into the structural volume
6. Terrace
7. Concrete bunker
8. Surface grid
9. Planting soil
10. Inlet for air and water supply



adapt materials selection to what is available locally
and if possible in the first place recycled materials



TRÄGROPP I HÄRDGJORD YTA MED MARKGALLER,
STAMSKYDD SAMT LUFTHINGSBRUNN
PLAN
SKALA 1:20
TRÄSK LÄNDRÅDSTÄMME
STRÖMSTAD 2009-02-23

NOTES

Soil equipment such as gratings, trunk guards, tree support are specifically adapted to the project. Fine crushed rock must not be used in structural soil profile for adjusting air inlet or concrete bunker. In specially constructed tree holes with narrow dimensions tree root diameter must be observed. With increasing trunk circumference clump diameter increases, see Quality regulations for nursery plants, GRO's Plantskolesektion, 3:e upplagan, augusti 2003.

NOTESANMÄRKNING

All data in mm unless otherwise specified.

Status	Datum
TH-TYPTRITNING	2009-02-23
Godkänd	B.EMBRÉN



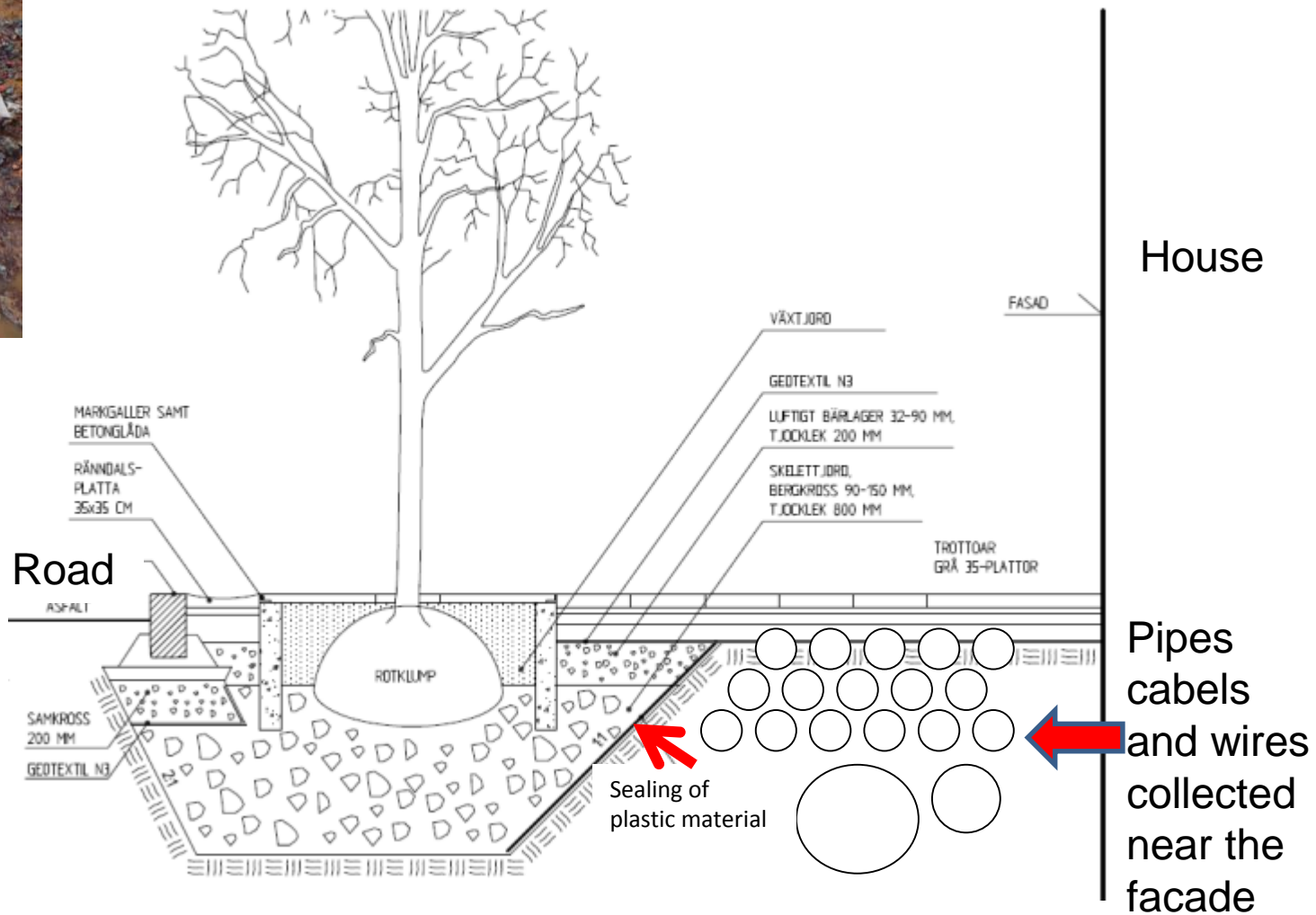
TREE IN PAVED AREA
WITH SURFACE GRID

SECTION

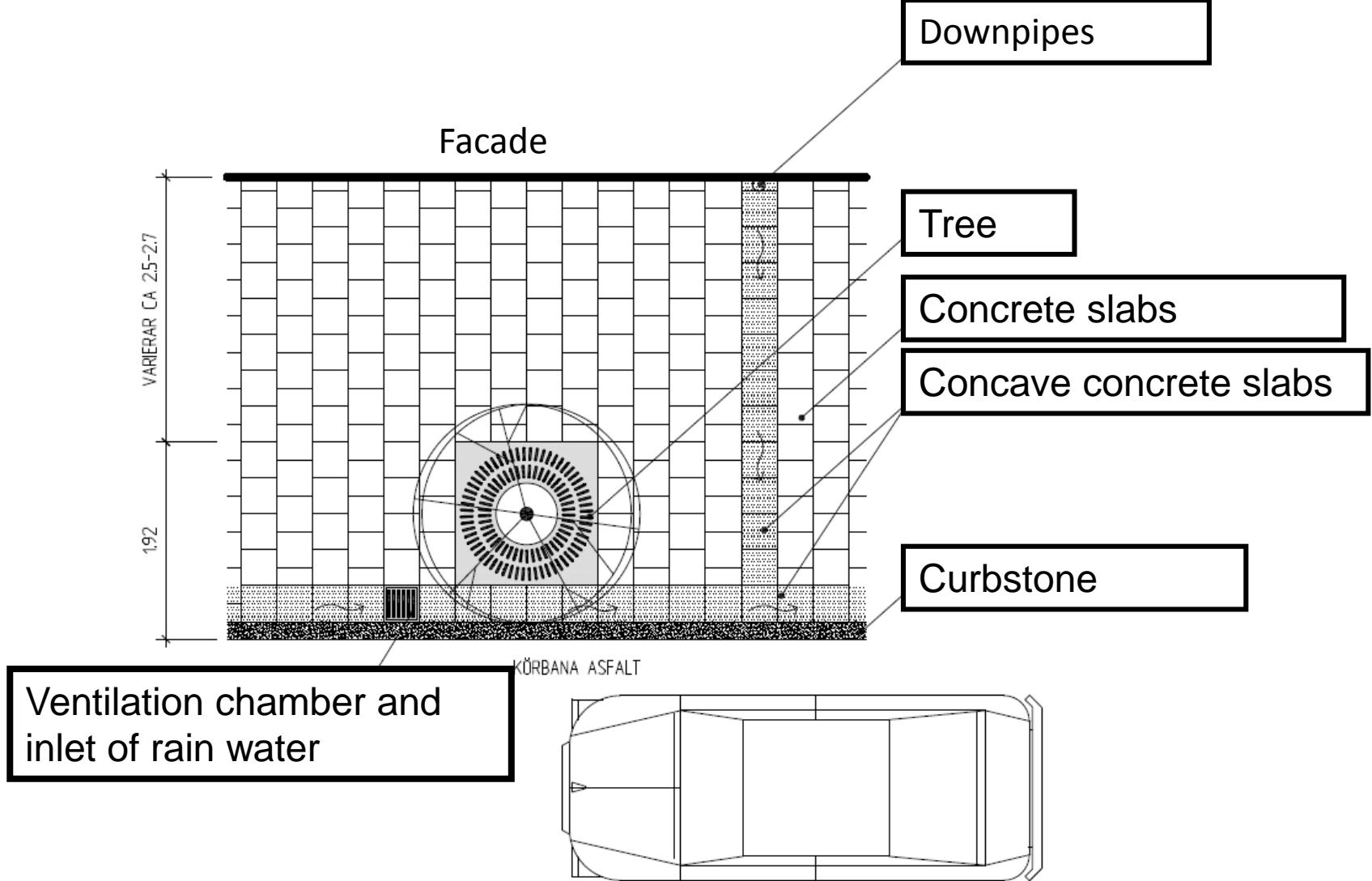
Skida	Ritningarn	Foto	Reg.
1:20(A2)/1:40(A4)	THVB004		



