GREEN INFRASTRUCTURE

AND ITS EFFECT ON REDUCING AIR POLLUTION IN AN URBAN ENVIRONMENT

EUROPEAN UNION
European Regional Development Fund

PRESENTATION OF THE CLAIRO PROJECT

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CLEAR AIR AND CLIMATE ADAPTATION IN OSTRAVA AND OTHER CITIES

CLAIRO

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Moravian-Silesian Region

OSTRAVA!!!

VSB TECHNICAL UNIVERSITY OF OSTRAVA

SILESIAN UNIVERSITY

SOBIC Lab of the future

Palacký University Olomouc

Regionální sdružení územní spolupráce Těšínského Slezska

EUROPEAN UNION

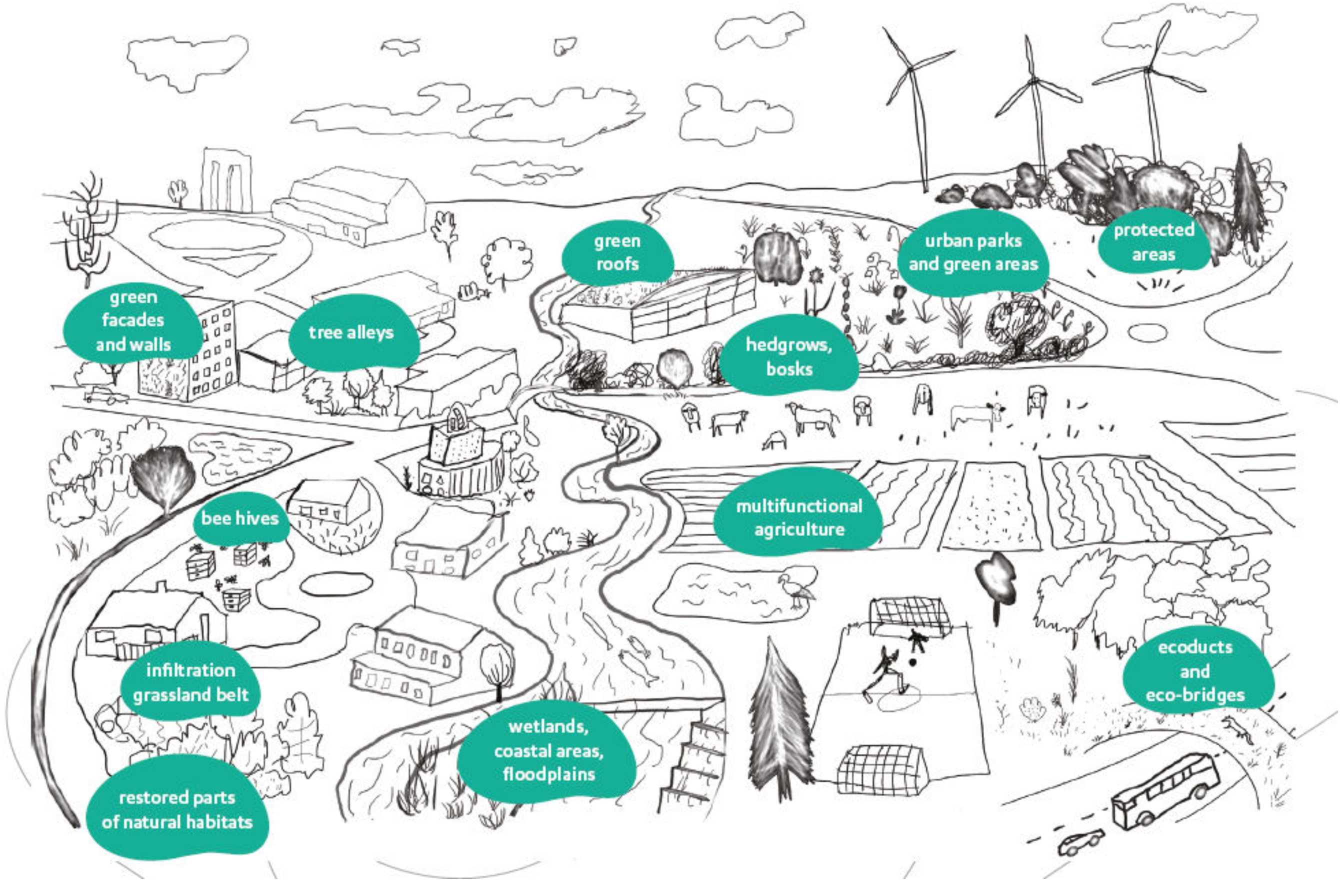
UIA URBAN INNOVATIVE ACTIONS

GENERAL BASES

GREEN INFRASTRUCTURE

- a network of high-quality natural and semi-natural areas with additional environmental elements
- green infrastructure is a spatial structure that provides the benefits of nature and aims to strengthen nature's ability to supply more ecosystem goods and services, such as clean air or clean water
- green infrastructure helps to improve the urban environment during periods of climate change, it mitigates floods, increases carbon sequestration and prevents soil erosion
- it consists of a wide range of environmental elements such as hedgrows, bosks and green roofs, to entire functional ecosystems such as such as intact floodplains, forests, peat bogs or free-flowing watercourses

GREEN INFRASTRUCTURE COMPONENTS



ADAPTED BASED ON: European Commission (2013).

SERVICES PROVIDED BY GREEN INFRASTRUCTURE

- **Support services:** soil formation, nutrient cycle, primary production
- **Supply services:** provision of food, drinking water, wood and natural fibres, provision of natural medicines and other biochemicals
- **Regulatory services:** regulation of air composition, regulation of climate, regulation of water cycle, water purification and removal and disposal of waste, regulation of the spread of diseases, pollination, etc.
- **Cultural services:** spiritual and religious values, aesthetic, inspirational and educational values, recreation

ADAPTED BASED ON: European Commission (2013).

SERVICES PROVIDED BY GREEN INFRASTRUCTURE

- **Population health:** along with improved air quality, pollutant filtration, oxygen generation and noise absorption
- **Resilient cities:** better adaptation to climate change and an associated increase in the frequency and intensity of temperature extremes
- **Increased biodiversity:** preservation and development of the number of species of animals and plants living in cities
- **Inhabitants' quality of life:** people in green cities are more active and more satisfied

ADAPTED BASED ON: European Commission (2013).

SERVICES PROVIDED BY GREEN INFRASTRUCTURE

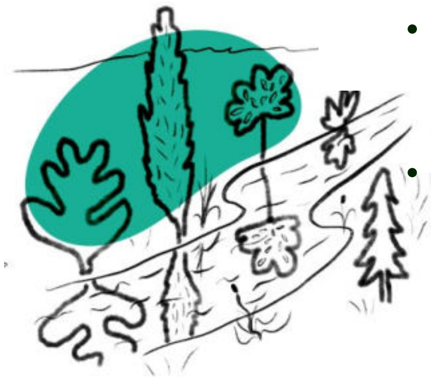
- **Reduced stress:** by improving concentration, memory, learning ability or regeneration
- **Attractiveness of the environment:** green cities attract groups of people who are often more active, more enterprising, more educated
- **Economic growth:** new jobs, value of housing and land
- **Strengthened communities:** they promote neighbourly relations, reduced crime rate

ADAPTED BASED ON: European Commission (2013).

HOW DOES GREEN INFRASTRUCTURE IMPROVE AIR QUALITY?

DIRECTLY

- **A larger vegetation surface removes air pollutant**



- Leaves capture PM_1, $PM_{2.5}$, PM_{10} particles
- Leaf stomata absor gaseous pollutants (ozone, nitrogen oxides)

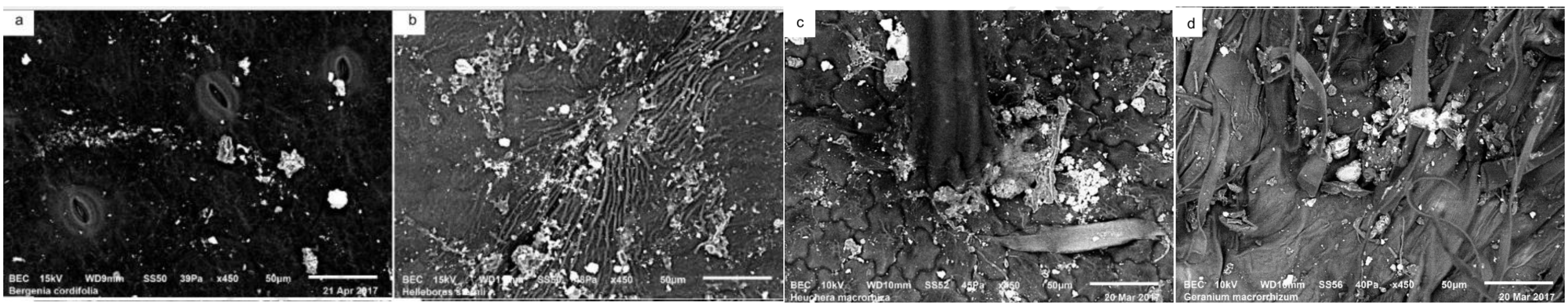
INDIRECTLY

- **Vegetation provides shade and increases evapotranspiration**

- Reduced ambient temperature near the surface (maximum in summer)
- Reduced photochemical reactions leading to the formation of ozone

CAPTURE OF SUSPENDED PARTICLES ON THE LEAF SURFACE

Illustration of the capture of suspended particles (white spots) on the surface of the leaf blade. Scanned by an electron microscope.



