Stockholm Rock Gardening

<u>Environmentally</u> friendly <u>Sustainable</u> urban plant beds

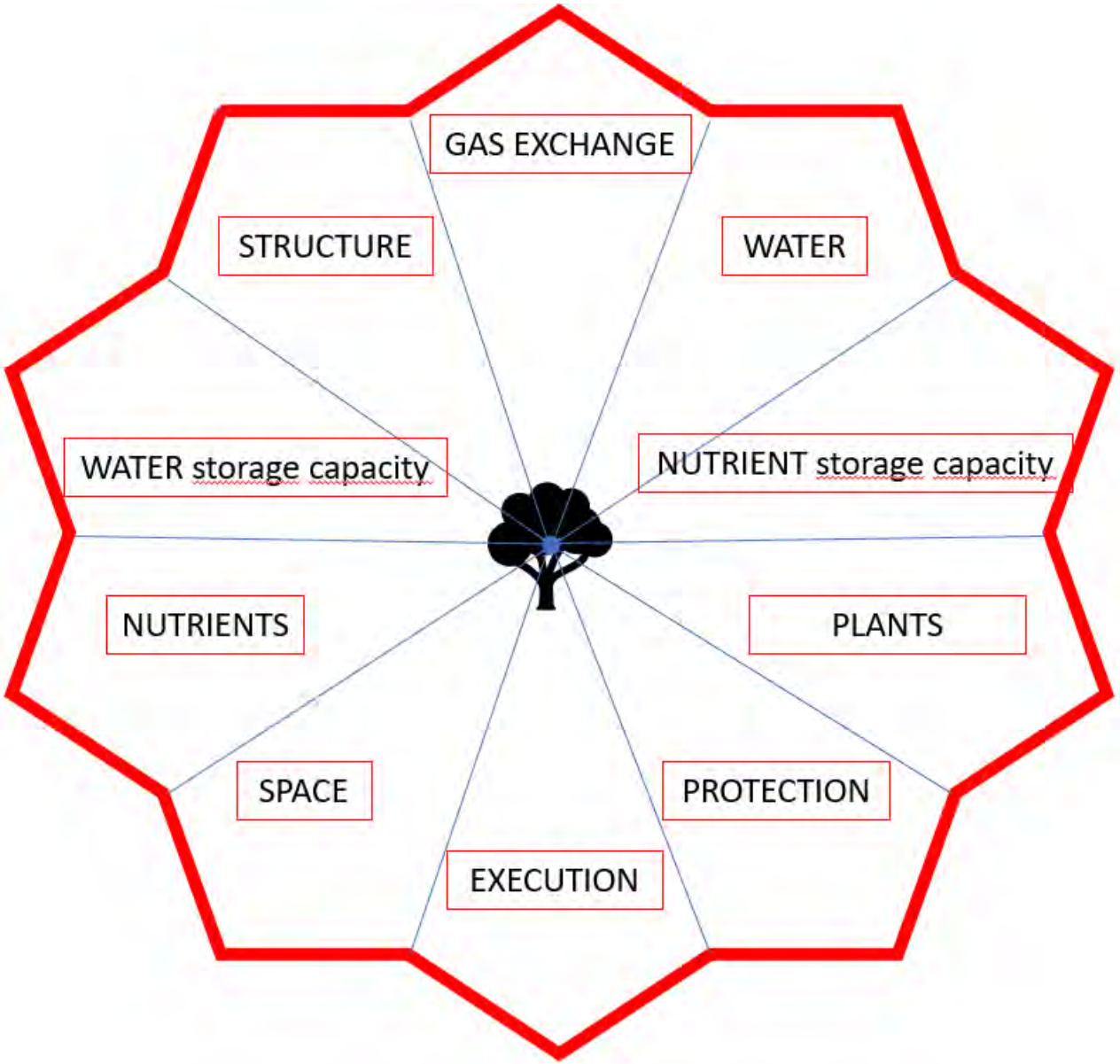
Björn Embrén 2023

A support in dealing with basic problems with urban plant beds.
Description based on research and practical experience of how to deal with urban plant beds based well-known factors of plant needs, adapted to today's urban conditions and environmental requirements in Stockholm over a forty+year period.

More than 3,000 trees have been planted in stone-based plant beds over the past 22 years in Stockholm (+20 000 Prunus avium)

