Interreg CENTRAL EUROPE
European Union
European Regional Development Fund

SALUTE4CE

URBAN ENVIRONMENTAL ACUPUNCTURE SPECIALISTS

E-LEARNING - COURSE

INTRODUCTION

The e-learning course has been elaborated within the Salute4CE project. The SALUTE4CE project has been implemented under the INTERREG Central Europe Programme. The main goal of the course is to introduce the professionals and general public with the concept, goals, opportunities and procedures of urban environmental acupuncture (UEA) approach. The UEA application is part of cities' adaptation strategies as a response to climate change negative effects. UEA can also be addressed a problems, such as air pollution, lack of biodiversity or inconvenient social situation.

The e-learning course aims at giving participants a quality overview on a full range of issues on UEA. Meanwhile, thanks to the inclusion of an additional list of references, every participant has the opportunity to improve their knowledge on specific issues. . At the same time, the course also includes additional List of references to improve the knowledge of specific issues. For further self-study, the Salute4CE Handbook is also prepared which solves individual problem areas in greater detail, or expands the basic portfolio of knowledge.

Who can participate?

The course is open to all who are interested in sustainable urban development. It is primarily intended for urban planners, architects, students, citizens, local and regional authorities ect.

Why attend the course?

Thanks to the chosen form, the participant has the opportunity to gain an intensive overview of the entire UEA issue. Thanks to the self-evaluation system, the participant has the opportunity to find out if he / she has understood the given issue correctly

How the e-learning course is divided?

The course is divided into two parts. Educational part and certificated part-

The educational part is accessible to everyone without registration. This part includes all educational modules, including the possibility of self-evaluation.

The certificated part is intended for those e-learning participants who want to obtain a certificate URBAN ENVIRONMENTAL ACUPUNCTURE SPECIALISTS, awarded by the Salute4CE project.

Where the Training e-learning Manual is promoted and made available?

All information is accessible via links from this document - this entrance page. If any of the links do not work and the forwarding has been disabled, you can find the entrance page at www.iurs.cz by clicking on the link in Figure 1.