SOURCE: Weerakkody, et al. 2018.

WHAT FACTORS AFFECT THE EFFICIENCY OF POLLUTANT CAPTURE BY VEGETATION?

MICROSCOPIC

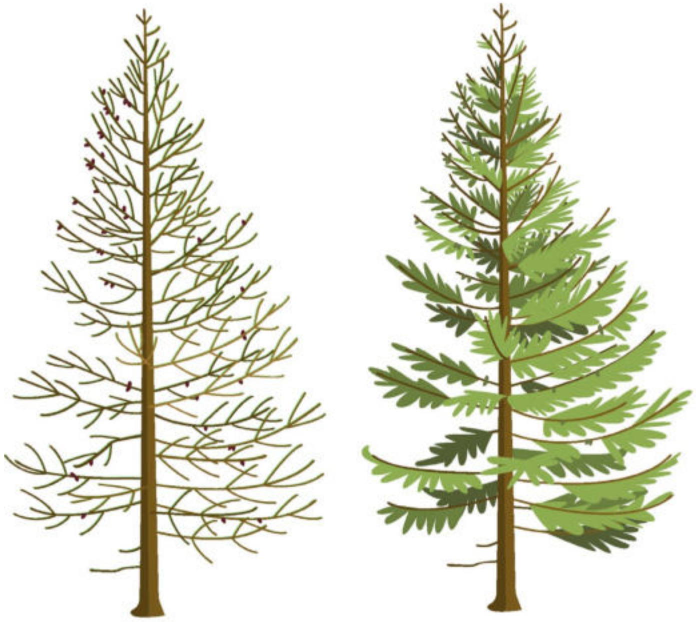
- the shape and arrangement of the leaf apparatus
- The roughness of the leaf blade surface

MACROSCOPIC

- The overal structure of the vegetation cover
- The height, canopy density and spatial layout of branches
- composition

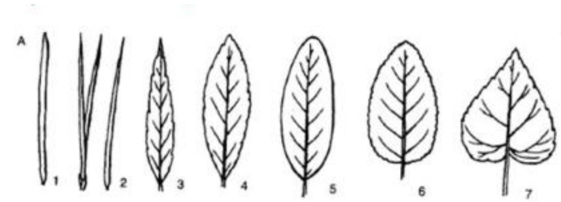
DEFOLIATION

- higher capture of pollutants on the surface of evergreen trees throughout the year compared to deciduous trees, which have a limited capture ability outside the growing season
- selection of a suitable phenology with respect to the course of local pollution

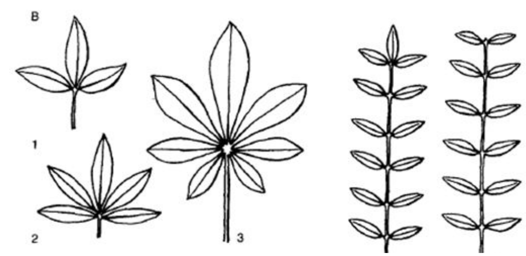


LEAF BLADE SIZE AND SHAPE

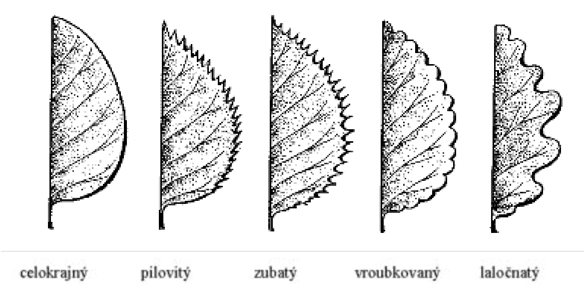
- The needles of coniferous species generally appear to be very effective, providing higher deposition rates than the leaf apparatus of broadleaf species
- Complex (lobed, sinuate) leaf shapes show greater potential for pollutant capture than simple (elliptical, round) leaf shapes
- Pinnate and segmented leaf shapes are generally more effective than simple, entire leaves



Simple leaves



Segmented leaves



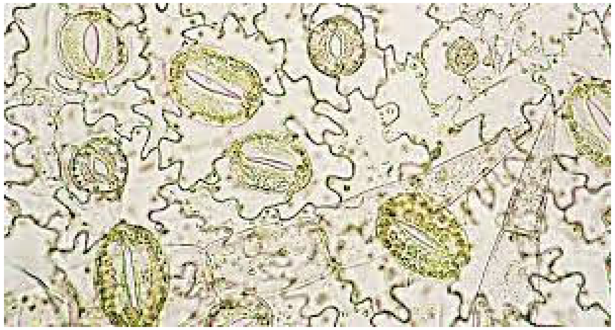
Blade edge

SOURCE: Mendelu, 2020

SURFACE OF LEAF BLADE

- rough, hairy or glandular leaf surfaces are more effective at capturing pollutants than smooth surfaces
- with a more pronounced cuticle
- the presence of trichomes, epicuticular wax, or pronounced, profiled veins increases the uptake of pollutants
- density and size of stomata

Trichomes on leaf surface



Stomata on leaf surface

SOURCE: Botanická fotografie, 2020.

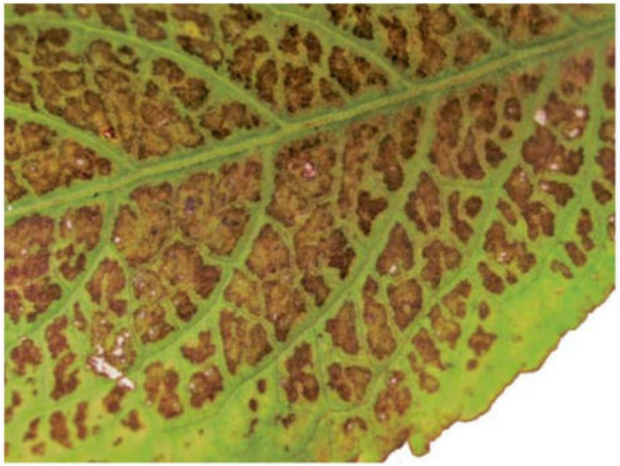
SURFACE OF LEAF BLADE

- the larger the surface area of the vegetation per unit area, the greater the capture of pollutants
- the properties of plant organs and their
- arrangement, as well as the overall connectivity and density of the growth, the height, crown shape and spatial layout of branches
- wide, tall and dense vegetation barriers in the direction of the predominant air flow reduce the concentrations of air pollutants

Different canopy density based on hemispherical photographs

POLLUTION TOLERANCE

- the choice of vegetation species should further reflect the topographic, soil and climatic conditions at the site
- the sensitivity of certain species to air pollution at the given site, the measured air pollution load
- deciduous tree species are more sensitive to high concentrations of tropospheric ozone than coniferous tree species
- salinisation of soils from road treatment (pine)



Damage caused by ground-level ozone on elderberry leaf blades (Novotný et al. 2009)

SOURCE: Novotný et al. 2009

SOURCE OF POLLEN AND VOLATILE ORGANIC COMPOUNDS VOC

- vegetation itself may be a source of pollution
- it produces pollen grains and volatile organic compounds (VOC)
- *Fagales*, *Lamiales*, *Proteales* and *Pinalesorders*
- species: birch (*Betula spp.*), ash (*Fraxinus spp.*), plane tree (*Platanus spp.),* or cypress tree (*Cupressus spp.*)

Plane tree alley in the centre of Barcelona. Plane trees (*Platanus spp.*) are an example of trees that produce VOCs and are a source of allergens (Grote et al. 2016)

SOURCE: Grote et al. 2016

SPECIES COMPOSITION

- combination of multiple species > increased resistance, canopy density
- combination of deciduous and coniferous species
- consideration of the pros and cons of each species
- the effect of some species may be ambivalent (*e.g. Platanus acerifolia*) - dense crown, tolerant to pollution, but they produce VOCs

Black pine (*Pinus nigra*) is an example of a tree species effective in capturing air pollutants

SOURCE: Wikipedia commons, 2020.