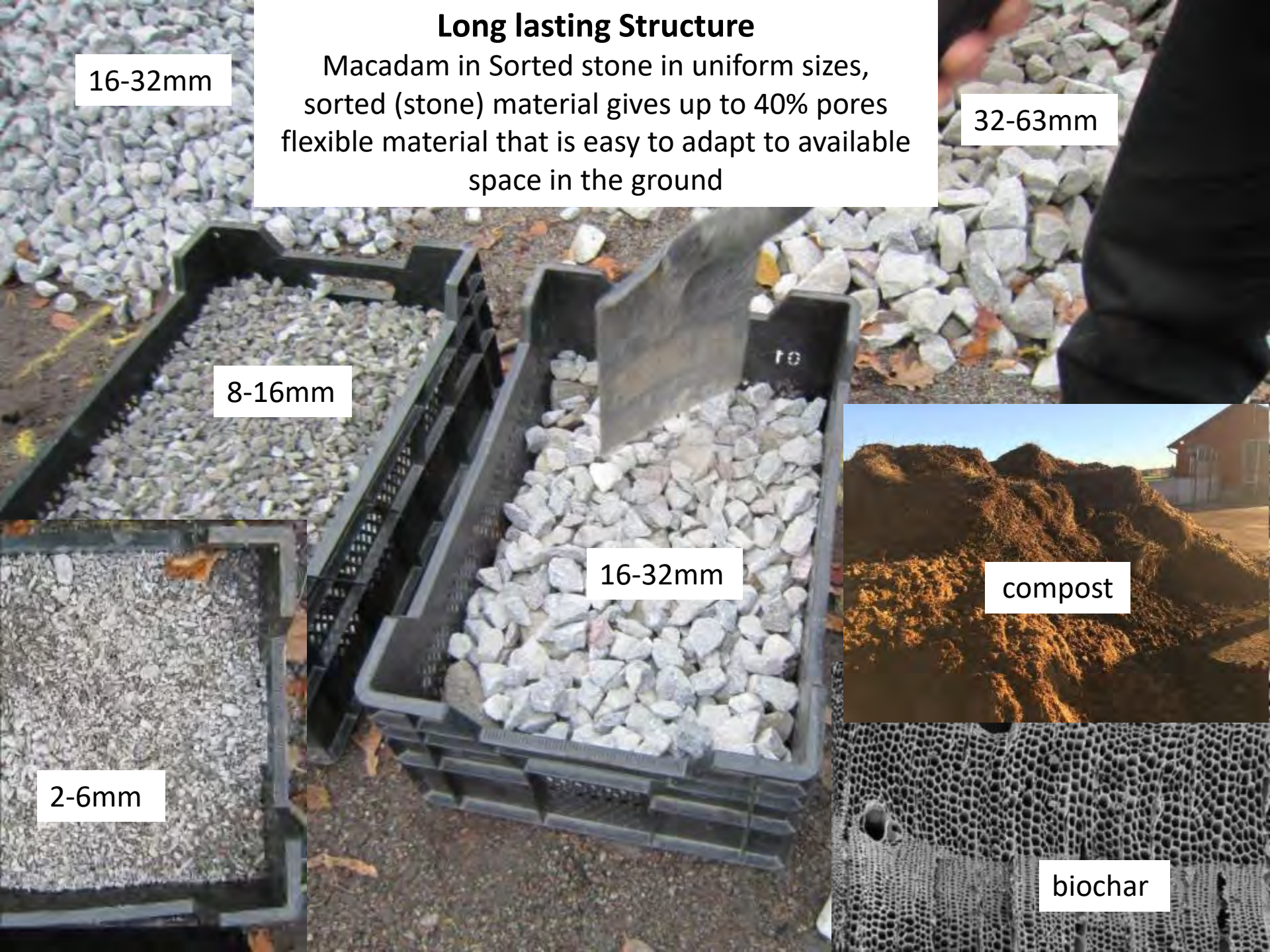
The issue of urban plant beds.
Sealed surfaces, compact materials gives lack of oxygen and water.
Gives a need for strong plant bed constructions that support all needs for plants, traffic and all other infrastructure, is easy to build and possible to excavate and recreate in perspective over centuries that cities and trees live.

The 10 most important factors
that you must solve (understand) in order to get a functioning urban plant bed



Long lasting Structure

Macadam in Sorted stone in uniform sizes, sorted (stone) material gives up to 40% pores flexible material that is easy to adapt to available space in the ground