Sidewalk Cross section of planting bed



connected plant beds along the block for the best conditions for the trees







Granit 90-150mm
Each layer 300 mm compacted for stability

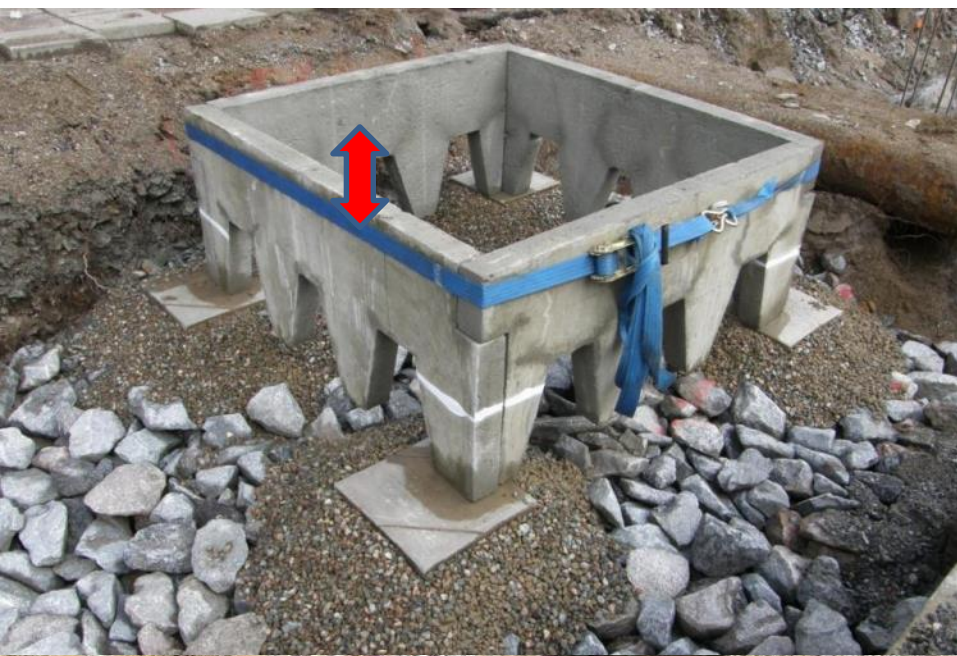
Recycled concrete used as a part of the structural soil instead of granite



Granit size 90-150mm



Concrete box to hold the paved surface in place



Compacting befor soil is washed in to the voids



The stone shall fall into the box to get a stabel construction



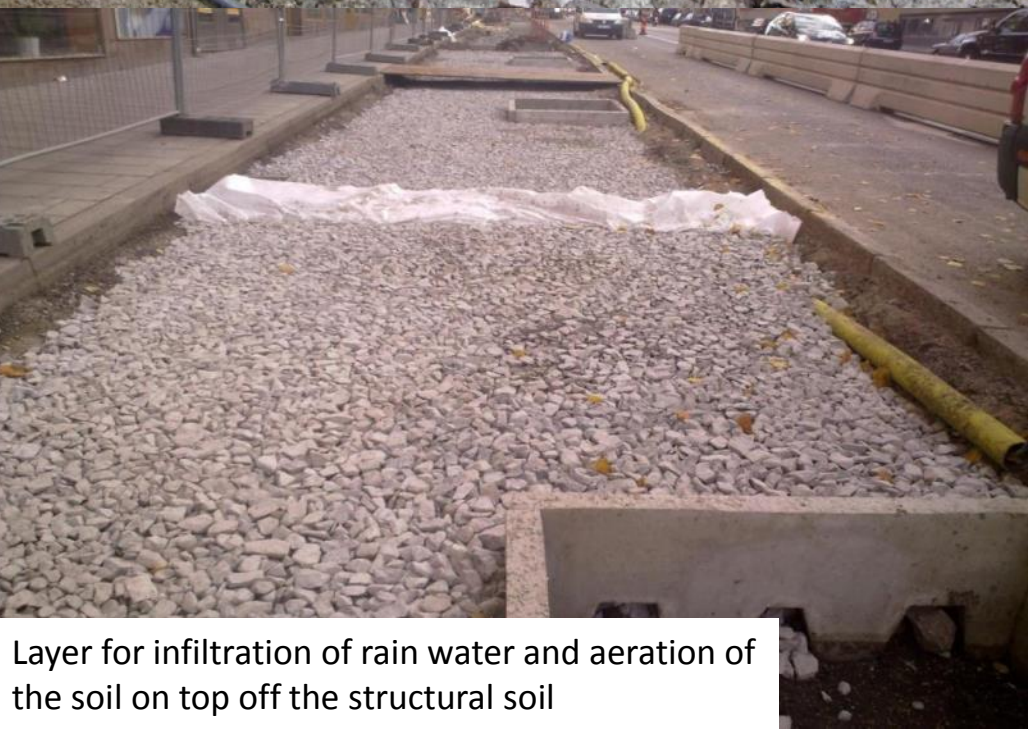
Flushing the soil into the structure



Ventilation chamber and inlet of surface water



Slow release fertilizer



Layer for infiltration of rain water and aeration of the soil on top off the structural soil

Layer for infiltration of rain water and ventilation of the ground

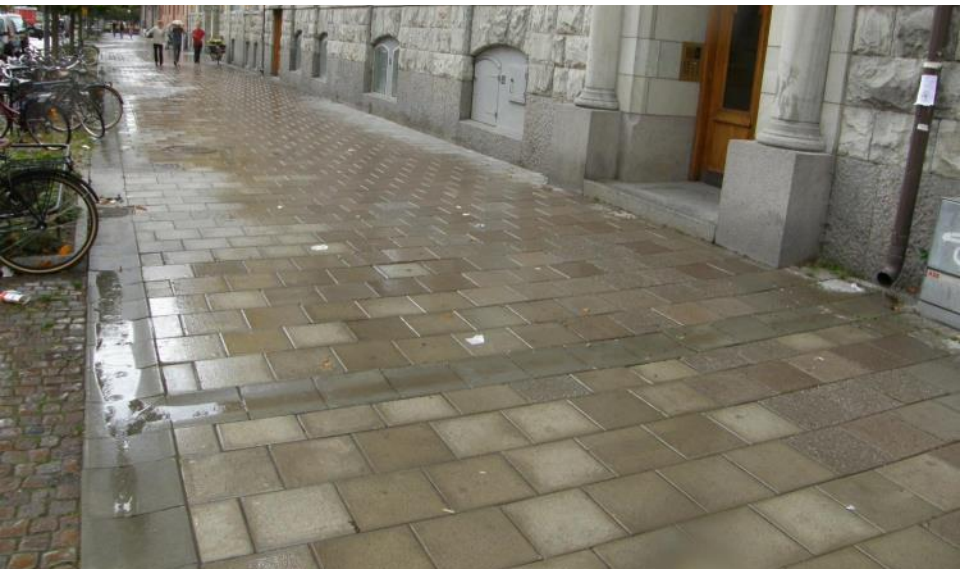






Important with geotextile connection against curbs inlets concrete boxes etc. so that no fine material could run into the airy base course

- We take water from roofs and pavements through inlets to the ventilated bearing layer and the structural soil.



If the percolation layer is full, the storm water flows into the old street inlet.