SPECIES COMPOSITION

Name	Apparatus	Georelief	Climate	Sensitivity to acid	Sensitivity to O_3	Capability of capturing dust particles
Pinus nigra	evergreen	alpine	subtropical	resistant	tolerant	high
Picea abies	evergreen	alpine	boreal	sensitive	resistant	medium
Abies alba	evergreen	upland	mild	tolerant	resistant	medium
Quercus robur	deciduous	lowland	mild	resistant	resistant	medium
Quercus petraea	deciduous	highland	mild	resistant	resistant	high
Malus sylvestris	deciduous	highland	mild	resistant	resistant	medium
Ulmus minor	deciduous	lowland	submediterranean	tolerant	tolerant	high
Cornus sanguinea	deciduous	highland	mild	tolerant	resistant	medium
Populus tremula	deciduous	highland	mild	resistant	resistant	medium
Prunus avium	deciduous	highland	mild	resistant	resistant	medium
Juglans regia	deciduous	upland	subtropical	resistant	tolerant	medium

SOURCE: Wikipedia commons, 2020.

SPECIES COMPOSITION

Selected tree species with higher resistence to air pollution

and more efficient pollutant capture

Malus sylvestris - **European crab apple**

Picea abies - **Norway spruce**

Pinus nigra - **Black pine**

Populus tremula - **European aspen**

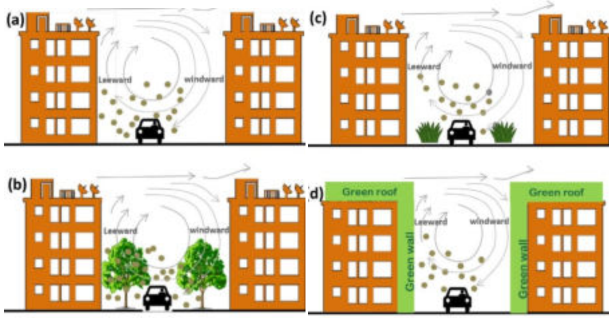
Quercus robur - **Robur English oak**

Ulmus minor - **Field elm**

SOURCE: Wikipedia commons, 2020.

COMPOSITION

- species combinations should be compatible in terms of growth and demands
- combination of several layers with trees and a shrub layer in the undergrowth
- surrounding buildings, their configuration and height must be taken into account
- prevention of negative effects in a street canyon



Pollutant flow and dispersion in a street canyon: (a) street canyon without vegetation, (b) street canyon with trees, (c) street canyon with hedgerows, and d) street canyon with green roofs and walls (Abhijith et al. 2017)

SOURCE: Abhijith et al. 2017

CASE STUDY

OSTRAVA - BARTOVICE, RADVANICE

AIR QUALITY IN THE OSTRAVA AGGLOMERATION

- The air quality in the Moravian-Silesian Region has long been one of the worst in a pan-European context. According to the results listed in the ISKO CHMI database (CHMI 2019) for air quality management, the annual limit value for suspended particulate matter PM_{10} and $PM_{2.5}$ was exceeded at most monitoring stations in 2018 in Ostrava
- The southeastern part of Ostrava is a particularly polluted area due to the accumulation of large industrial sources and local heating. Moreover, the shape of the valley by the river Ostravice limits dispersion of emissions when there is no wind

AIR QUALITY IN THE OSTRAVA AGGLOMERATION

- The main sources of air pollution in Ostrava are stationary sources (metallurgical and energy production), household heating sources and transport. The fourth most important factor in Ostrava is cross-border pollution from the nearby industrial agglomeration of Katowice (Poland). The situation in Ostrava is worsened by local climatic and weather conditions - particularly relatively long windless periods, which lead to lengthy inversions in the winter, increasing pollutant concentrations regardless of the reduction in emissions

CASE STUDY BARTOVICE, OSTRAVA – RADVANICE

- Near the Liberty Ostrava, a.s. iron works in Ostrava Kunčice (about 0.5 km to the west)
- A 44 µg/m³ average annual concentration of PM_{10} (110% of the limit) was measured at the nearby Health Institute station in 2018, placing the station in 1st place among stations where the limit was exceeded. (CHMI 2019)

SOURCE: CHMI, 2019.

OSTRAVA – RADVANICE CASE STUDY

- **1,0 ha**
- **solitary trees (Juglans regia)**
- **current forest stands extend to the edges (Populus tremula)**
- **there is also a herbaceous layer**




Current vegetation at the Ostrava – Radvanice site as of 2018.

OSTRAVA – BARTOVICE CASE STUDY

- **0,7 ha**
- **industrial waste landfill**
- **no vegetation**




Current vegetation at the Ostrava – Bartovice site as of 2018.

MONITORING AIR POLLUTION LOAD

VSB - Technical University of Ostrava

THE IMPORTANCE OF A SENSOR NETWORK

1. sensors are an appropriate addition to the existing network
2. sensors are suitable for assessing pollutant capture by green infrastructure
3. sensors are much cheaper than stationary monitoring systems
4. sensors can reveal "unusual" situations in the area and show the time of specific events
5. sensors should record both air pollution concentrations of individual pollutants (PM_x, NO_x, O_3 etc.) and meteorological conditions, which affect the efficiency of pollutant capture
6. sensors are easy to install and require almost no manual operation

THE IMPORTANCE OF A SENSOR NETWORK

7. sensors do not have to be dependent on an energy source thanks to their connection to a solar panel

8. each sensor is different, and they must be calibrated

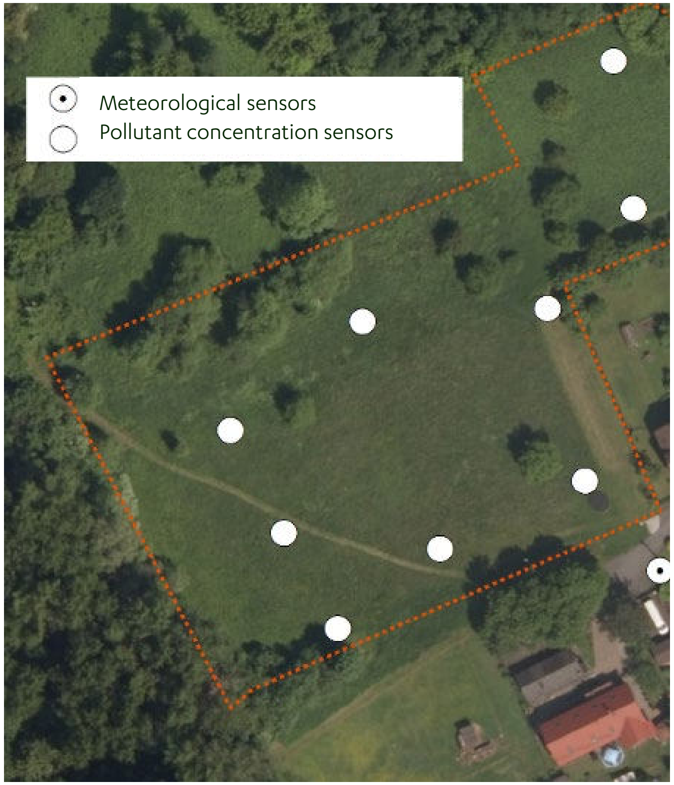
9. data from sensors can be transmitted in real time to an online system for their quick visualisation and evaluation

10. however, sensors with wireless data transmission via a mobile data network (GPRS) are more expensive

11. evaluated data from sensors should be taken into account when proposing the composition and layout of local green infrastructure

INSTALLATION OF A SENSOR NETWORK IN AREAS OF INTEREST

- 19 sensor units and one reference system
- installation before planting greenery, evaluation of the effectiveness of pollutant capture by the newly planted green infrastructure
- continuous measurement for at least another 8 years are anticipated so that the development over time can be evaluated with the development of the greenery and connectivity of the growth



SENSOR PARAMETERS

- A sensor unit is a composite device consisting of a 300 x 400 x 220 mm measuring part and a 620 x 670 mm solar panel
- Each sensor is alternately independent of the energy source; they contain a battery and are connected to a solar panel and 220 V mains
- The sensors are installed on metal poles up to a height of about 4 metres