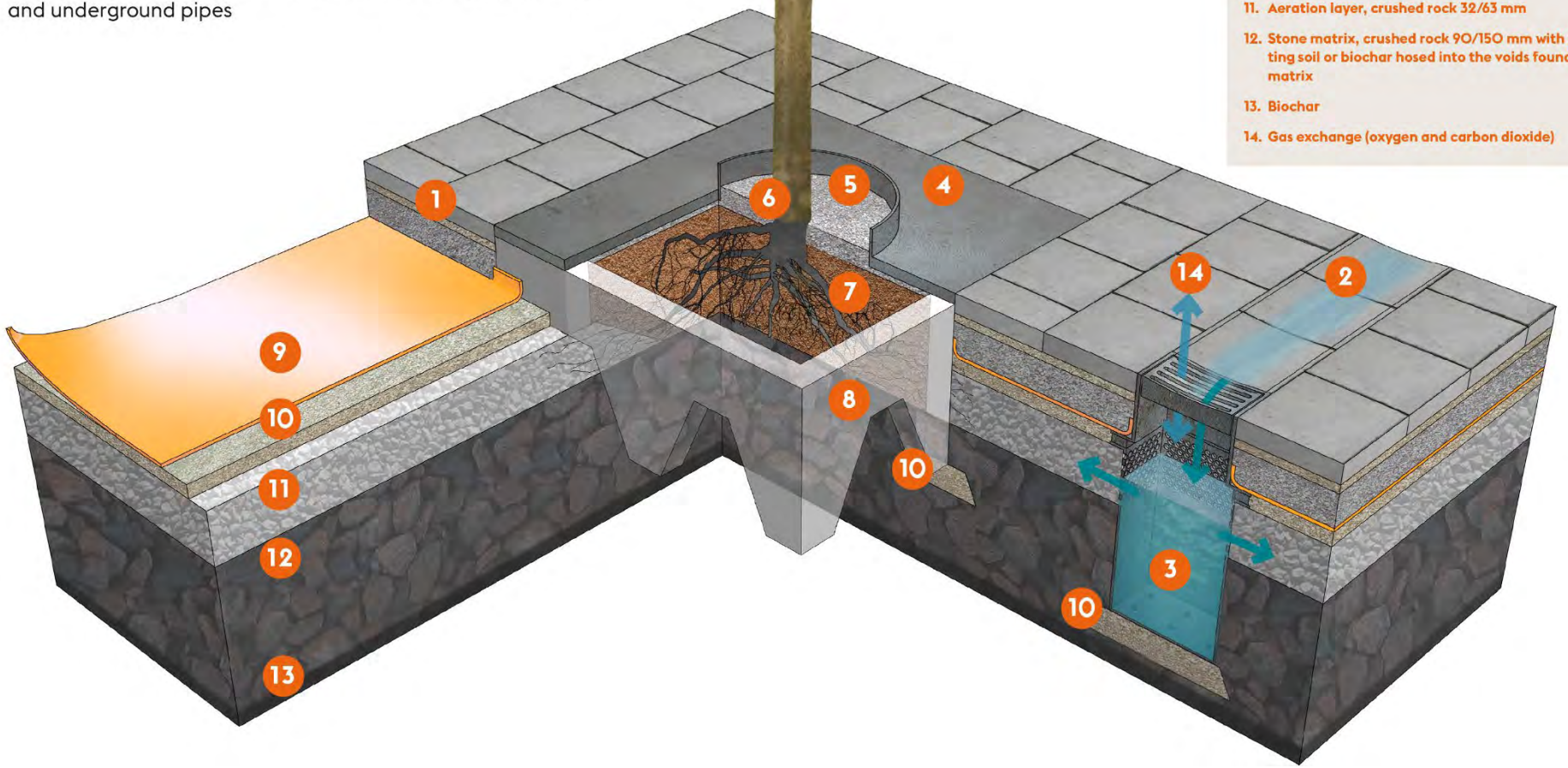


note that what has been washed down in number **12** has changed over the years we started with ordinary factory made soil and now it is biochar and various forms of compost