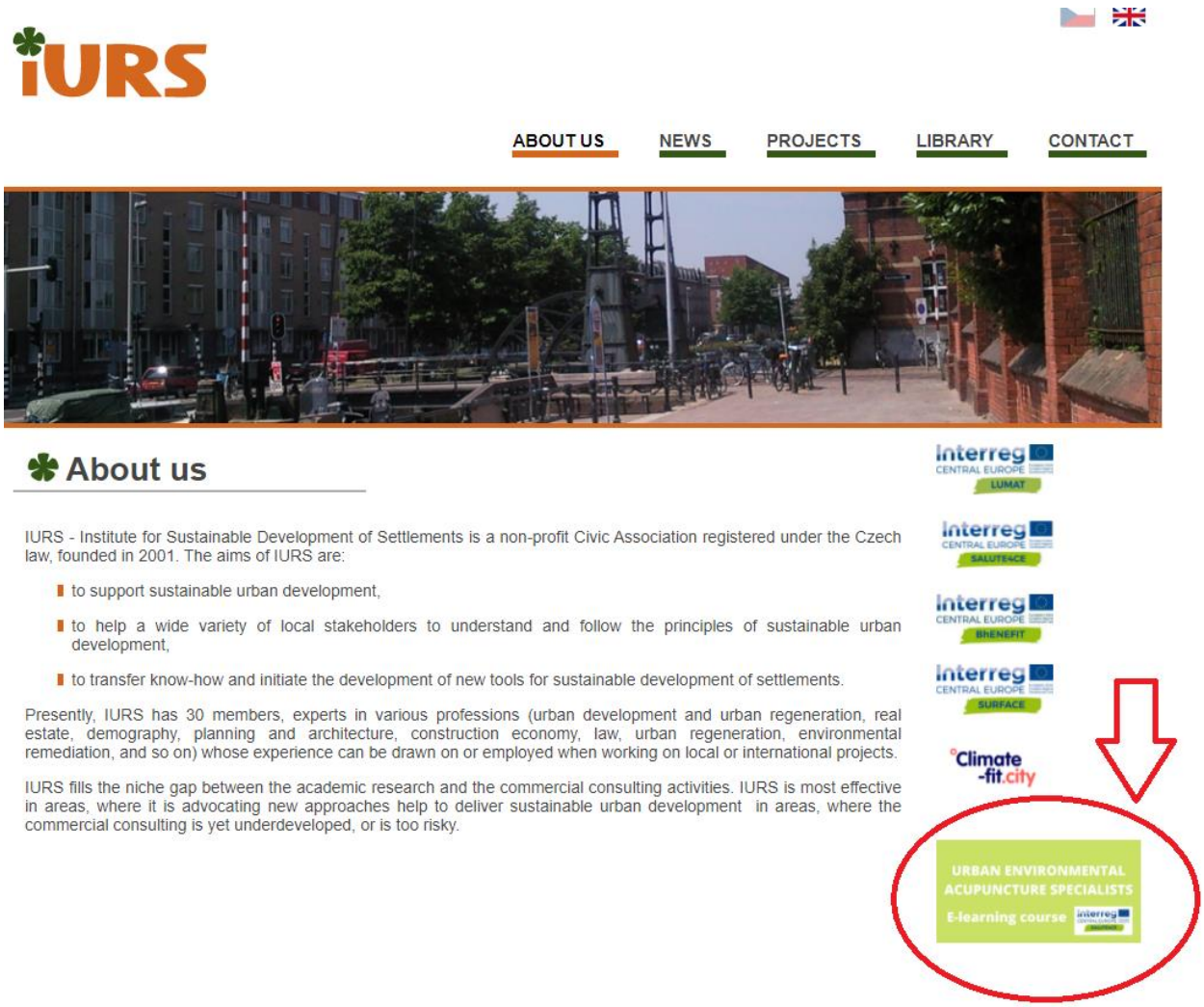


Figure 1 - entrance page on website

If there happens to be a problem with your access to the manual due to some technical reasons that we cannot predict (for example, nationwide blocking of access), please email us (iurs@email.cz) and we will send you all the documentation.

How to proceed in the e-learning course to get a certificate?

In the beginning is necessary to study the information in materials from the **educational** part. After **you feel that you are familiar with UEA,** then it is necessary to register. After registration project representatives will open a special on-line test. **Before you start with registration please read Private Policy - GDPR information.** By registering, you agree to the terms of the GDPR

How to use this manual?

The e-learning manual is divided into 7 separate chapters and a special section (Module 4) describes each Nature Based Solution (NBS).

For a better overview, the chapters are divided into modules. Each chapter must be opened separately. For those interested, a self-evaluation text is prepared for each chapter.

Module 1 - Introduction

It introduces the participant to the UEA issue and the selection of suitable green spots for its implementation.

Module 2 - Challenges that need to be overcome

The second module is divided into 4 separate chapters, which address the individual challenges that cities face in relation to climate change, problems with air pollution, hearth stress, soil sealing and rain water.

Module 3 Connecting UEA with urban planning

Module include chapter focused on selection **of suitable, sustainable native plants. Also is part of this module chapter** introducing **Action planning for UEA.** Both chapters are important for the communication of our UEA idea. Good communication and is necessary in order to be acceptable both for the city for which they are intended and for the inhabitants of the city who will be users of the UEA.

Module 4 Special section - Nature Based Solutions – examples for shaping UEA green space.

This section describes key information about each Nature Based Solutions. Descriptions contain pictures, main ecosystem services, short description, typical/possible locations, and list of references.