MEASURED CHARACTERISTICS

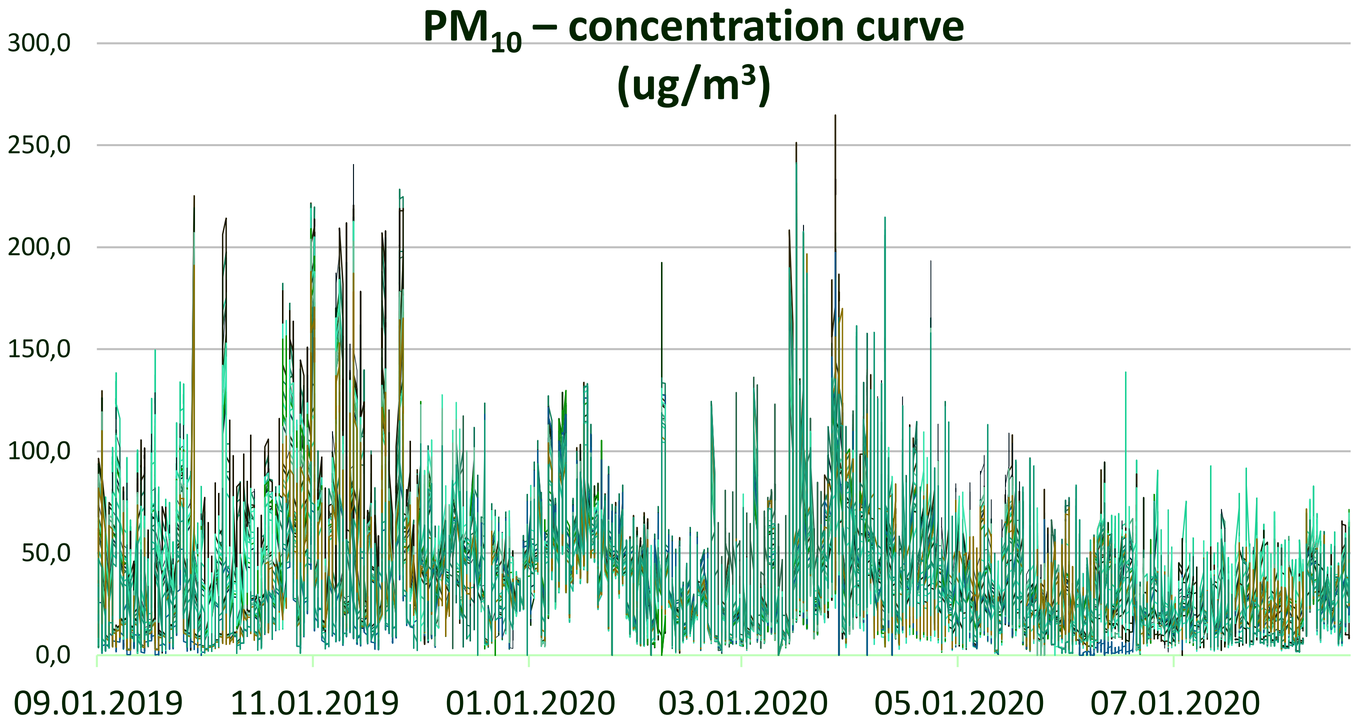
PM_{10}, O_3 A NO_X CONCENTRATION

- 15-minute step
- spatial interpolation (ordinary kriging) of monthly averages in a 1 x 1 m network

MEASURED METEOROLOGICAL PARAMETERS

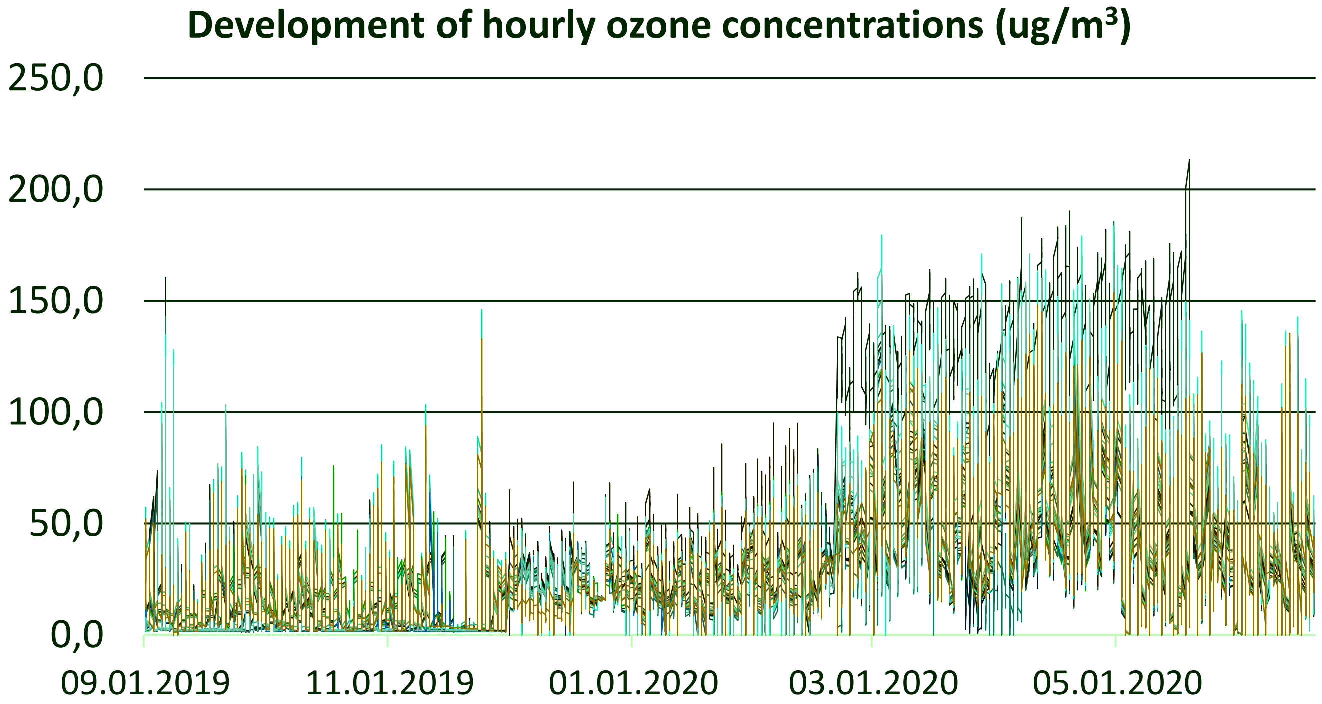
- global radiation ($W*m^{-2}$) T
- ambient temperature (°C)
- wind speed ($m\ s^{-1}$)
- relative humidity (%)

PM_{10} CONCENTRATIONS



Results to date indicate very good conformity with reference stations for PM_x

O_3 CONCENTRATIONS



AIR POLLUTION MONITORING INFORMATION SYSTEM

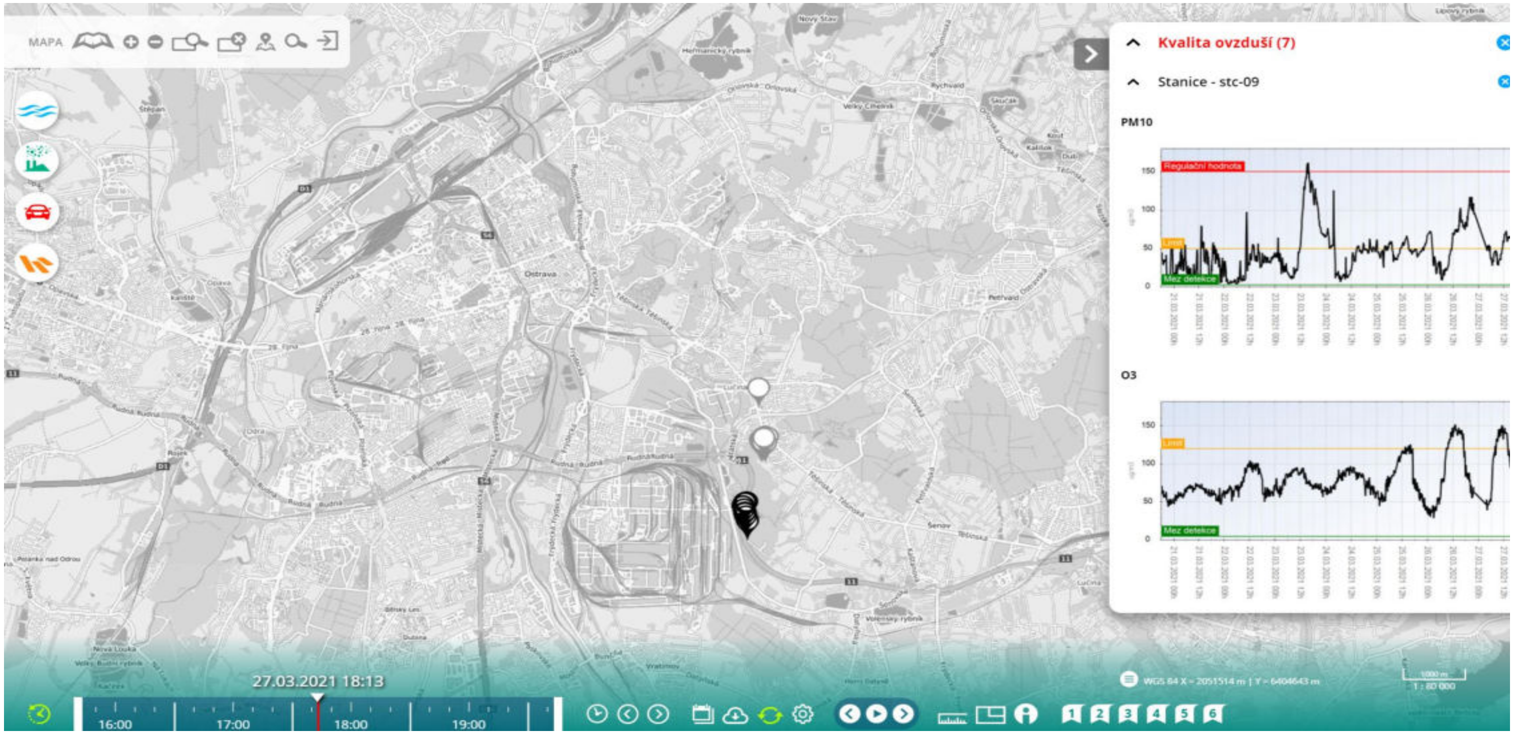
The sensor units are connected to one common network and they provide online data wirelessly. Data are transfered to the existing intelligent information system, which allows:

- **collection of short-term concentrations from sensors**
- **transferred data are stored in a specially structured database**
- **automatic data inspection**
- **validation based on reference measurements**
- **manual evaluation of data validity**
- **concentration map for individual pollutants**

AIR POLLUTION MONITORING INFORMATION SYSTEM

- model calculation based on measured meteorological indicators (wind speed and direction)
- animated sequences for various intervals (hour, day, month)
- automatic marking of the place and time of a "non-standard" concentration in concentration tables
- data export for individual IIS network points into tables
- data and maps are stored in a well-arranged archived

AIR POLLUTION MONITORING INFORMATION SYSTEM



Data can be viewed at the web map portal: **www,floreon.eu/mapa/ or www.airsens.eu**

GREENERY PLANTING DESIGN

Silesian University in Opava

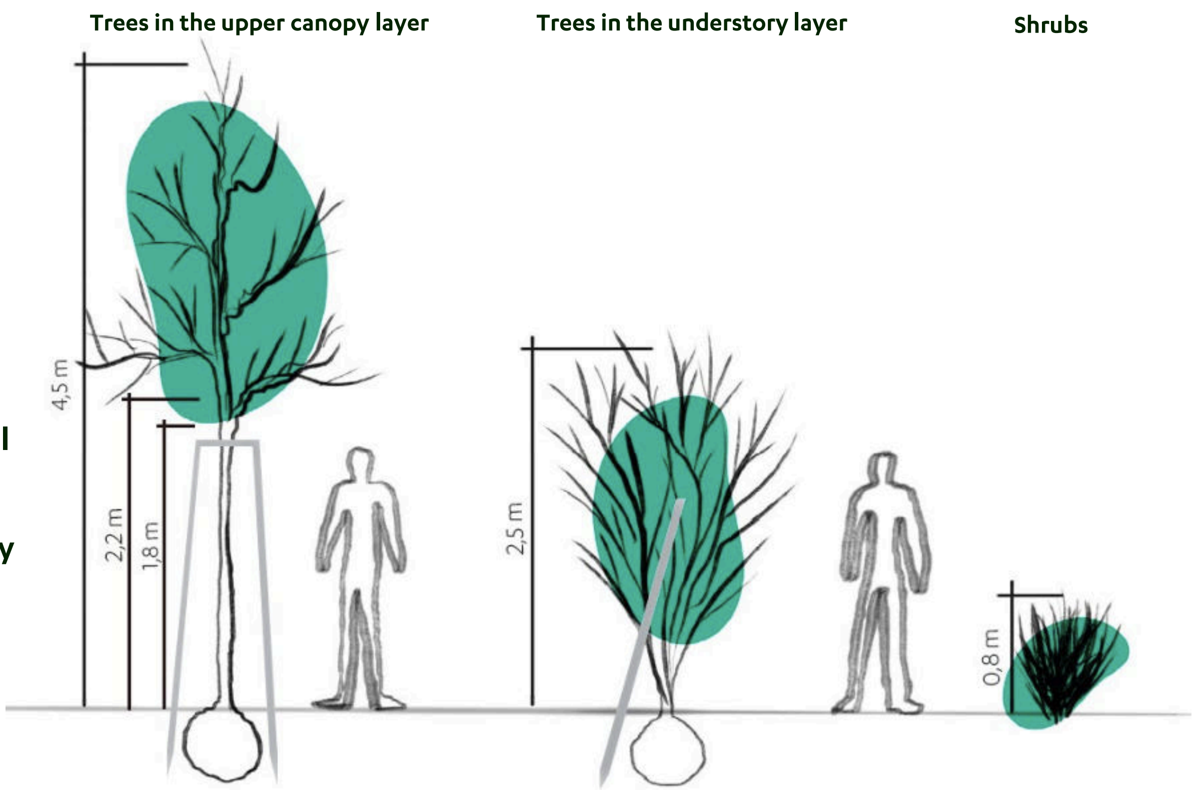
PROCESS OF CREATING A PLANTING DESIGN

Creation of an initial plant list	Taking into account local development and urban composition	Revision of the list	Prioritization of plants depending on their ability to capture pollutants
Viability and resilience Will the proposed vegetation thrive in local environmental conditions? What to consider: • The current air pollution (according to local monitoring). • Climate and soil conditions. • Soil salinity. • Other environmental risks (drought, toxicity of the environment).	**Morphology and ecophysiology** What are the local conditions and overall context in terms of surrounding development? Is the greenery planted in an open space or a street canyon? • In general: Sun-loving species for open areas, shade-loving species for street canyons.	**Source of pollution** • Species with lower volatile organic compound (VOC) and pollen emissions. **Species diversity** • Multiple species. **Native species** • Elimination of non-native, invasive species or species incompatible with local legislation. **Competition** • Species combinations should be compatible in terms of growth and demands.	**Air pollutant capture potential** How can we maximize the efficiency of pollutant capture by the proposed vegetation? What to consider: • The type of vegetation (evergreen, coniferous species over deciduous species). • The structure of the vegetation (height, densely branched crown, multiple layers). • Size and complexity of the leaf apparatus. • Leaf surface (rough, sticky).

SOURCE: Edited based on Barwise and Kumar, 2020.

GREENERY PLANTING – COMPOSITION

- **Anticipated heights: 4.5 m for the canopy layer, 2.5 m multi-stemmed trees in the understory layer and 0.80 m for shrubs**
- **Vertical and horizontal layout with the aim of maximizing the canopy in further growth**



GREENERY PLANTING – SPECIES COMPOSITION

Trees in the upper canopy layer

Abies alba, Pynus sylvestris, Larix decidua, Quercus cerris, Tilia platyphyllos

Trees in the understory layer

Betula pendula, Prunus mahaleb, Carpinus betulus, Crataegus monogyna, Sorbus aria

Shrubs

Ribes alpinum, Sambucus racemosa, Ligustrum vulgare, Lonicera xylosteum, Euonymus europaeus, Viburnum lantana, Lonicera xylosteum, Cornus sanguinea