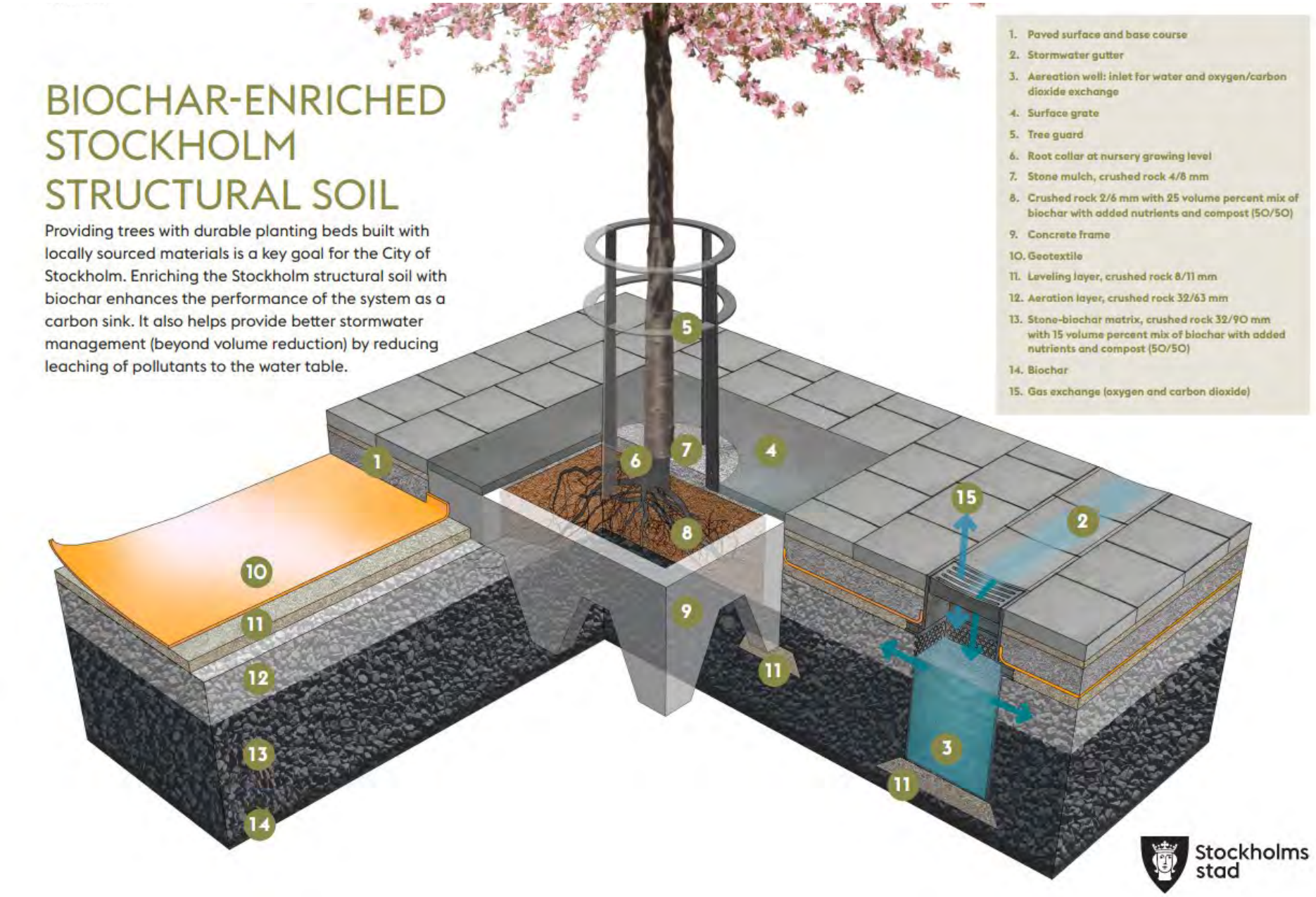
STOCKHOLM STRUCTURAL SOIL

A construction method that optimises gaseous exchange and use of stormwater runoff to create good conditions for trees in paved areas and provide excellent load bearing capacity for streets while minimising risks of damage to paving and underground pipes

1. Paved surface and base course
2. Stormwater gutter
3. Aereation well: inlet for water and oxygen/carbon dioxide exchange
4. Tree grate
5. Stone mulch, crushed rock 4/8 mm
6. Root collar at nursery growing level
7. Crushed rock 2/6 mm with 25 volume percent mix of biochar with added nutrients and compost (50/50).
8. Concrete frame
9. Geotextile
10. Leveling layer, crushed rock 8/11 mm
11. Aeration layer, crushed rock 32/63 mm
12. Stone matrix, crushed rock 90/150 mm with planting soil or biochar hosed into the voids found in the matrix
13. Biochar
14. Gas exchange (oxygen and carbon dioxide)



(latest drawing)This solution is used on walkways, parking areas and square it becomes cheaper and faster to build. Macadam biochar and compost are purchased ready-mixed and compacted when it has been laid out. Compost and macadam is 15% in the volume it it does not increase the volume of macadam.



1 Gas exchange

An open structure created from stable graded materials to create a large amount of voids in the material that is durable over time under load.
A locally recycled material can bring environmental benefits.
Added water pushes bad gases out of the plant bed and draws new air into the soil as it sinks away.
In order to maintain the porosity, avoid other mineral without pores, which steals pore volume if it is mixed with the supporting material.
All materials in small fractions involved including humus and porous materials, can reduce the gas exchange and the infiltration rate of stormwater if the amount becomes too large in relation to the voids in the load bearing material.
Compact the mixture and test the rate of infiltration to get an idea if the new chosen mixture will work.
Avoid finite materials.
Locally available recycled sufficiently strong material such as stone, concrete, brick etc.
Use air and infitrations wells in hard surfaces.

Arguments for

An absolute necessity for plants to be able to develop a root system.
Mycorrhiza benefits from a good gas exchange.
Beneficial to all life in the soil, provides increased biological diversity and provides the opportunity for increased carbon storage in the soil and thus the ability to handle incoming nutrients and pollutants.
It is a common technique to pump down oxygen and mix humus (and biochar) into the soil to manage lightly contaminated soil, which is based on the same knowledge that good conditions for bacteria and other organisms in the soil make the breakdown of certain pollutants work better.

Gas exchange (oxygen)

2 Water

See also point 1 what concerns gas exchange is also good for the infiltration capacity of water.

Open Planting Areas. Submerged plant beds, avoid edges that prevent stormwater access to the plant bed.

Place plant beds and inlets/wells in low spots, gutters that collect rainwater can be an easy way to direct water to the plant bed.

For high water levels in the soil profile, use raised plant beds or choose plants that love standing in water.

Artificial irrigation when there are no alternatives.

Rapid infiltration if you want to reduce the risk of flooding.

Control flow rate in the plant bed with the density in the bottom material under the plant bed.

Proper watering is one of the really difficult parts of gardening, the most common cause of failed plant establishment.

Make a water balance calculation if you want to have a safe basis for important projects.

Arguments for Water (2)

An absolute necessity for plants to survive.
Relieves the existing stormwater system and recipients like lakes, seas, rivers, streams.
Reduces the risk of discharge of untreated wastewater at treatment plants during heavy rains.
The plant bed may be able to take care of pollutants and nutrients in storm water.
Increases plant evaporation, which lowers the temperature in the urban environment and counteracts the heat island effect.
Can counteract falling groundwater levels and subsidence in buildings. See also No. 4
Rapid infiltration reduces the risk of flooding.
Do not drain away water, use dome wells or similar at the surface if it is necessary to remove water if the plant bed becomes full of water.
LDS= local disposal of stormwater.

Water

3 Structure

An open structure created from stable graded macadam materials to create a large amount of voids in the material that is durable over time.
Materials that are local and recycled can provide environmental benefits.
Choose material that meets requirements for stability in the construction of hard surfaces.
When using fractions over 32mm, rats cannot settle in the plant bed, which can otherwise be a problem in urban environments.
Avoid finite materials. In order to maintain the porosity, avoid other mineral without pores (such as sand, silt, clay), which steals pore volume if it is mixed with the supporting material.
Examples of possible materials:
Locally available recycled sufficiently strong materials such as stone, concrete, brick.