MODULE 1 - Introduction

Chapter 1 What is Urban Environmental Acupuncture? Short Description of Selection Methods of Green Acupuncture Spots

Authors: Jiří Kupka, Adéla Brázdová, IURS – Institute for sustainable development

Self evaluation test

MODULE 2 - Challenges that need to be overcome

Chapter 2 Soil Sealing and Soil Degradation Reduction by application of Urban Environmental Acupuncture solution

Authors: Anna Starzewska- Sikorska, Justyna Gorgoń, IETU - The Institute for Ecology of Industrial Areas

Self evaluation test

Chapter 3 Urban Environmental Acupuncture as One of the Solutions for Reduction of Heat Stress in Urban Space

Authors: Juliane Mathey,Jessica Hemingway, Peter Wirth, IOER The Leibniz Institute of Ecological Urban and Regional Development

Self evaluation test

Chapter 4 Possibilities of application of Urban Environmental Acupuncture in Reducing Problems with Rainwater in the Urban Space

Authors: Barbara Vojvodikova, Božena Schejbalova, IURS – Institute for sustainable development

Self evaluation test

Chapter 5 Urban Environmental Acupuncture for Increasing Air Quality

Authors: Matteo Tabasso, Elena Masala, LINKS Foundation

Self evaluation test

MODULE 3 Connecting UEA with urban planning

Chapter 6 Selection of suitable - sustainable - native - plants - country specific native plants

Authors: Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden

Self evaluation test

Chapter 7 Action planning for urban environmental acupuncture (small green space)

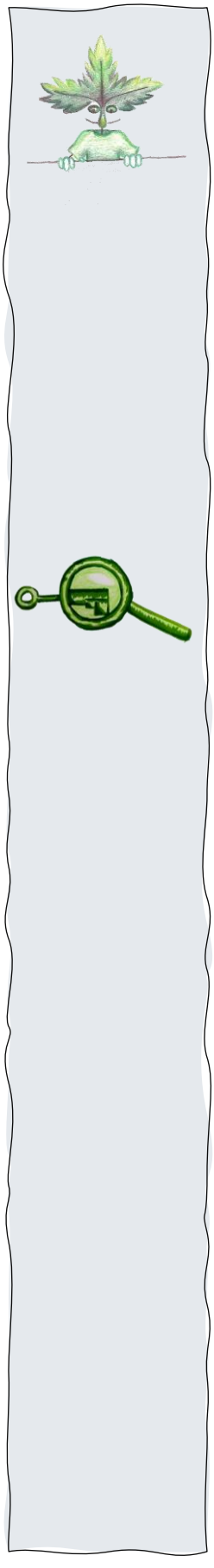
Authors: Jessica Hemingway, Juliane Mathey and Peter Wirth, IOER The Leibniz Institute of Ecological Urban and Regional Development

Self evaluation test

MODULE 4 - Nature based solutions – examples for shaping UEA green space

Positive effect on Soil sealing	Positive effect on rainwater accumulation	Positive effect on heat stress reduction	Positive effect on social situation	Positive effect on air quality

1.	Urban meadows	16.	Herb spiral
2.	Verges / flower beds with native perennials	17.	Urban wilderness / succession area
3.	Ground cover plants	18.	Ground crops of vegetables / herbs
4.	Lawn	19.	Vegetated reinforced soil slopes with green fences
5.	Green pavements	20.	Green pergolas/ green arbors
6.	Street trees	21.	Green facades with climbing plants
7.	Park trees	22.	Wall-mounted living walls
8.	Fruit trees/ shrubs/	23.	Hydroponic mobile living walls / vertical gardens
9.	Large shrubs	24.	Vertical vegetable / herb gardens
10.	Rain gardens (under-drained)	25.	Hanging wall planters (as green street furniture)
11.	Road-side swales for retention and infiltration	26.	Compacted pollinators' module
12.	Linear wetlands for stormwater filtration	27.	Rain gardens in planter (=self-contained)
13.	Natural pollinators' modules	28.	Street planters (as green street furniture)
14.	Hedge/hedgerow	29.	Green covering shelters
15.	Rockery	30.	Green roof /roof terrace