- Roof and pavement surface 4600kvm Rainfall 600mm year (2 fot)
 Approximately 2.3 million liters of water year Saved cost for the treatment of stormwater = 2300 £ /year
 Reduced load on the Baltic Sea / and lakes at torrential rains



If the old trees has no damage, we will remove the material around the roots and re-fill with structural soil

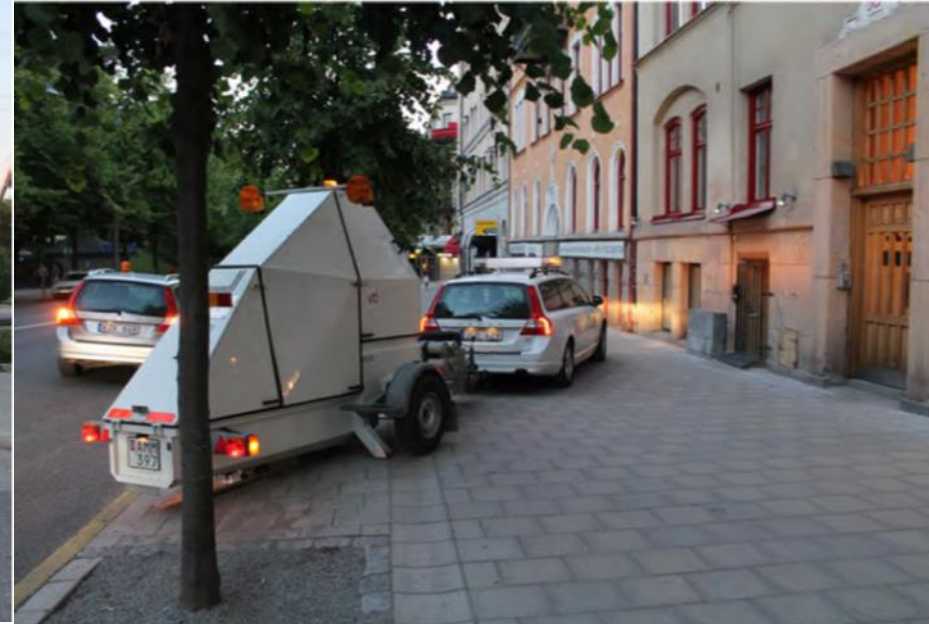


VTI

Research and development on infrastructure, traffic
and transport

VTI, Swedish National Road and Transport Research Institute, is an independent and internationally prominent research institute within the transport sector. The main task is to conduct research and development on infrastructure, traffic and transport. The quality system and environmental management system is ISO certified according to ISO 9001

www.vti.se/



Figur 29. Fallviktsmätning vid Odengatan 86 i Stockholm.

Vti measures the stiffness of the paved surface on the Structural soil

Field measurements from Malmö, Stockholm and Kristianstad municipalities shows that skeletal soil superstructure has a good stiffness and bearing strength corresponds to the standard superstructure if they are built in a good way. It is possible to use skeletal soil structures even on busy streets if they designed and built in a right manner.

Om projektet

Resultat

Partners

Kalendarium

Start | Resultat | WP 2 Hårdgjorda ytor



Resultat

WP 1 Attraktiva stadsmiljöer

WP 2 Hårdgjorda ytor

WP 3 Stadsträd

WP 4 Dagvatten

WP 5 Stadsklimat

WP 6 Livscykelanalys

Slutseminarium

WP 2 Hårdgjorda ytor

CBI Rapport "Rätt dimensionering av markstensplattor"

Hanna Ivarsson, examensarbete: Att lyckas genom hela plan- och byggprocessen

Axel Lilja, examensarbete: Betydelsen av naturstenshällens ytbearbetning mot underlaget för att undvika att stenen glider i sidled

Tidningen Utemiljö nr 8 2014 Gröna Fakta

Stenindustrins Forskningsinstitut, rapport: Kontrollrutin för naturstens- och markbetongöverbyggnader

Stenindustrins Forskningsinstitut, Bilaga A: Dimensioneringsberäkning av överbyggnad

Stenindustrins Forskningsinstitut, Bilaga B: Dimensioneringssystem för naturstenshällar

Stenindustrins Forskningsinstitut, rapport: Överbyggnad med naturstens- och markbetongbeläggning

MTI, rapport: Spårjupbildning och styvhet i konstruktioner av betong- och natursten

CBI, rapport: Markstensbeläggningar för gröna ytor: state of the art



2 years after planting



4 years after planting 3.5 meters from the tree

Erik Dahlbergsallén





As a proof that we are on the right path, we find mykorrhitza in our structural soils which only thrives in good conditions (planting pits acting as a biological filter)

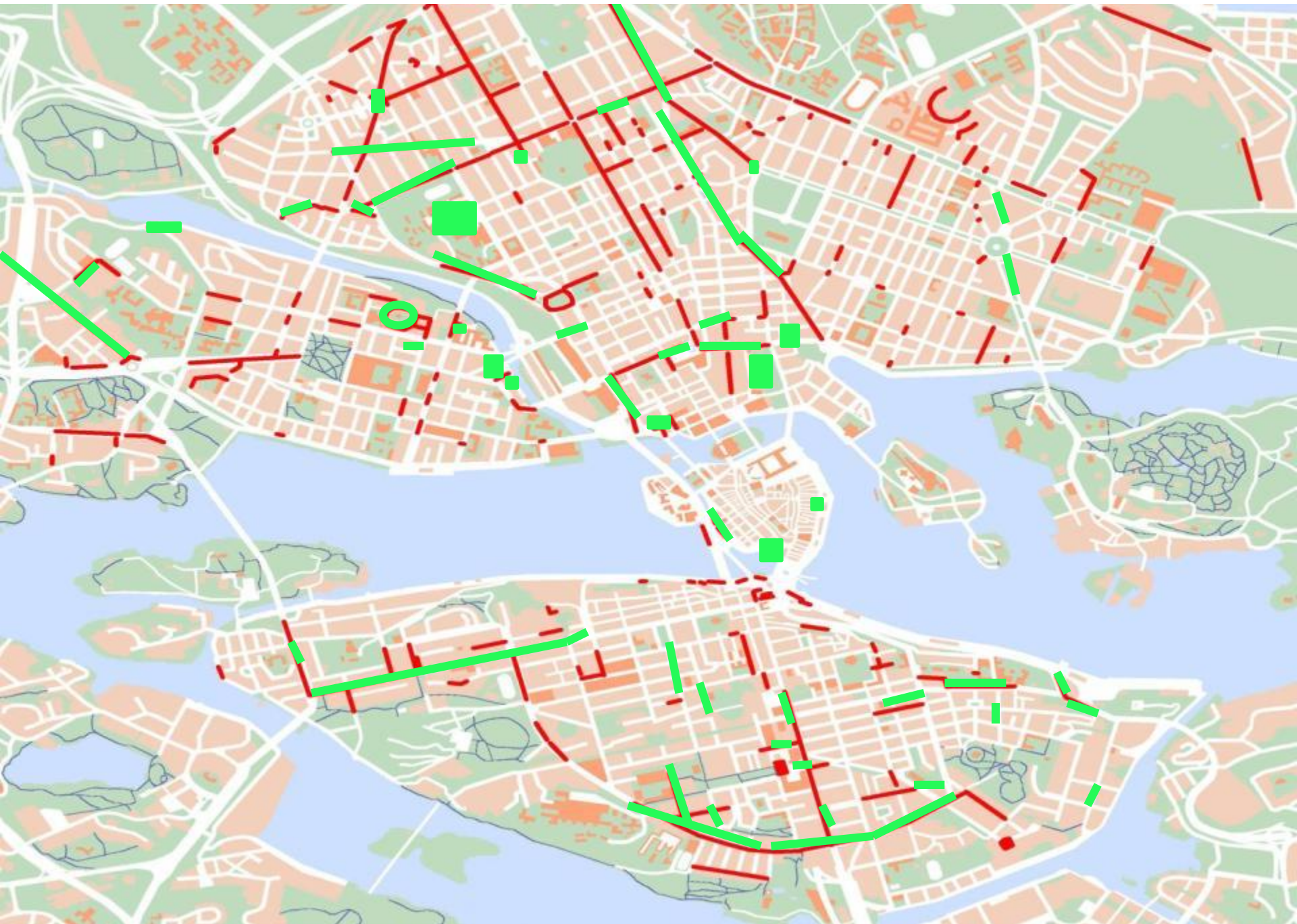
Narvavägen

test holes 4 years after planting in structural soil

surface coating pumice fraction 2-8mm mixed with crushed granite
fraction 0-8mm volume 1/1



Approximately 2 000 planting beds have been rebuilt with structural soil



planted as 30-35cm after 8 years, the trees are 70 - 83cm in circumference



2004-2012

Erik Dahlbergsallén

Kocksgatan

Prunus
'Umineko'