Arguments for

Sorted stable materials with large pore volume provide the possibility of infiltrating large volumes of water quickly. Flexible material that is easy to adapt to available space in the ground.
Can be a way to recycle local materials and benefit the circular economy and avoid the use of finite resources. Use (bricks, concrete, recycled stone materials easy to recycle the materials durable over time. By not using plastic the spread of microplastics is reduced so avoid complicated products made of plastic which are not durable over time and cannot cope with the need for excavation in the urban environment. Makes it possible to have functional green areas on areas that are overused, such as daycare centers, schoolyards. Coarser stone material prevents rats from establishing themselves in the ground.
Gravel ridges that were created after the Ice Age have existed for more than 15,000 years in Sweden, large parts of the Swedish forest grow on these gravel ridges. Gravel ridges are also an important part of our drinking water supply where they act as filters for rainwater. There are examples of these being used by municipalities to clean polluted lakes by allowing lake water to filter through the gravel ridge.

Structure

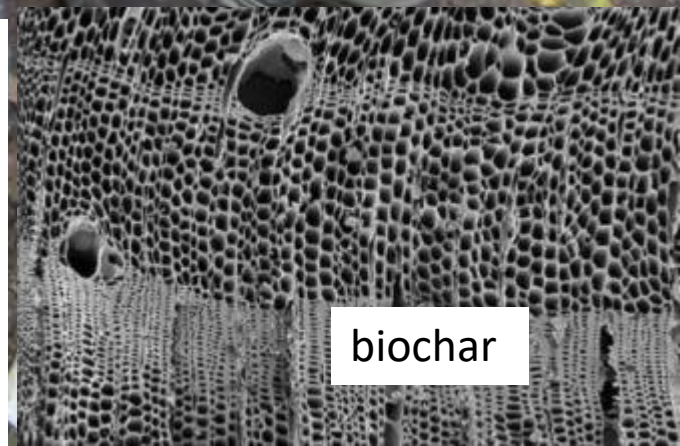
Trees on a esker (gravel ridge)

Structure

Long lasting Structure

Macadam in Sorted stone in uniform sizes, sorted (stone) material gives up to 40% pores flexible material that is easy to adapt to available space in the ground

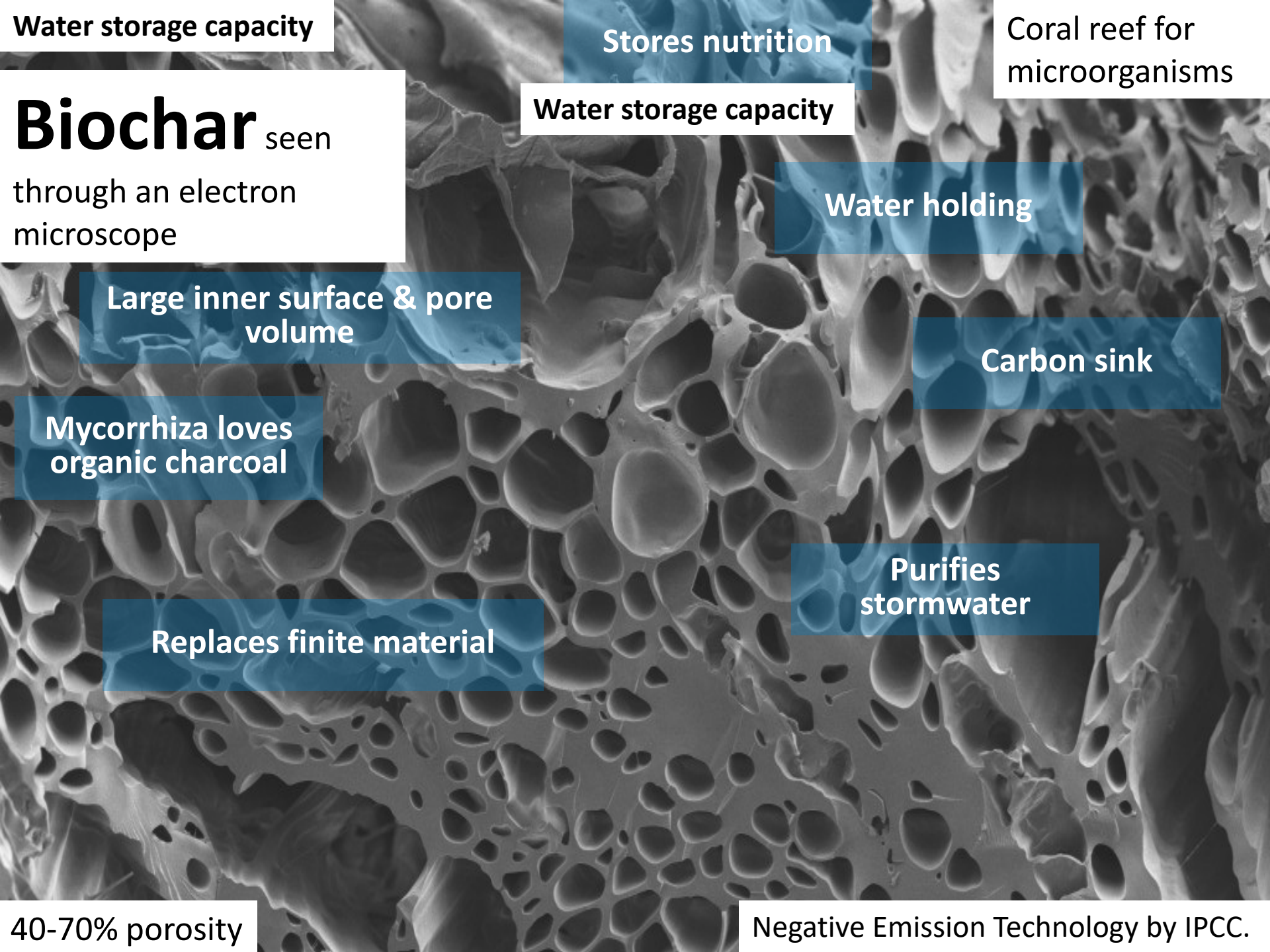
Gas exchange
= Porosity
= macadam fractions
= stone, biochar, pumice, lava stone, concrete, brick, foam glass.
if possible local environmentally friendly recycled materials