Chapter 1 What is Urban Environmental Acupuncture? Short Description of Selection Methods of Green Acupuncture Spots

Authors: Jiří Kupka, Adéla Brázdová, IURS – institute for sustainable development

Learning targets

Where and how to find vacancies for greenery in the densely built-up centres of our cities? What functions does greenery in cities have and why is it so important to us? What forms can greenery take in cities and what is green and blue infrastructure? The central idea of this chapter is to introduce urban environmental acupuncture as a method that allows you to find and use different places in the urban environment to plant greenery. By studying this chapter, you will not only find the answers to the above questions, but you will be able to perceive the need for greenery in the city. In Urban Environmental Acupuncture, you will find a suitable tool that will allow you to find meaningful and feasible solutions for locating green infrastructure in an urban environment.

Keywords

urbanisation, urban greening, ecosystem services, urban ecosystem services, green infrastructure, blue infrastructure, urban environmental acupuncture, city resilience

Part1: Background

All human settlements, from the oldest cities to the megalopolis of today, retain an internal contradiction. On the one hand, they draw on the long-standing traditions of the existing ways of creating settlements, on the other, they are transformed by continuous technological progress and social changes. The same city can live its cultural and historical memory, and at the same time set out its new residential visions. (Brázdová et all, 2020a; Brázdová et all, 2020b)

Have you ever thought about how much city centres have changed in the last 200 years? Which elements and processes in the development of cities and their infrastructure have completely receded into the background? And which elements and processes, on the contrary, have become more important, or are they completely new? In what places in the city were spaces for greenery created, and for what purpose did these places originally serve?

What is your original idea when you hear the word “city” or “town”? Not every city means “the city” in the true sense of the word. And how most of the European cities were born? Was there anything different about their origins in America? For example, New York is one of the most famous American megalopolis, which began to be settled in the early 17th century, compared to London which was originally conquered as a settlement and subsequently built as a city by the Romans sometime around the beginning of our era.

The hallmark of contemporary urban development is a process that is called urbanisation. Urbanisation is also associated with an increase in population and a decrease in open space, for example for planting greenery (Yoon et all, 2019). It is estimated that in economically developed countries, more than 80% of the total population will live in cities, while in some countries, such as the United Kingdom, this proportion has already been reached today!

However, contemporary cities cannot be compared to small compact urban formations that have been characteristic of recent historical periods in Europe. Today's cities are characterized not only by intensively urbanised centres with a high built-up, a large concentration of offices, equipment and services, and a lack of greenery. On the contrary, they are becoming an integral part of increasingly large suburbs, spread many kilometres around the cities' cores, which integrated elements of greenery in the process of their development.

In some countries, these industrial and residential agglomerations (clusters of settlements) cover an area of many tens of thousands of square kilometres, and their populations reach tens of millions. A good example is a belt on the East coast of the United States, including cities such as Boston, New York, Baltimore and Washington. In Europe, the German Ruhr is such an agglomeration, and also the entire densely populated area stretching from central England through London and the Dutch agglomerations to the Rhineland and further through Switzerland to northern Italy. Similar agglomerations, sometimes called megacities, exist in Japan, China, India or Central and South America. Under such conditions, questions concerning the sustainability of suitable conditions for human life generally referred to as urban sustainability, come to the fore (Han et all, 2019). We need to ask questions about the sustainability of favourable conditions for human life generally referred to as urban sustainability (Brázdová et all, 2020c).

If we want to look at it in a simplified way, the general features of urbanisation in the 19th century include: the close relationship between industrialization and demographic growth, urban sprawl (spatial expansion and growing development) and the associated disruption of urban fortifications, which in this period completely lost their military significance and increase hygienic standards on the one hand, but reduce the quality of construction on the other. If we want to get a picture of what such a medieval city – completely enclosed between the walls looked like – we don 't have to travel through time. You can just visit the castle of Carcassonne in Southern France (Fig. 2).