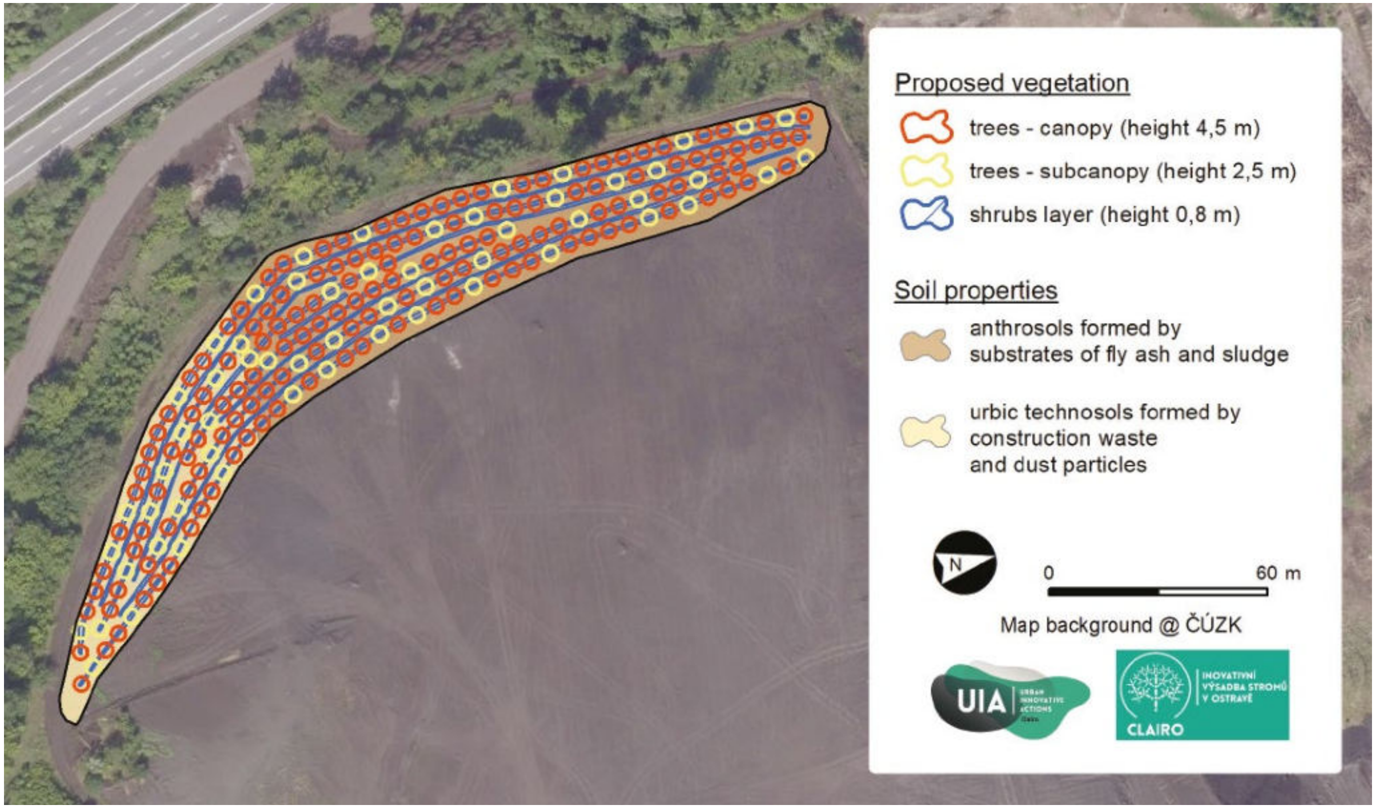





SOURCE: Wikipedia commons, 2020.

DESIGN OF GREENERY STRUCTURE – RADVANICE

DESIGN OF GREENERY STRUCTURE – BARTOVICE



TREATMENT AND FERTILISATION OF GREEN INFRASTRUCTURE

Palacký University in Olomouc

STRENGTHENING THE RESISTANCE OF PLANTS

- for the permanent preservation of the functions of the green infrastructure, further care is also necessary
- trees and shrubs in good health will better photosynthesize and create a denser and better leaf area, which will subsequently have a positive effect on the capture of pollutants from the air
- urban greenery is commonly treated with commercial inorganic fertilisers
- environmentally friendly products based on 'smart fertilisers' containing biostimulants
- and phytohormones that help plants overcome various forms of abiotic stress

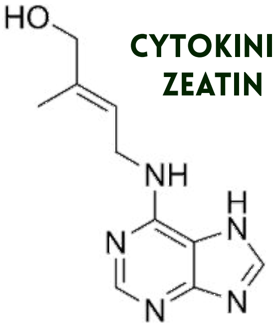
PLANT HORMONES PHYTOHORMONES

- These are substances that play a key role in regulating plant growth and development. They occur naturally and act in small concentrations, forming in certain parts of plants, from where they are transported by the bast of the vascular bundle to their destination, eliciting a physiological response.
- The effect of the hormone must always be preceded by binding to a specific receptor. The function of phytohormones is non-specific; one hormone can affect multiple processes. In a relationship, hormones can act in a synergistic or antagonistic way.

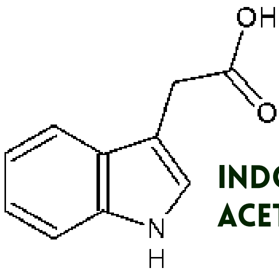
PLANT HORMONES PHYTOHORMONES

- **Phytohormones are used as growth regulators in plant production and plant biotechnology; in high concentrations, they act as herbicides for weed control. The main groups of phytohormones are: auxins, cytokinins, gibberellins, abscisic acid, ethylene, brassinosteroids, jasmonates, strigolactones**

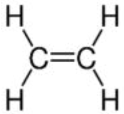
CYTOKININ ZEATIN



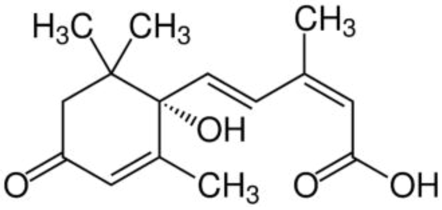
INDOLYLE-3-ACETIC-ACID



ETHYLEN



ABCISIC ACID



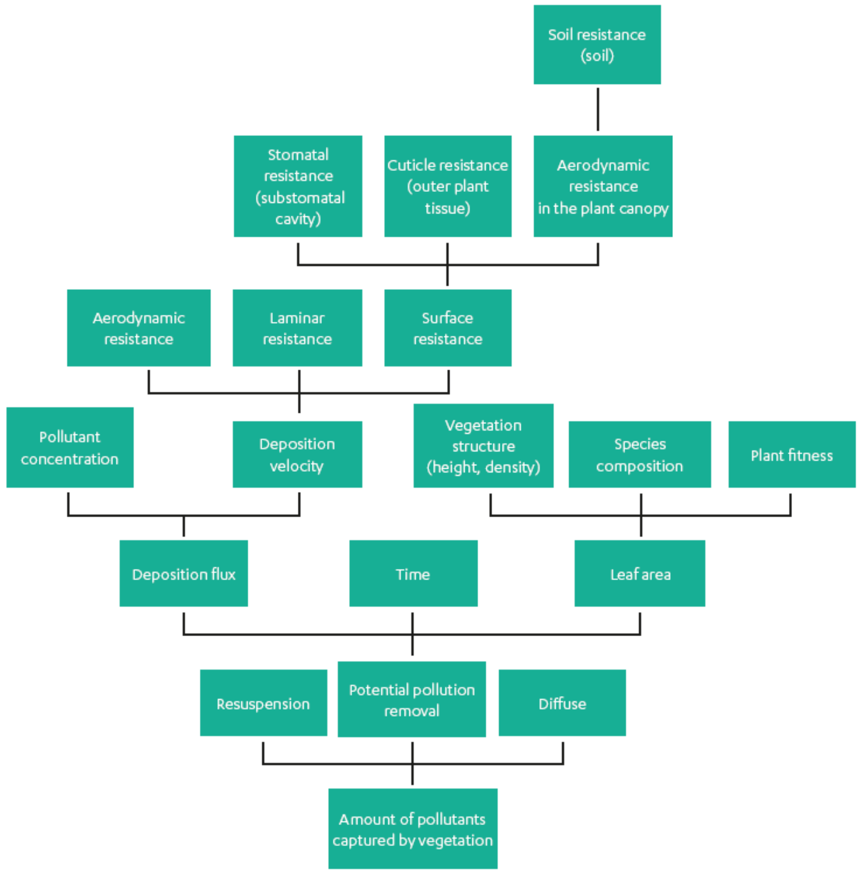
PLANT BIOSTIMULANTS

- Biostimulants are biologically active substances obtained from natural or waste materials. They can support plant growth and/or strengthen the resistance of plants to various stressors. The peculiarity of biostimulants is that they do not contain a high percentage of active substances, so they cannot be considered typical fertilisers or plant protection products. The active ingredients in biostimulants affect the metabolism of the plant and trigger processes in the plant that generally improve its growth and health. Interestingly, the exact mechanism of the action of most biostimulants is unknown, which opens up a number of possibilities for scientific research. Biostimulants may contain phytohormones, but this term is most commonly associated with protein hydrolysates, seaweed extracts and humic acids.

MODELLING POLLUTANT CAPTURE

Silesian University in Opava

MODELLING POLLUTANT CAPTURE BY VEGETATION



SOURCE: Nowak 1994; Zapletal 2001; Zapletal et al. 2011; Janhäll 2015.

MODELLING PM_{10}, O_3 A NO_X CAPTURE

$$Q = LAI \times F \times T$$

- Q is the amount of gases and particles captured by vegetation in a certain area and time period ($g\ m^{-2}$)
- F is the deposition flux of gases and particles ($g\ m^{2}\ s^{-1}$)
- LAI is the leaf area index($m^2\ m^{-2}$) and T si the time period (s)

$$F = V_d(z) \times c(z)$$

- V_d is the deposition rate of the component ($m\ s^{-1}$)
- c(z) is the concentration of the component at height z above the ground ($g\ m^{-3}$)

SOURCE: Nowak 1994; Zapletal 2001; Zapletal et al. 2011; Janhäll 2015.