Odengatan first growing season



Swedenborgsgatan
trees before and after structural soil

Planted
around
1935 about
80 year old

Planted in
autumn 2003
10 years at the
location





2005-2010

Hamngatan 60cm structural soil



Quercus
palustris
3 growing
seasons



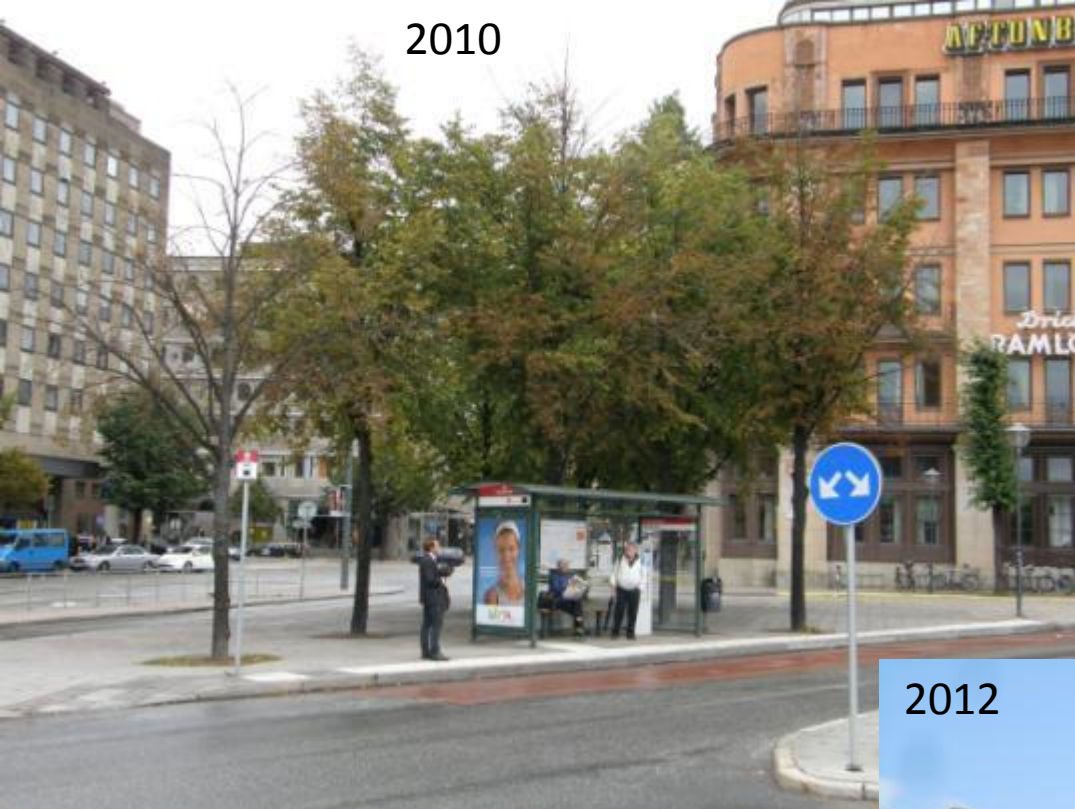
trees without structural soil 1965-2010



trees with structural soil 2005-2010



2010



Tegelbacken
before and after the trees have
got structural soil

2012





left 2002 right 2013 Kungsbroplan tree before and after structural soil



Reduce the risk of flooding

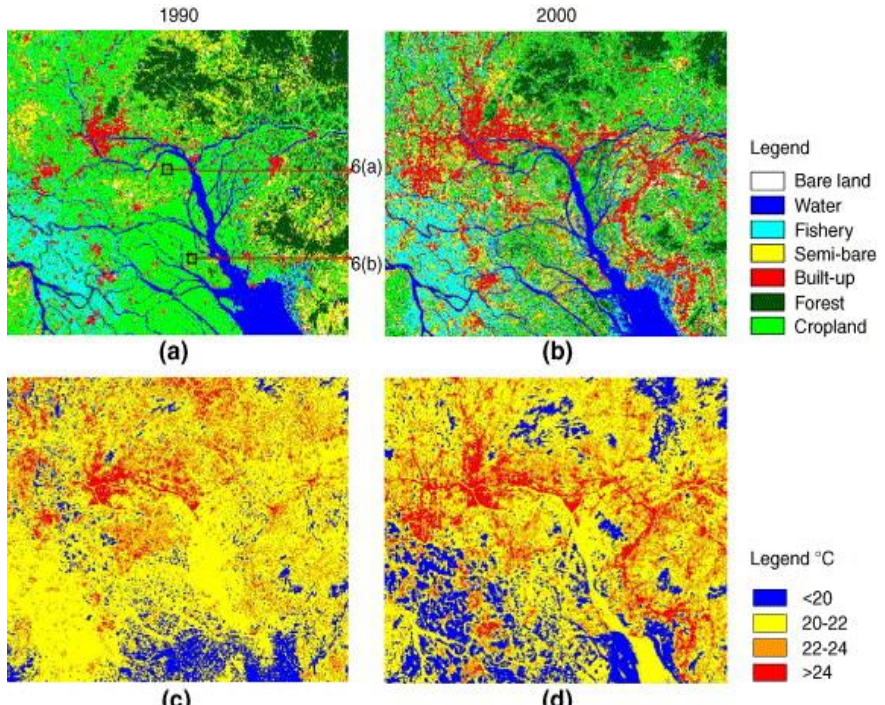


Reduce the presence of particles and carbon dioxide in the air

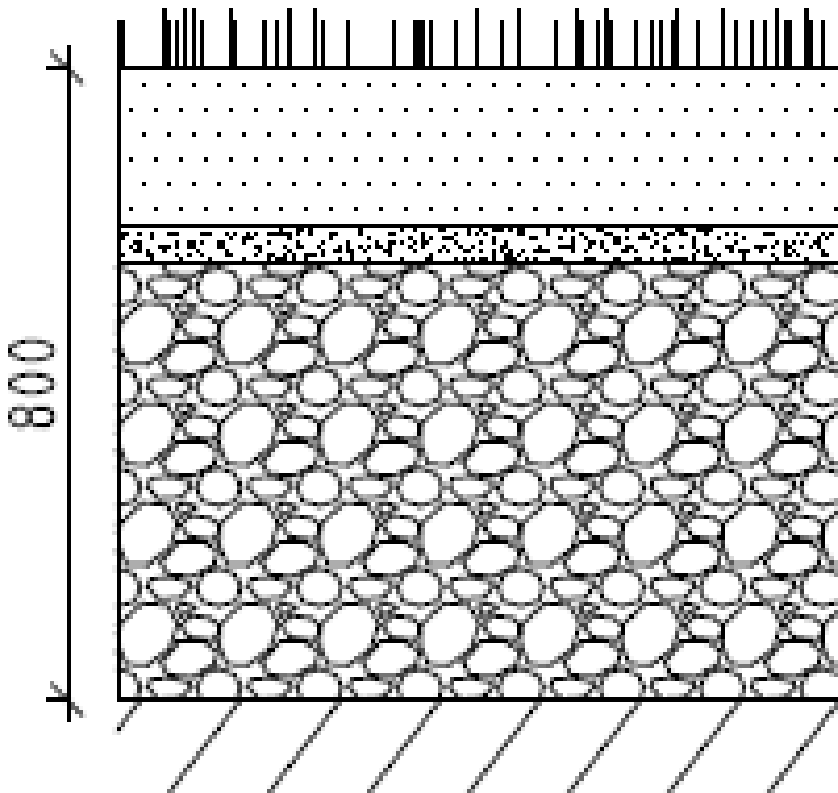


Reduce the load on storm water systems and thereby reduce pollution in Lake Mälaren and the Baltic Sea

Counteract heat island effect



Pure rock that was covered with coir mat and 3-inch soil mixed with charcoal blend 50/50 continuous plant bed 80 cm deep about 2 meters wide