Urbanisation is often seen as a negative trend, with negative effects on quality of life and the environment. But flats require much less heat than houses, and commuting by public transport rather than by cars can reduce pollution and energy use, and cities offer improved opportunities for jobs (and often for education and housing as well), so city growth doesn't make everyone unhappy. (Merriam-Webster, 2020a)

This process, called suburbanisation, places increased demands on the occupation of the natural environment and agricultural land. Its transport, engineering and social infrastructure creates much greater energy needs than in traditional concentrated cities.

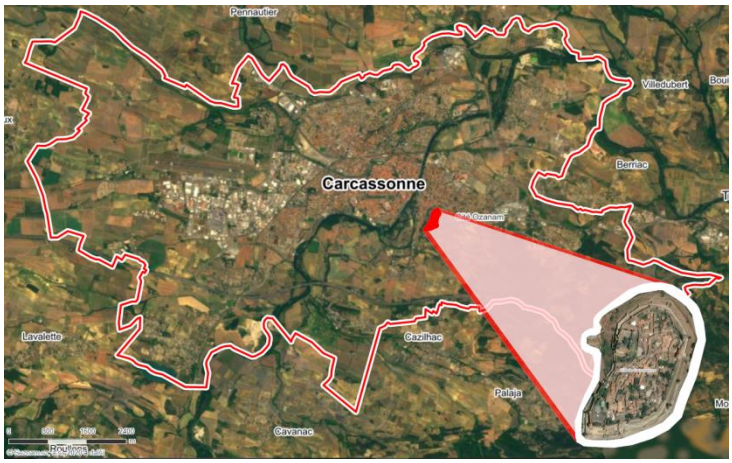


Fig. 1 In urban areas there is great variability of the usage of green infrastructure elements. (picture made by Jiří Kupka, Adéla Brázdová)

This original fortified residence was completely absorbed by the new city during urbanisation. As a result, the greenery, which was once completely accessible behind the walls, gradually receded.

If we want to recapitulate the development of cities in relation to the placement of greenery in cities, we can summarize them in the question: "Where to get a suitable place when there is nowhere to take it?" But before we try to find an answer to this insidious question, we need to think about why we should address the issue of greenery in cities at all and what forms it can take? (Kabish et all, 2016)

Greenery in cities fulfils a number of functions, although at first glance it may not seem so.

Trees filter the air, and thus improve air quality, balance temperature extremes, create oxygen, dampen noise, contribute to the atmosphere of the place, and are often the last remnants of nature in cities. We must also not forget that they are a habitat that allows other organisms to live. For example, a single full-grown tree with a crown diameter of 10 m, sufficiently watered, releases 400 l of water per day by transpiration (evaporation) in the summer and cools it with an output of 20-30 kW. But because such a tree does not grow alone, but rather in a park, for example, surrounded by other trees, shrubs and herbs, rooted in soil in which different species of animals live, it is more accurate to talk about the whole ecosystem.

If trees can perform such functions (and their enumeration was far from definitive), imagine what a whole functional ecosystem can do! Indeed, ecosystems perform a variety of functions, whether they are artificial or close to nature. In this context, we are talking directly about ecosystem services. By ecosystem services, we therefore mean the benefits that ecosystems provide to people free of charge and maintenance-free every day of the year. In general, ecosystem services are divided into four categories: regulating services, provisioning services, cultural services, and supporting services (Fig. 2). Provisioning services are usually the easiest to quantify (for example, food and feed production or soil fertility). It's much more difficult to quantify regulating services working on the principle of a positive and negative feedback (e.g.,

Agglomeration - a large, densely and contiguously populated area consisting of a city and its suburbs.