MODELLING PM_{10}, O_3 A NO_X CAPTURE

- The deposition flux of gases and particles (*F*) on the surface of receptors is determined by tehir concentrations in the air and turbulent transfer processes in the boundary layer of the atmosphere on one hand, and by their chemical and physical properties and the ability of the surface to capture or absorb these gases and particles on the other hand

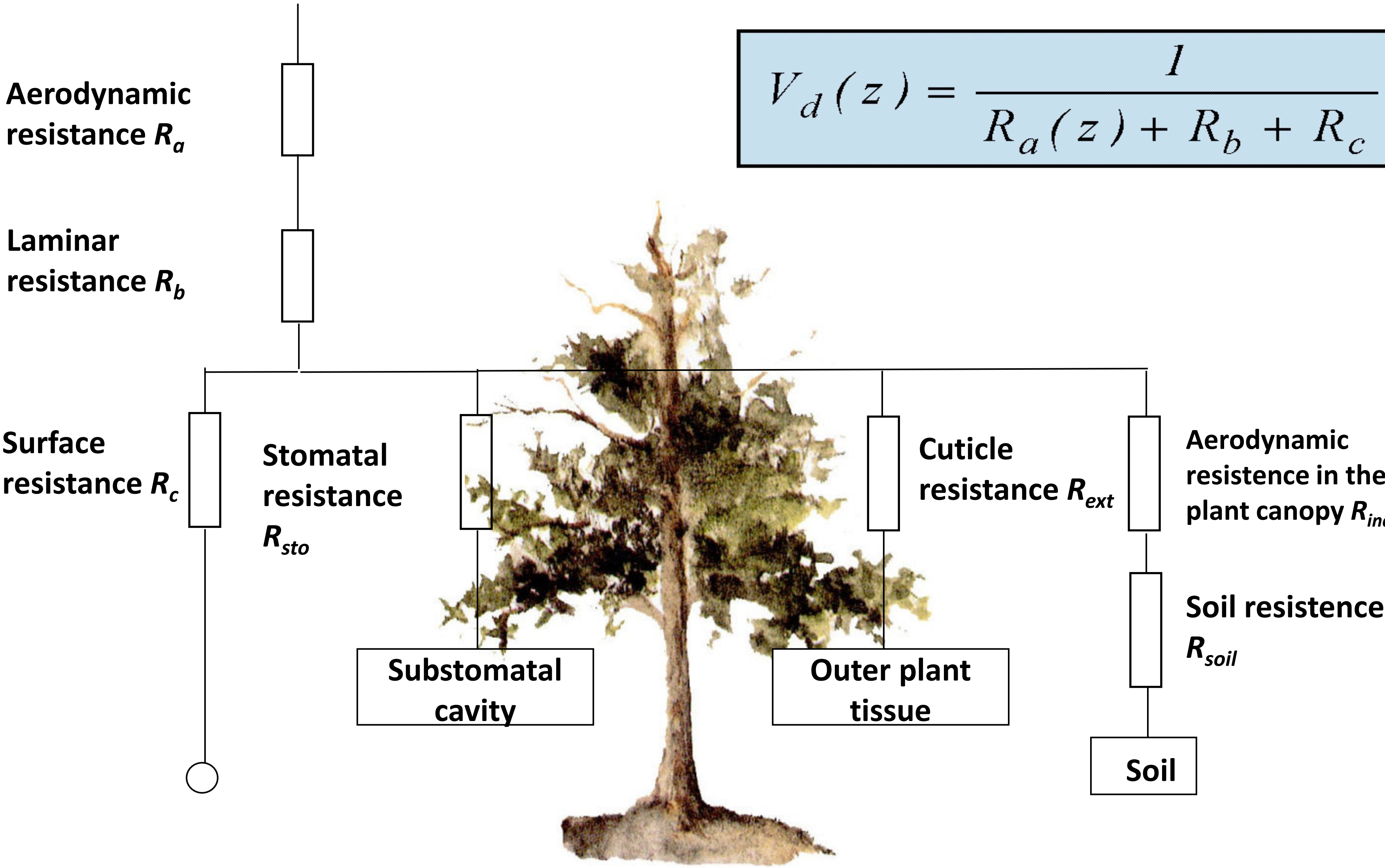
SOURCE: Nowak 1994; Zapletal 2001; Zapletal et al. 2011; Janhäll 2015.

RESISTANCE MODEL FOR CALCULATING THE DEPOSITION V_d

The deposition rate V_d can be expressed as the inverse of the sum of three resistances (three gas transfer phases):

- **Aerodynamic resistance R_a**
- **Laminar resistance R_b**
- **Surface resistance R_c**

$$V_d(z) = \frac{1}{R_a(z) + R_b + R_c}$$



MODELLING POLLUTANT CAPTURE BY VEGETATION RADVANICE – PM_{10}

Capture of PM_{10} (g) before the planting (on the left) and after the planting of the proposed vegetation (on the right) in a 1x1 m network at the Radvanice site. Modelled for a two-month period (at the end of the growing season)

MODELLING POLLUTANT CAPTURE BY VEGETATION RADVANICE – O_3

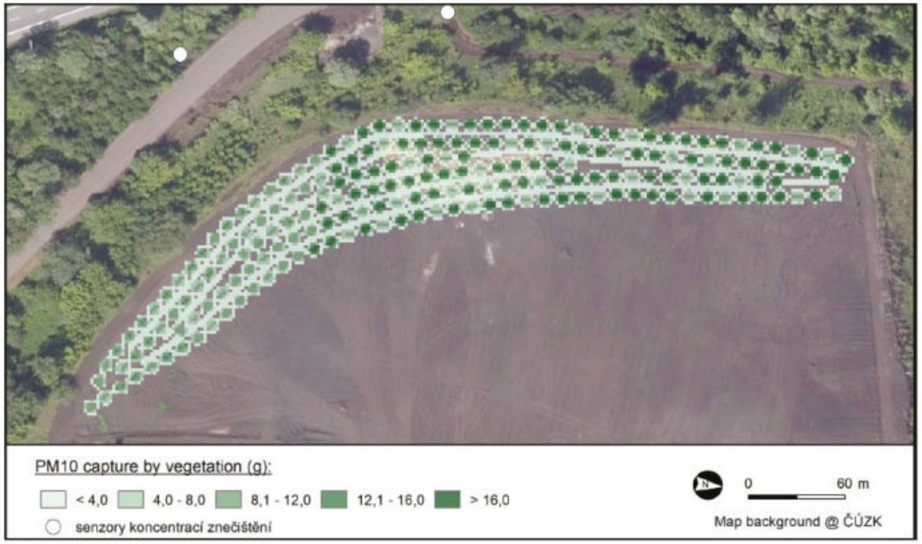
Capture of O_3 (g) before the planting (on the left) and after the planting of the proposed vegetation (on the right) in a 1x1 m network at the Radvanice site. Modelled for a two-month period (at the end of the growing season)

MODELLING POLLUTANT CAPTURE BY VEGETATION RADVANICE – NO_X

Capture of NO_x (g) before the planting (on the left) and after the planting of the proposed vegetation (on the right) in a 1x1 m network at the Radvanice site. Modelled for a two-month period (at the end of the growing season)

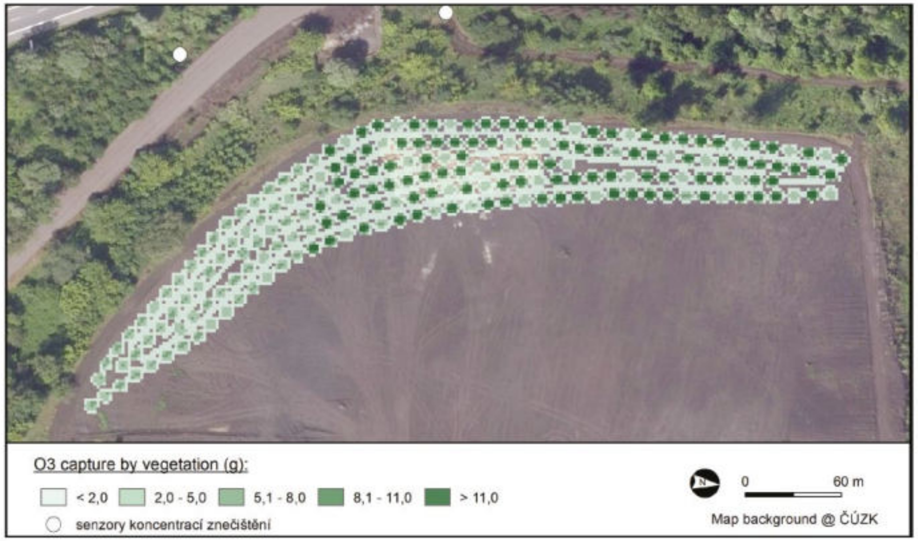
MODELLING POLLUTANT CAPTURE BY VEGETATION BARTOVICE – PM_{10}

Capture of PM_{10} (g) after the planting of the proposed vegetation in a 1 x 1 m network at the Bartovice site. Modelled for a two-month period (at the end of the growing season). At the Bartovice site, no significant capture is currently expected before the planting due to the absence of any current greenery