2012-06-20



Herrhagsvägen

Trees planted in a mixture of
soil / charcoal 50/50

Second growing season



Terra preta

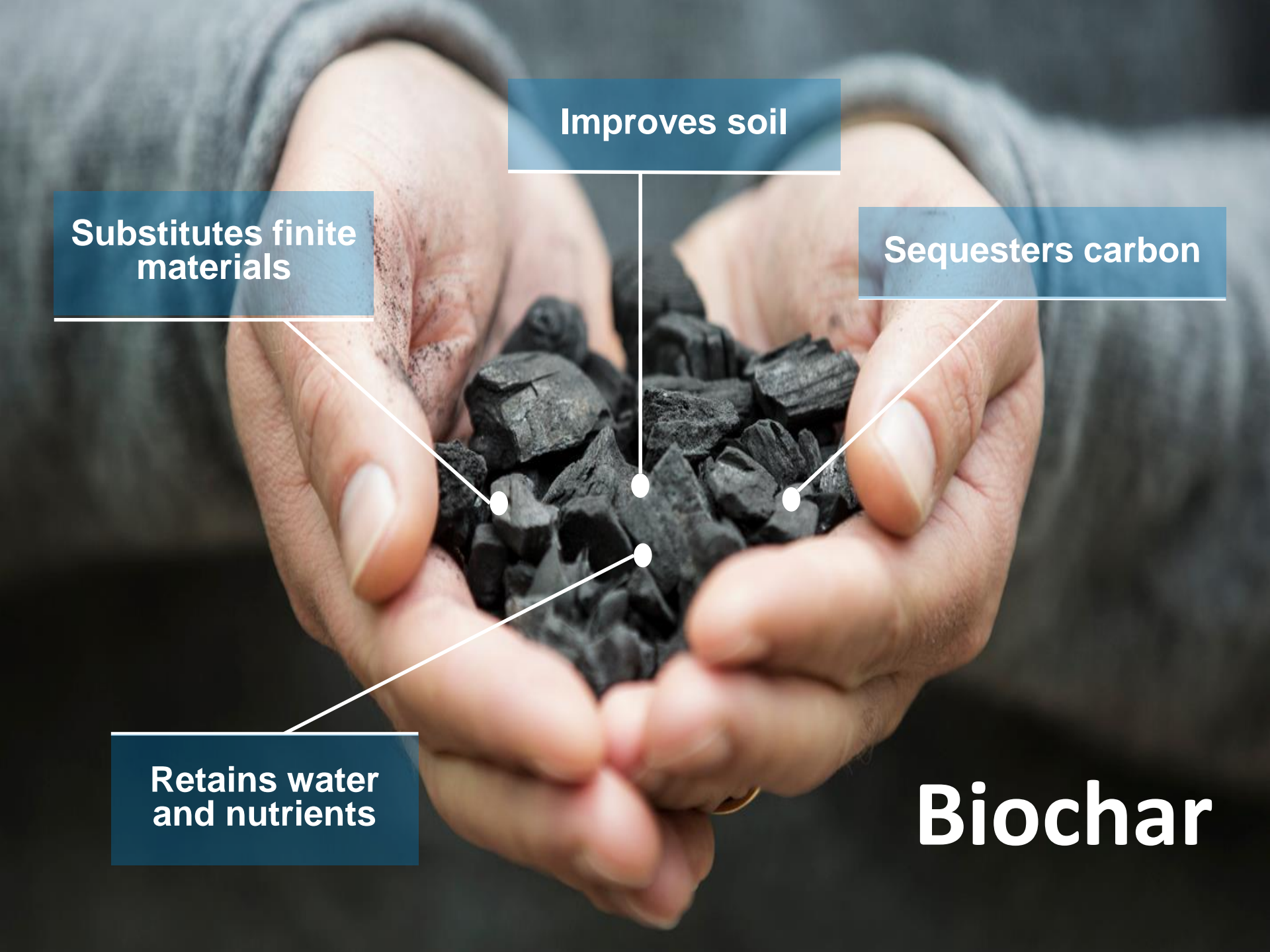
From Wikipedia, the free encyclopedia

Jump to: [navigation](#), [search](#)

Terra preta (Portuguese pronunciation: [ˈtɛɐ̃ ˈpɾɛtɐ], locally [ˈtɛhɐ ˈpɾɛtɐ], literally "black earth" or "black land" in [Portuguese](#)) is a type of very dark, fertile [anthropogenic soil](#) found in the [Amazon Basin](#). Terra preta owes its name to its very high [charcoal](#) content, and was made by adding a mixture of charcoal, bone, and manure to the otherwise relatively infertile Amazonian soil. It is very stable and remains in the soil for thousands of years.^{[1][2]} It is also known as "**Amazonian dark earth**" or "**Indian black earth**". In Portuguese its full name is *terra preta do índio* or *terra preta de índio* ("black earth of the [Indian](#)", "Indians' black earth"). *Terra mulata* ("mulatto earth") is lighter or brownish in colour.^[3]

Terra preta is characterized by the presence of low-temperature charcoal in high concentrations; of high quantities of pottery [sherds](#); of organic matter such as plant residues, animal [feces](#), fish and animal bones and other material; and of [nutrients](#) such as [nitrogen \(N\)](#), [phosphorus \(P\)](#), [calcium \(Ca\)](#), [zinc \(Zn\)](#), [manganese \(Mn\)](#).^[4] It also shows high levels of [microorganic](#) activities and other specific characteristics within its particular [ecosystem](#). It is less prone to [nutrient leaching](#), which is a major problem in most rain forests. Terra preta zones are generally surrounded by *terra comum* ([ˈtɛhɐ koˈmũ] or [ˈtɛhɐ kuˈmũ]), or "common soil"; these are infertile soils, mainly [acrisols](#),^[4] but also [ferralsols](#) and [arenosols](#).^[5]

Terra preta soils are of [pre-Columbian](#) nature and were created by humans between 450 BC and AD 950.^{[6][7]} The soil's depth can reach 2 meters (6.6 ft). Thousands of years after its creation it has been reported to regenerate itself at the rate of 1 centimeter (0.39 in) per year^[8] by the local farmers and [caboclos](#) in [Brazil](#)'s Amazonian basin, who seek it for use and for sale as valuable potting soil.



Improves soil

Substitutes finite materials

Sequesters carbon

Retains water and nutrients

Biochar



Charcoal is incredibly stable if we dig it down into the ground, it stays there for thousands of years as a Co2 sinker

By using biochar and a crushed mineral content such as rock or recycled concrete for municipal plant beds, growth is stimulated, finite resources for soil production are spared (peat, sand and clay), and the possibilities of local stormwater infiltration increases. Thus promoting crucial urban ground water production, filtering of pollutants and less risk of contaminated recipients from flooded stormwater and sewage systems. The increase of green biomass in the cities also provide a whole array of other auxiliary benefits such as better air quality, increased bio-diversity and lowered temperatures.



Biochar is a name for [charcoal](#) when it is used for particular purposes, especially as a soil amendment. Like all charcoal, biochar is created by [pyrolysis](#) of [biomass](#). Biochar is under investigation as an approach to [carbon sequestration](#) to produce [negative carbon dioxide emissions](#).^[1] Biochar thus has the potential to help mitigate [climate change](#), via carbon sequestration.^[2] Independently, biochar can increase [soil fertility](#), raise agricultural productivity and reduce pressure on [forests](#), though the degree to which results offer long term carbon sequestration in practice has been challenged.^[3] Biochar is a stable solid, rich in [carbon](#) and can endure in soil for thousands of years.^[1]

Wikipedia



- The first time we use charcoal filters in structural soil was 2013 at Swedenborgsgatan. One block with coals under airy base course and in one block below the structural soil.



Photo: Christina Berger

Biochar and activated carbon filters for greywater treatment – comparison of organic matter and nutrients removal