4 Water storage capacity

Examples of materials:
Biochar, compost , pumice.
Biochar is the material in which I have obtained the best water retention ability, so if increased water retention is desired, top up with biochar.
Several of the materials in plant beds described can often have a very low water content from the start, which makes it important to irrigate the entire volume of the newly laid plant beds before planting.
In case of limited availability of water, one possibility may be to use water reservoirs as part of the plant bed volume to improve the availability of water over time.
Pond liner, concrete, clay are useful materials for creating water reservoirs.
Surrounding material outside the plant bed can be of great importance for water availability, these are usually heavily compacted with very low porosity. Ordinary soil material is possible to have under and to the side of porous plant beds but not on top, there is a great risk that the water will stuck, with a lack of water as a consequence in the underlying porous materials. A normal soil needs to have a relatively large depth if the drainage is to work.

Arguments for
Required for good growth.
Gives a greater possibility that cope with dry periods, can increase the ability of plants to evaporate over time, which can help keep the temperature down in urban environments (counteract the heat island effect).


Water storage capacity
Stores nutrition
Coral reef for microorganisms
Biochar seen through an electron microscope
Water storage capacity
Water holding
Large inner surface & pore volume
Carbon sink
Mycorrhiza loves organic charcoal
Purifies stormwater
Replaces finite material
40-70% porosity
Negative Emission Technology by IPCC.

Water storage capacity

Compost

Decomposed

Fresh

Water storage capacity

the terrace under the plant bed can be a gold mine

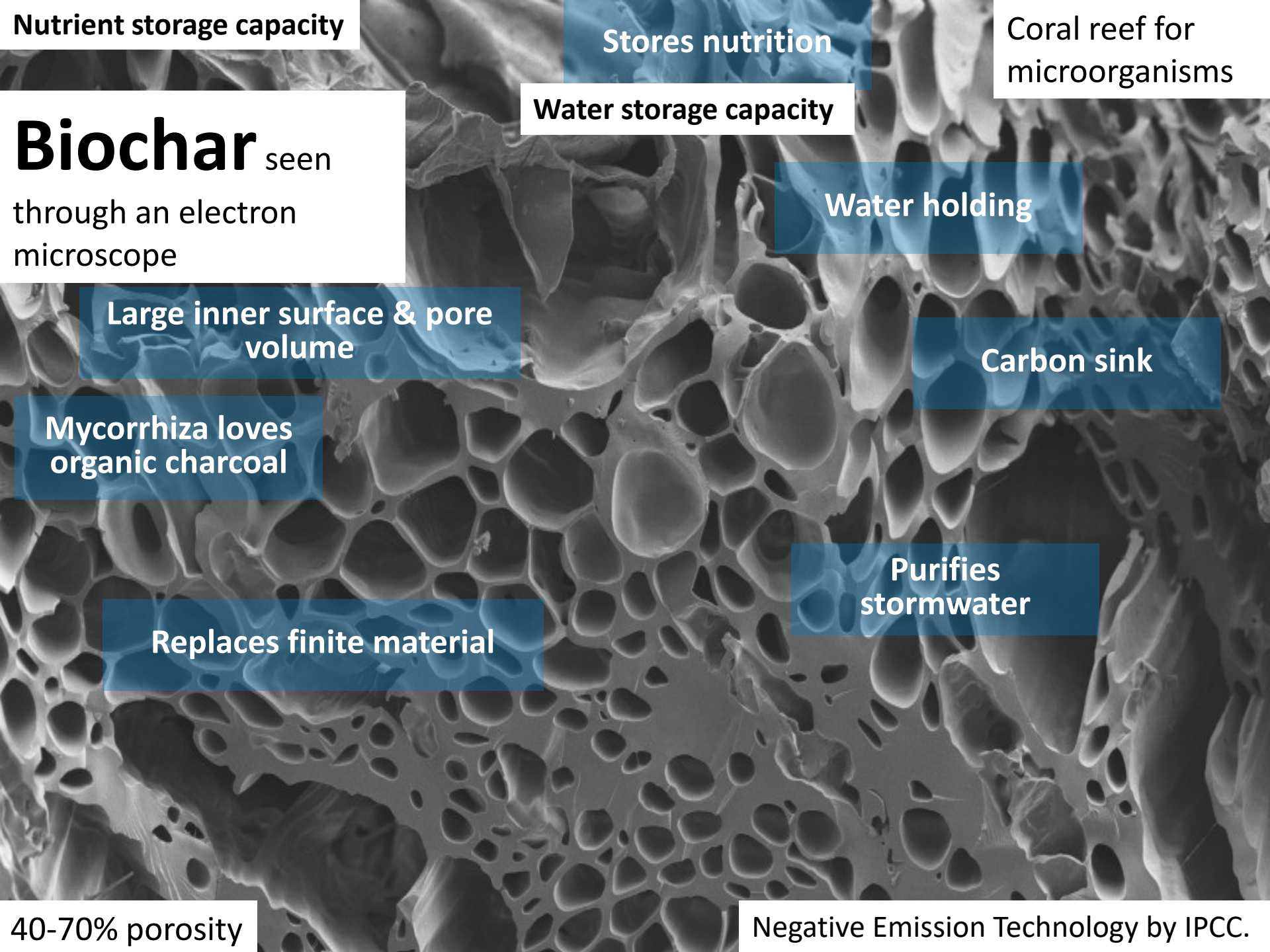
The sides of the shaft consist of heavily compacted road construction with very poor infiltration capacity and gas exchange due to low porosity