MODELLING POLLUTANT CAPTURE BY VEGETATION BARTOVICE – O_3

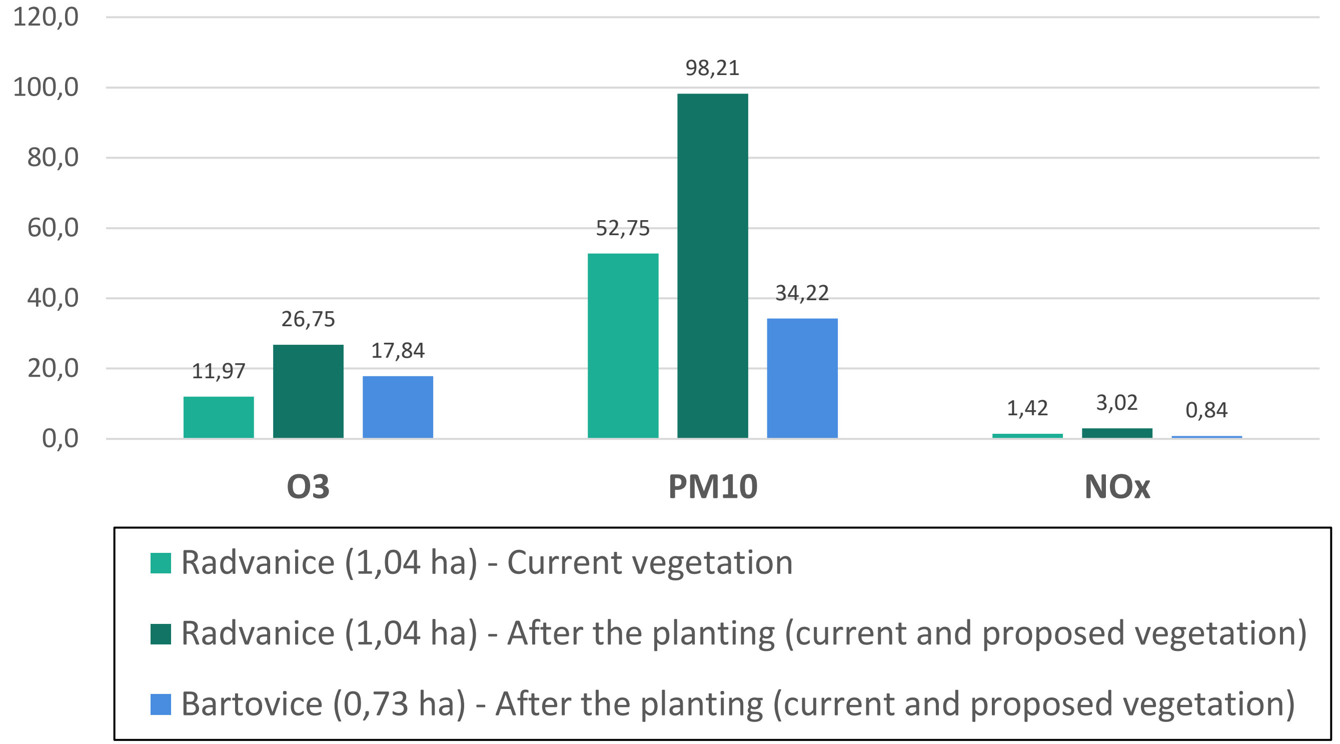
Capture of O_3 (g) after the planting of the proposed vegetation in a 1 x 1 m network at the Bartovice site. Modelled for a two-month period (at the end of the growing season). No significant capture is currently expected before the planting due to the absence of any current greenery



MODELLING POLLUTANT CAPTURE BY VEGETATION BARTOVICE – NO_X

Capture of O_3 (g) after the planting of the proposed vegetation in a 1 x 1 m network at the Bartovice site. Modelled for a two-month period (at the end of the growing season). No significant capture is currently expected before the planting due to the absence of any current greenery

THE EFFECT OF NEWLY PLANTED GREENERY ON POLLUTANT CAPTURE



TRANSFER OF KNOW-HOW AND PUBLIC SURVEYS

SOBIC Smart & Open Base for Innovations in European Cities and the Regional Association of Territorial Cooperation of Těšín Silesia

TRANSFER OF KNOWLEDGE

- **The methods and experience gained during the project are also passed on to other partner cities (e.g. Opava, Třinec, Karviná) in the Moravian-Silesian Region. Both the professional and the general public in the Czech Republic and around the world are notified of the findings.**

- **Know-how on the importance of green infrastructure in cities and its planting with regard to improving air quality and adapting to climate change is transferred through workshops for city representatives, academics and students in primary and secondary schools and universities.**

PUBLIC OPINION POLLS – METHODOLOGY

- **The surveys were conducted in the Moravian-Silesian Region in 2019 and 2020 and were carried out by exclusive quantitative research using standardised face-to-face, in-home interviews.**

PUBLIC OPINION POLLS – METHODOLOGY

- Data was collected on: 15 October 2019-10 November 2019 and 5 October 2020-31 October 2020
- The research sample consisted of inhabitants of the Ostrava agglomeration over the age of 18
- The subsample consisted of 1,207 respondents (605 in 2020 + 602 in 2019) from selected towns and villages of the Ostrava agglomeration, specifically from towns (and small nearby villages):
- Bohumín (64), Český Těšín (75), Frýdek-Místek (112), Havířov (141), Hlučín (20), Jablunkov (15), Karviná (112), Opava (80), Orlová (20), Ostrava (476), Třinec (93)
- The structure of respondents can be distinguished by gender (men/women), age (categories 1-29, 30-39, 40-49, 50-59, 60+) and education (elementary, apprenticeship/without maturity diploma, secondary/higher vocational school, university) and other parameters

PUBLIC OPINION POLLS – FINDINGS

THE MOST IMPORTANT FINDING IS THAT:

- **Almost 30% of inhabitants in the region believe that the air quality has worsened in the last 10 years, which does not correspond with actual air quality measurements**
- **The topic of air quality is important to four fifths of inhabitants of the agglomeration. Almost one half of inhabitants are somewhat or definitely unsatisfied with the air quality**
- **The vast majority of respondents have a positive view of urban greenery. Over three fourths of respondents would welcome green facades, roofs, etc. in their area. Almost one half of residents would be willing to contribute financially to the planting of greenery or another form of air protection**

PUBLIC OPINION POLLS – FINDINGS

- **An overwhelming majority of respondents declare their willingness to personally contribute to improving the air and environment in their region. Most often by supporting the planting of greenery (90%) and not burning household waste (including leaves, grass, paper), but also by using sustainable forms of transport**
- **The topics of clean air and greenery in cities are especially important to university-educated and younger inhabitants, which is an important message for cities facing an outflow of population mostly from this group. Although we are facing this outflow in our region, we should also take advantage of the fact that there are universities in cities (Ostrava, Opava, Karviná), as it is young and educated people who produce leaders in thought and politics**

CONCLUSION

CONCLUSION

1. **Green infrastructure contributes to the improvement of air quality in urban environments by removing suspended particles and other pollutants by capturing them on the surface of leaves and pine needles. Some of the captured pollutants can be filtered into intercellular spaces through the stomata, but most of them remain on the leaf surface, from where they can be resuspended into the atmosphere or washed away by precipitation**
2. **Important aspects of quality and efficient green infrastructure in capturing suspending particulates (PM_x), ground-level ozone (O_3) and nitrogen oxides (NO_x) are both the properties of plant organs and their arrangement, as well as the overall structure of the stand, its height and the canopy density**

CONCLUSION

3. To monitor the effect of green infrastructure on the local air quality, sensors should be installed in the surrounding area. Due to their simple installation and operation, they are suitable for additional measurement, which can also detect 'unusual' situations, including the time of specific events

4. When planting green infrastructure in industrial areas with increased concentrations of air pollutants, species with increased resistance to air pollution should be preferred. Especially at high concentrations of ground-level ozone, it is necessary to select species resistant to this type of pollution

CONCLUSION

5. The use of environmentally friendly fertilisers containing biostimulants and phytohormones, which help plants overcome abiotic stresses, can ensure the long-term viability of existing and newly planted greenery even in heavily polluted environments around industrial areas
6. After the proposed vegetation is planted, a significant increase in the capture of pollutants can be expected on the basis of the modelled outputs, specifically more than double the current amount of captured pollutants, and thus an overall improvement in air quality in the given location
7. The methodology enables quantification of the capture of particles, ground-level ozone and nitrogen oxides by urban greenery on a local scale, taking into account the actual structural properties of local vegetation

THANK YOU FOR YOUR ATTENTION

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