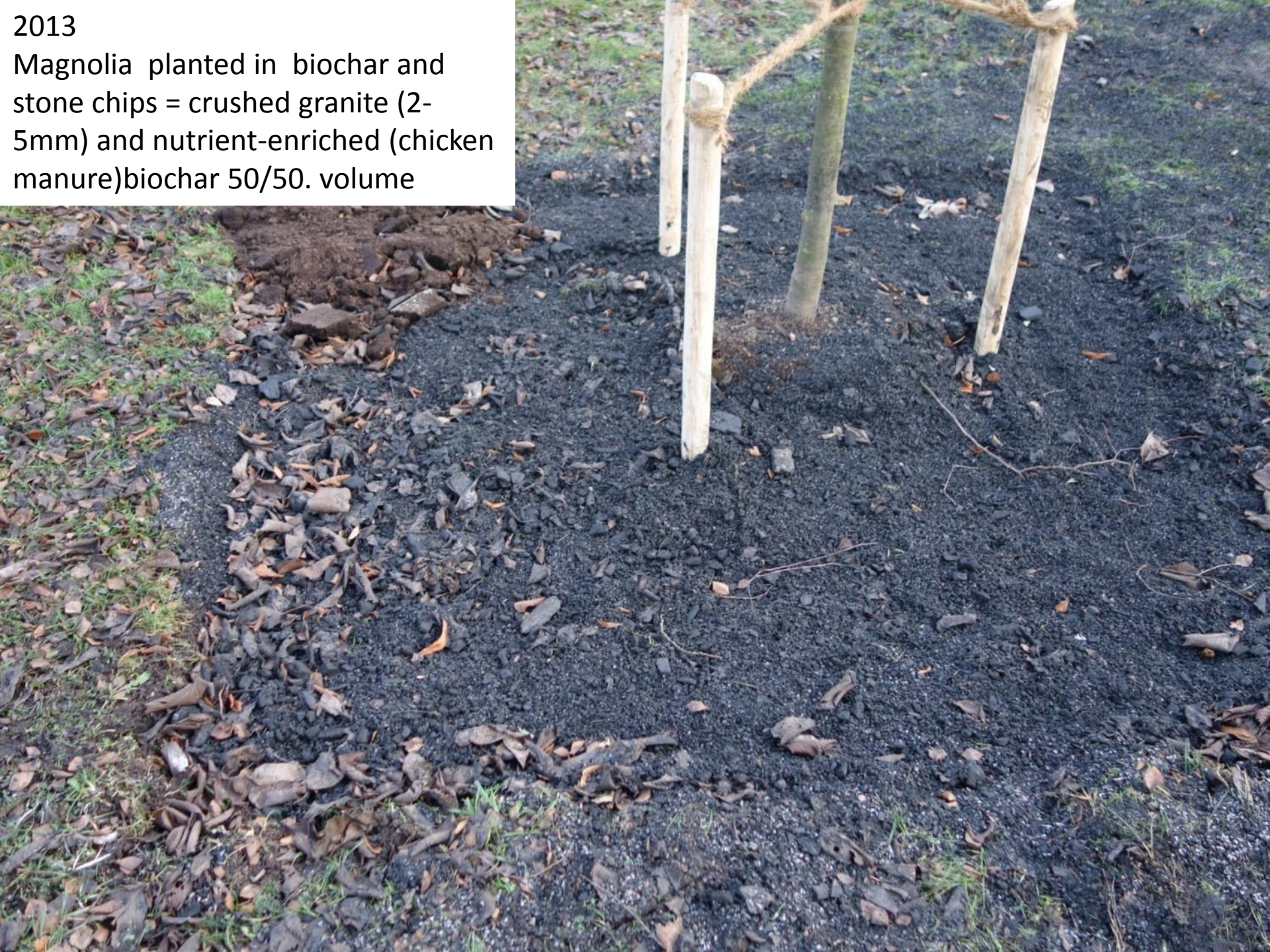
Christina Berger

Plant bed for street trees charcoal and macadam = crushed granite 32-63 mm mixed with 10% nutrient-enriched charcoal, granite can be replaced with recycled concrete with reinforcement (iron)



2013

Magnolia planted in biochar and stone chips = crushed granite (2-5mm) and nutrient-enriched (chicken manure) biochar 50/50. volume





distrustful English tree nursery man

flowering after the first growing season planted in 50/50 biochar crushed granite



Materials we test to use when we plant trees shrubs and perennials

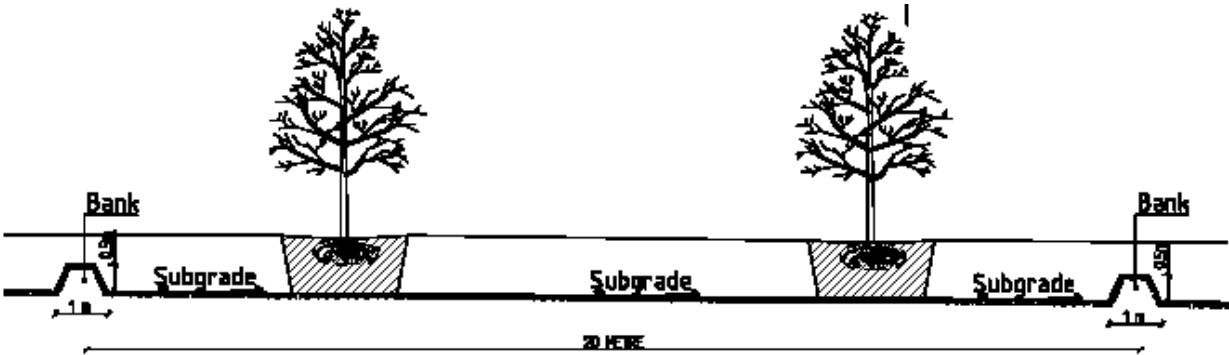
Biochar and stone chips = crushed granite (2-5mm) and nutrient-enriched charcoal 50/50. volume



Biochar and stone chips = crushed granite (32-63 mm) and nutrient-enriched charcoal 10/1. volume

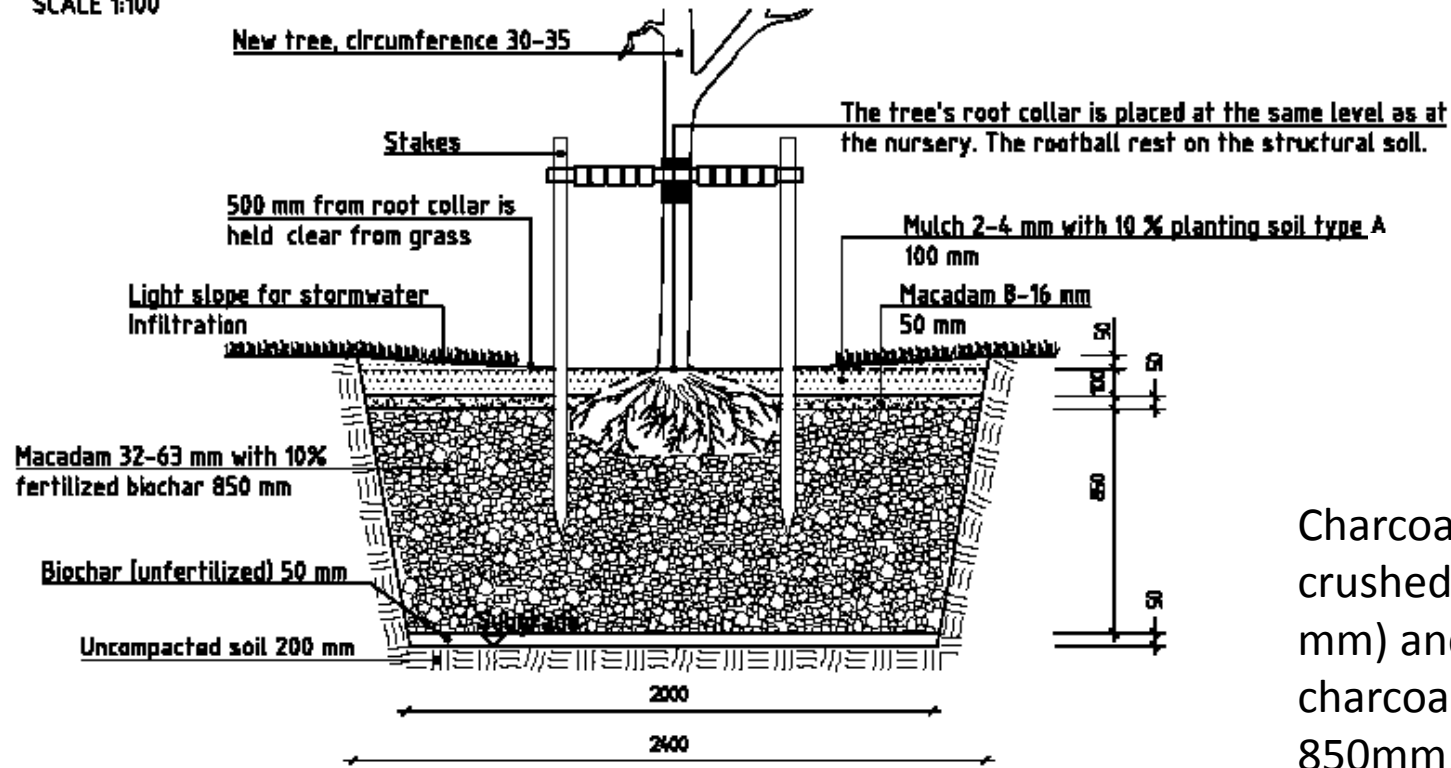
Biochar and soil = soil + nutrient-enriched charcoal 50/50. volume





PLANTING PIT WITH SLANTING SUBGRADE

ELEVATION
SCALE 1:100



TREE PIT WITH BIOCHAR IN GREEN SPACE, TYPE 2

TYPE SECTION
SCALE 1:20

Drawing showing how we build plant bed for trees in the green area along streets and roads to maximize infiltration of storm water through a charcoal filter in the bottom of the plant bed where we catch up nutrients and pollutants.