5 Nutrient storage capacity

Examples of materials:
Biochar (certified), particle size and quality matter.
Biochar has the ability to bind heavy metals such as mercury, cadmium, lead and more.
Biochar has a very good ability to store nutrients that become available to the plants.
Compost, ingredients and level of decomposition affect amount of nutrients thats available.
Experiments have shown that more than 25% biochar in a plant bed does not increase growth if the other conditions are optimal.

Arguments for

Gives the opportunity for the plants with the help of other organisms to get even access to nutrients in the plant bed. Can take care of nutrients/pollution in stormwater and prevents leakage of substances from the plant bed. If you use biochar, several environmental aspects are added, one of which is locking in carbon dioxide over a long period of time.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Nutrient storage capacity

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Nutrient storage capacity

the terrace and sides around the plant bed can be a gold mine

6 Nutrients

The location's conditions and need for nutrition determine how much and in what form it should be used.
Examples of possible materials:
Plant waste, green compost, Organic waste in different varieties, animal manure cow, horse, chicken, worm compost, bone meal, horn meal etc.
Inoculation of living organisms (soil from a healthy forest) can contribute to increased biological diversity in the plant bed and can provide healthier plants with greater resistance to disease and insect attacks on the plants.

Arguments for
Humus has the ability to filter out unwanted chemicals in stormwater and supplements biochar if it is used in the plant bed and acts as energy for the development of organisms in the soil.
Organisms in a living plant bed can store more carbon dioxide in the soil than the plants can store through their root systems.
For full control of available nutrients, it may be necessary to use mineral nutrients.

Nutrients

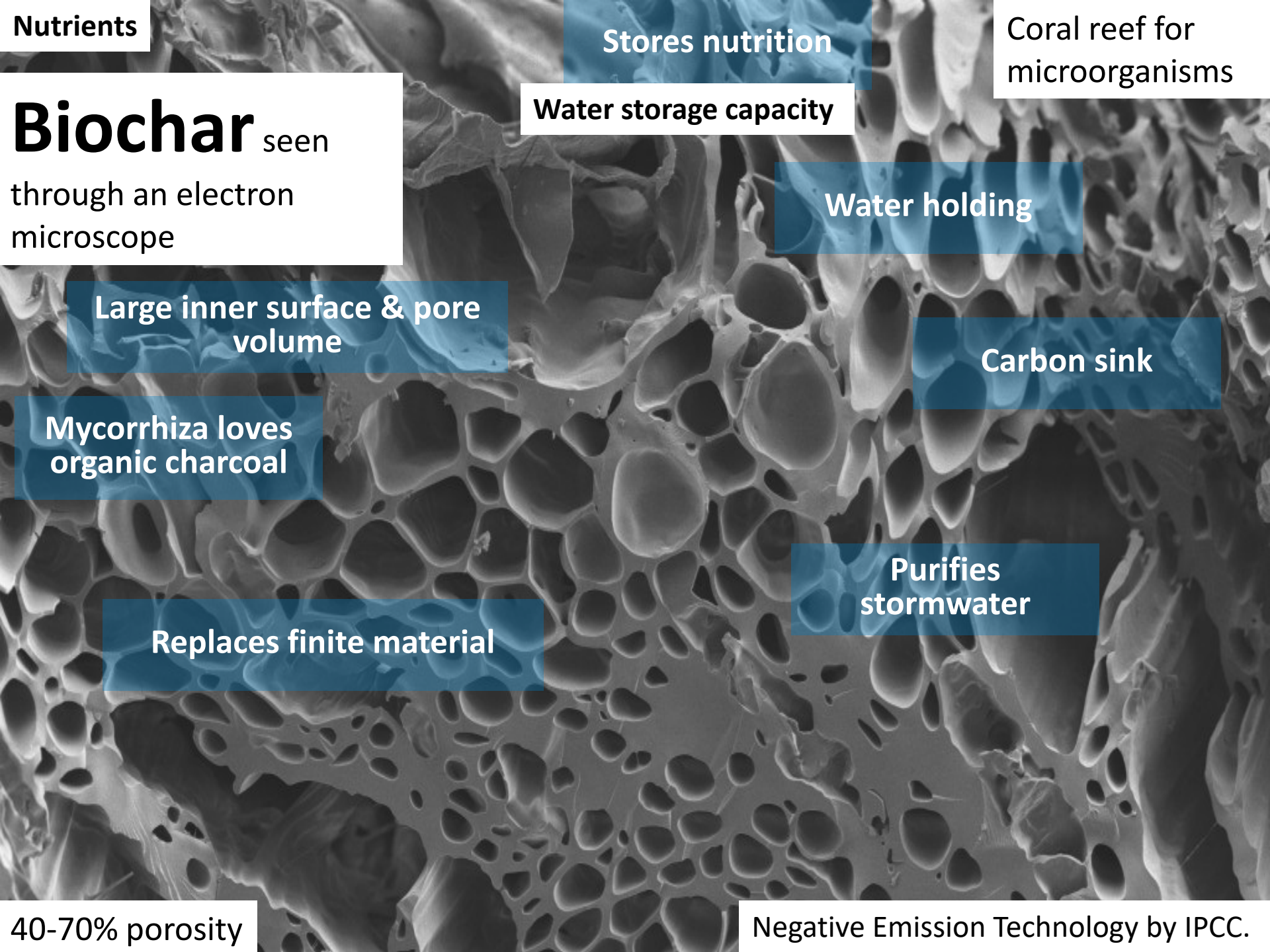
Think organic nutrition, there are many different to choose from compost, animal manure, horn flour, bone meal etc.
supports life in the soil