Charcoal stone chips = crushed granite (32-63 mm) and nutrient-enriched charcoal 10/1. volume. 850mm



ATA HYBT

ATA HYBT



Plant bed for street trees charcoal macadam = crushed granite 8-16 mm mixed with nutrient-enriched charcoal





2014
Perennials planted in
Biochar and stone chips =
crushed granite (2-5mm)
and nutrient-enriched
charcoal 50/50 volume



2014
4 months later



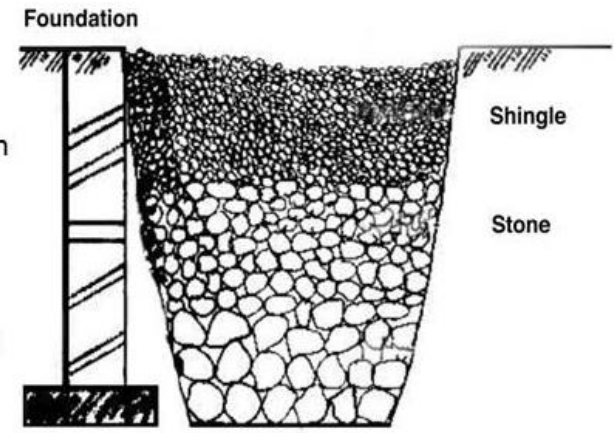


70 cm depth 15 cm width





A French drain is basically a trench filled in with large rocks. In heavy rains, water can flow between the spaces in the rocks.

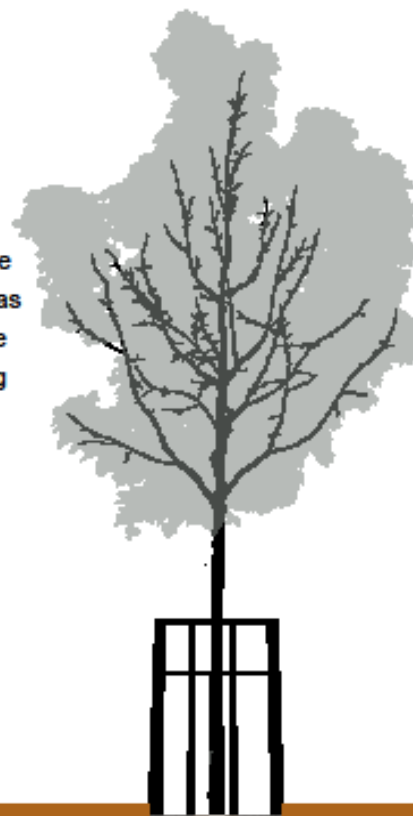
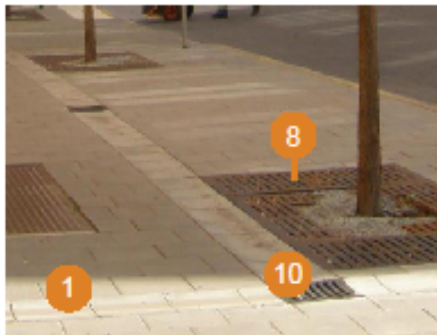


our trenches has a mixture of
1 part biochar
9 parts 4-8 mm crushed granite

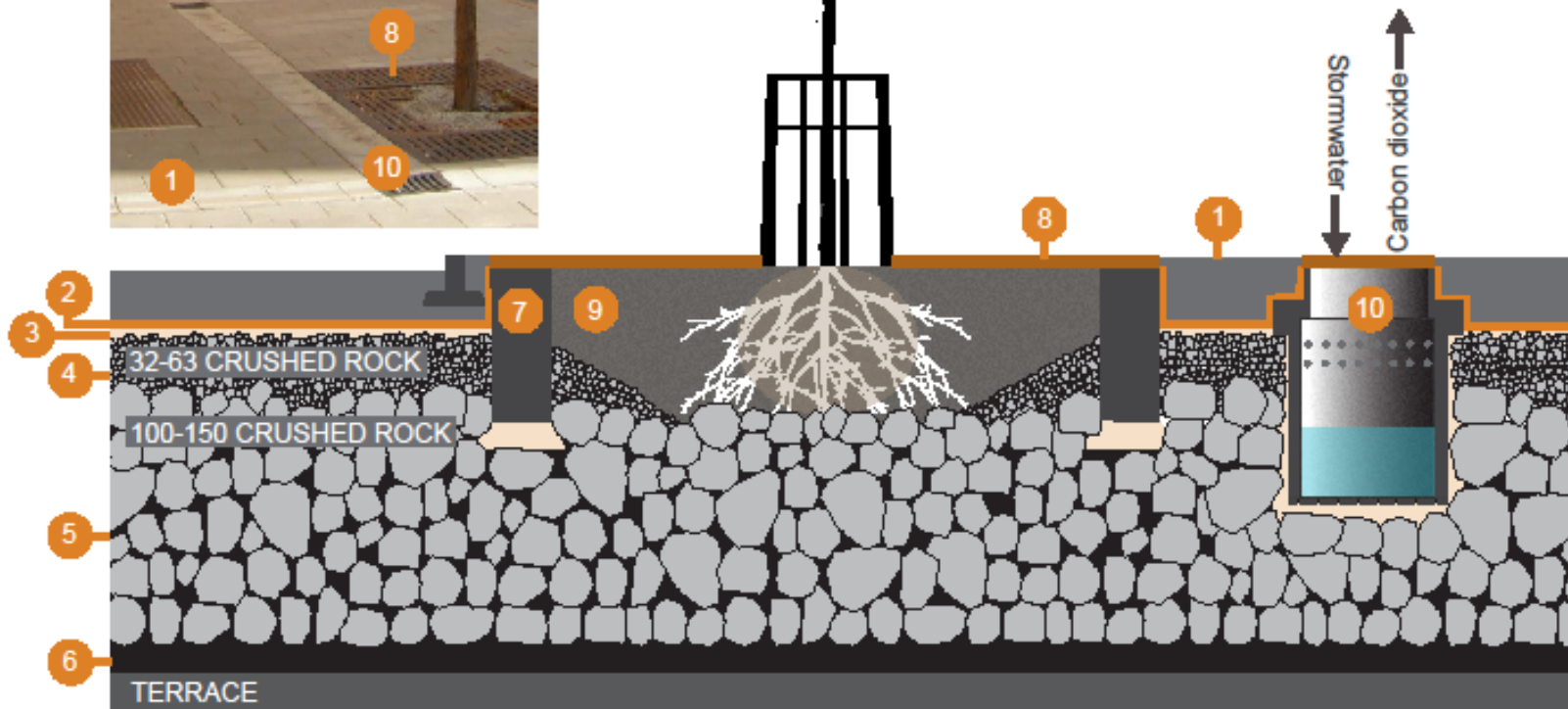


Structural soil with biochar

A method for building with stability and to create good growing conditions for trees in paved areas with the use of stormwater and the added value of decreasing the risk of roots damaging paving or underground pipes



1. Paved surface with dished stormwater gutters
2. Geotextile
3. Leveling layer (crushed rock 8-16 mm) – also used for concrete bunker and water/air inlet.
4. Aerated bearing layer (crushed rock 32-63 mm)
5. Structural soil (crushed rock 100-150 mm) with fertilized biochar hoses into the structural volume
6. Pure biochar on terrace
7. Concrete bunker
8. Surface grid
9. Crushed rock with fertilized biochar
10. Inlet for air and water supply



Stockholm Biochar Project

we got permission to start investigating the possibility
of producing biochar

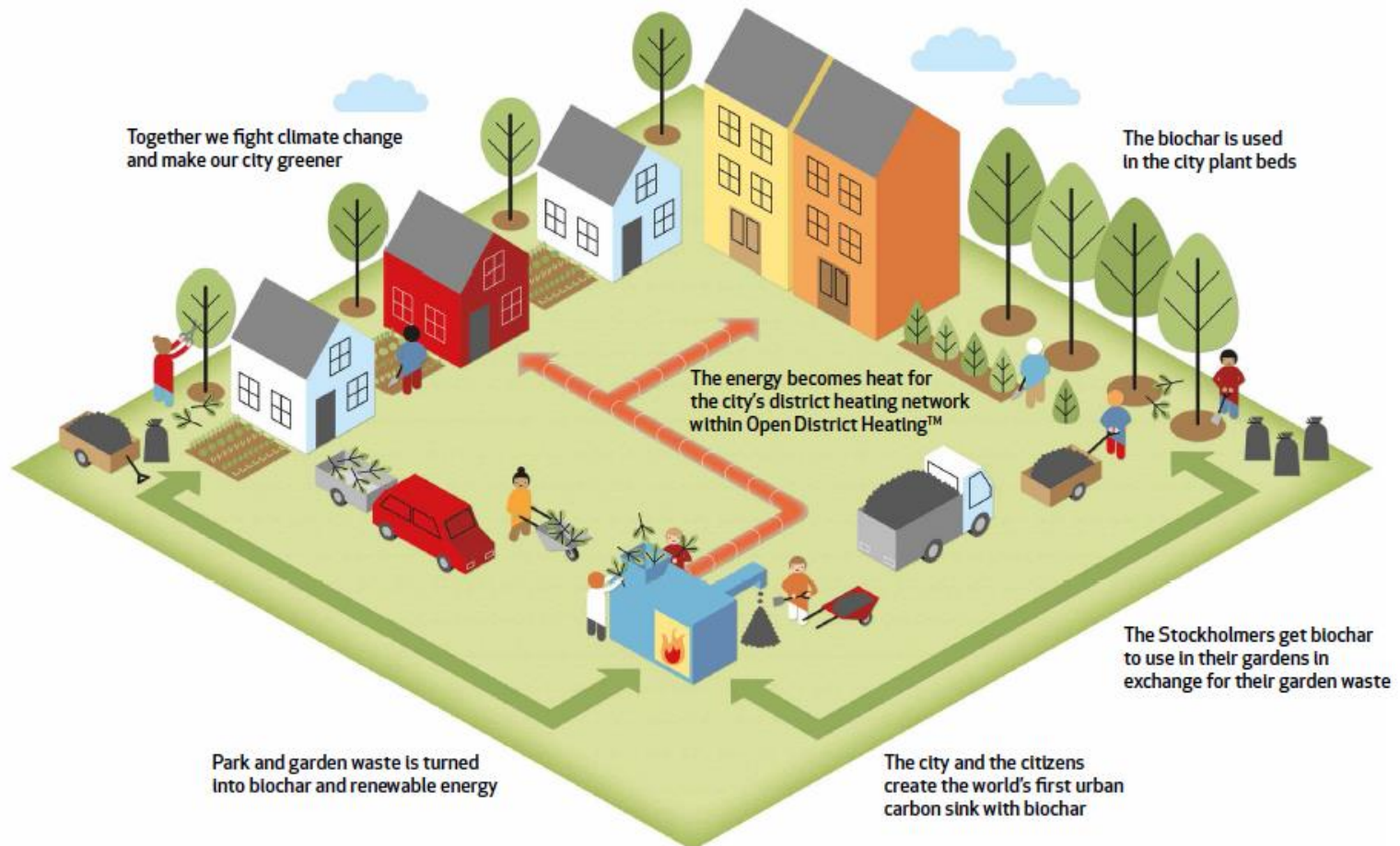
Park and garden waste

Today, poorly used resource



Tomorrow, turned into biochar and renewable energy

The world's first urban carbon sink with biochar. This is how it works!



A competition for bold ideas from city leaders



Applications are in! Stay tuned for more details...

European Cities are among the most innovative in the world.

The 2013–2014 Mayors Challenge is an ideas competition for European cities—a chance to win funding for a bold new solution to a major urban challenge. It exists to bring powerful new ideas to life—not only to help

Four key reasons to enter

€1,000,000

€1,000,000



€1,000,000

€1,000,000

Stockholm Biochar Project



Stockholms
stad

STOCKHOLM
Vatten



 **Fortum**

**Bloomberg
Philanthropies**



Om koncernen

▼ Energi och produktion

> Vattenkraft

> Kärnkraft

> Vindkraft

▼ Värmeproduktion och kraftvärme

▼ Värmeproduktion

• Bristaverket

• Hammarbyverket

• Hässelbyverket

▼ Högdalenverket



Högdalenverket

Högdalenverket, en av Europas modernaste anläggningar för avfallsförbränning, producerar el och fjärrvärme av avfall och andra biobränslen, såsom flis och behandlat industriavfall. Anläggningen har kapacitet att ta emot 700 000 ton avfall per år.



biochar unit
connected to
district
heating

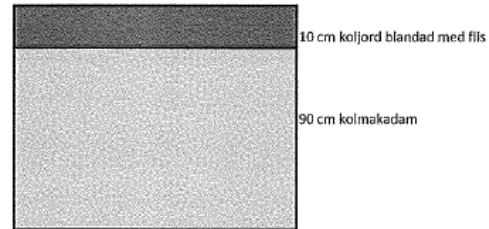




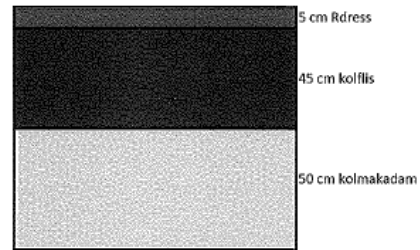
Exampels on species planted in mixtures of biochar and granit

Adress	sort	storlek	Antal	Typ
Bersågränd	Eucommia ulmoides	16-18	1	3
	Davidia involucrata	25-30	1	3
Birkagatan	Robinia x margareta 'Casque Rouge'		1	3
Enkehusparken	Cornus controversa	30-35	1	3
	Cornus controversa	40-45	1	3
	Eucommia ulmoides	16-18	1	3
	Rhus typhina	30-35	1	3
Enskedevägen	Magnolia Galaxy	18-20	3	2
	Magnolia Heaven Scent	20-25	2	2
	Magnolia Susan	20-25	1	2
	Magnolia Yellow Lantern	18-20	2	2
	Styrax japonica	30-35	2	2
	Tilia cordata x mongolica 'Harvest'	14-16	2	2
Farstaängen	Magnolia Yellow Lantern	18-20	1	2
	Magnolia Yellow Lantern	18-20	2	4
Grubbensringen	Betula albosinensis 'Fascination'	20-25	1	3
Hemmansvägen	Brousonetia papyrifera	35-40	1	3
Lingvägen/Hökarängen	Magnolia Yellow Lantern	16-18	1	3
	Malus toringo	25-30	1	3
	Brousonetia papyrifera	35-40	1	3
Mickelsbergsvägen	Tilia mongolica	18-20	6	3
Mikrofonvägen	Populus nigra 'Italica'	500-600	8	2
Pukslagargatan	Ilex aquifolium 'Alaska'	20-25	3	3
Sockenvägen 404	Ilex 'Nelly Stevens'	25-30	1	2
Sofielundsplan	Acer palmatum	18-20	1	1
	Acer pensylvanicum	400-500	1	1
	Magnolia Galaxy	18-20	2	1
	Magnolia Heaven Scent	20-25	2	1
	Magnolia Yellow Lantern	16-18	3	1
	Magnolia x soulangeana	20-25	1	1

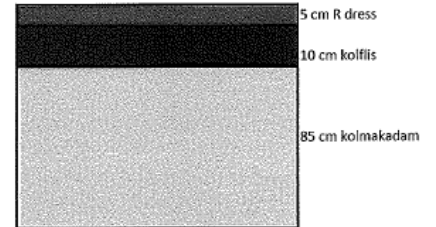
Typ 3



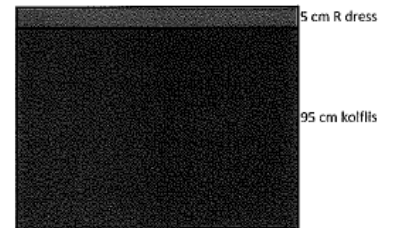
Typ 4



Typ 1



Typ 2



For more info

Mattias Gustafsson
mattias.gustafsson@extern.stockholmvatten.se

[WWW.google.se](http://www.google.se) <http://www.youtube.com/watch?v=UFXIsKOVmV8>

Our handbook is available at
WWW.stockholm.se
search for plant beds and select
'Plant Beds in Stockholm City'



Thank you for your attention, and if you are passing, Welcome to Stockholm we would be happy to show our projects.

Gustav Adolfs Torg 2015





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Norrbro







KAARISTU
KATU

HELENA
KATU