Nutrients

Life

Inoculate living soil organisms could help to produce nutrients and increases the content of organic matter/carbon

mykorrhitza in our structural soils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Nutrients

the terrace under the plant bed can be a gold mine

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7 Plants

Evaluate the location's conditions based on space, temperature, light, wind, water availability, history, aesthetics. High quality of purchased material and skilled handling and protection of plants from delivery and on site before planting. Bare rooted plants are easier to establish.
Potted plants in peat substrate require a great deal of knowledge about watering during the establishment period.

Arguments for
Can reduce pollution, wind, noise and solar radiation. Good choices based on the location's conditions produce healthy plants that in turn spread positive signals.

8 Space

Contiguous large volumes in the plant bed provide greater opportunities and are absolutely crucial for plants to find conditions for good development.
Trees/plants of the right size reduce the need for maintenance and keep costs down.

Arguments for
Good choices reduce operating costs. The plants get the opportunity to develop species-specifically and become more aestheticall.

Large continuous volumes provide better opportunities to satisfy the plants' needs for a good life together with other necessary organisms in the plant bed.

Space

Magnus Ladulåsgatan
First structural soil with biochar and kompost 2017

Macadam Granit shard 90-150mm
Each layer of 300 mm is compacted for stability
Recycled concrete can be used as a part of the structural soil instead of stone

9 Protection

To counteract deformation of surrounding hard surfaces and superstructure, but also gravel surfaces that are used by heavy traffic have the same need for protection. Protects against excavation and enables easy replacement of trees without affecting surrounding surfaces.
Prevents roots from coming out in the upper part of the surface construction.
Trunk protection for trees in hardened surfaces.
Fence around plantings.
Edge protection against contaminated stormwater (salt).

Arguments for

Reduces the risk of damage and provides the opportunity for increased longevity of the plants and surrounding structures. Protection around planting pits counteract deformation of surrounding load-bearing material. Also gravel surfaces that are used by heavy traffic have the same need for protection. Protects against all nearby excavation and enables easy replacement of trees/plants without affecting surrounding surfaces. Prevents the root system from getting out into the superstructure outside the plant bed, usually at least down to 300mm, can be deeper depending on the surrounding surface and plant bed construction.

Protection

A concrete box around the planting pit protects surrounding pavements.

10 Execution

Describe and agree very clearly how the work (contract) is to be carried out and documented.
Control throughout the work also during establishment/warranty maintenance.
Soil sample, simple and effective way to control plant beds.
Don't trust a contractor.
Don't close your eyes analysis of completed projects gives opportunity for development.
Water bags have saved many trees but do not help if they are not filled with water according to instructions.
Lack of and incorrectly performed watering is the most common cause of poor establishment of plants.
Trust is good but control is better.

Arguments for

That the plant bed is built in the right way and that establishment care is carried out provides value for the money invested. Can ensure the execution will be correct.

Stockholm's structure (rock) plant beds

Björn Embrén
www.arborkonsult.se

2018 The first carrots in macadam 4-8 mm 3 parts biochar and compost 1 part

Here you can find inspiration and people who may have ideas about good plant beds

7 Growing Secrets of the Alpine Gardener

https://www.alpinegardensociety.net/plants/7-growing-secrets-of-the-alpine-gardener/

Rock garden

Soil and mulching

Alpines like a soil which is nutrient rich and free draining; light and porous in winter and cool and moist in summer. A mix of 50% peat-free multi-purpose compost and 50% horticultural grit will do the trick.

https://www.theenglishgarden.co.uk/expert-advice/gardeners-tips/create-a-rock-garden/