It is understandable that the development of the current megalopolis (in America, Asia) compared to European cities was completely different. In some cities in Central Europe, for example in the Czech Republic, many municipalities with 2,000 inhabitants also have an urban character, but a population limit to be designated as a town is 5,000 inhabitants. (Merriam-Webster, 2020b)

Greenery in cities can also cause problems for residents. For example, falling oak acorns destroy car bodies, fallen maple leaves need to be removed, and spruce and pine trees obscure the view from the windows. Is the greenery in the city just a "like / dislike" question?

climate or disease regulation) and cultural services (e.g., recreational or relaxation). Supporting services, which are also difficult to quantify, provide a “service” for the good functioning of the previous three categories (e.g., biogeochemical cycles, biodiversity, soil formation, etc.). As this applies to urban areas, it will be more appropriate to use the term urban ecosystem services. (Gómez-Baggethun et all, 2013; Johnston, 2018)

Fig. 2 Butterflies, as pollinators, not only perform an important ecological function, but they are also beautiful (cultural function as aesthetic function); Author: Jiří Kupka)

What do you imagine under the term "urban greenery"? You can probably imagine a park, an alley of trees along the way or you can imagine a green roof. In addition to those large-area types, such as a park or a city meadow, suitable solutions for small spaces are also available. At the beginning of the chapter, it was noted that at this moment we are interested in planting greenery in compact parts of cities, especially in small areas. And in these compact parts of the city, there is an inexhaustible number of suitable places for potential implementation of small-area elements of greenery. For our purposes, the majority primarily serve as what is termed Nature Based Solutions (NBS). As many as 30 types of NBS that could be used as urban greenery have been put together (Fig 3)! If we approach these green elements from the systemic point of view of the city, then we are talking about green infrastructure. Green infrastructure elements can also be combined with water elements (blue infrastructure) (Interreg – Central Europe; Eggermont et all, 2015).

An ecosystem is a system consisting of biotic and abiotic components that function together as a unit. The biotic components include all the living things whereas the abiotic components are the non-living things. In the urban environment, we can exceptionally encounter ecosystems close to nature, but the vast majority of them have the character of man-made artificial ecosystems.

Urban green and blue infrastructure therefore plays a much more important role than an aesthetic aspect or atmosphere of the place (for example, the impact on air quality, soil, water retention).

Nature based solutions are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience.

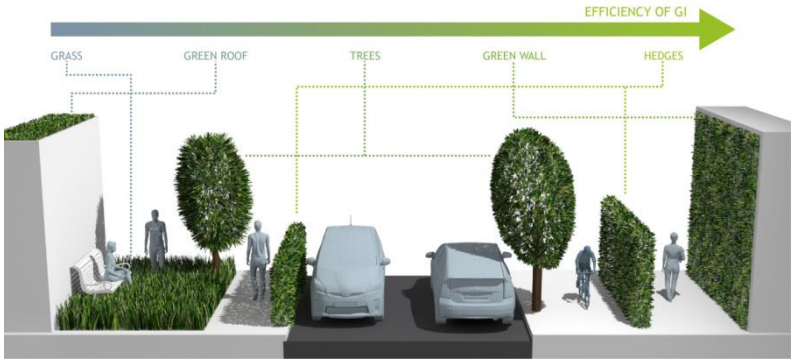


Fig. 3 In urban areas there is great variability of the usage of green infrastructure elements. (picture made by E. Masala)

Part 2: What is Urban Environmental Acupuncture?

We have already said that green areas in the urban structure bring not only the inhabitants of the cities, but also the city itself, number of benefits. In the context of the outlined development of urban centres, we have asked ourselves a key and burning question, where and how to find a suitable place to place new (more) greenery in cities when there is a lack of free space?

The idea of green acupuncture is based on the assumption that the current growth of cities with high population density no longer allows the placement of elements of green infrastructure in the form of larger green areas in the core of cities, such as a park or an urban meadow. However, in exposed urban areas, such as historic squares, we can still find many places suitable for placing small elements of Urban Green Acupuncture (Fig. 4). These places can then be used to increase the attractiveness of abandoned and unused areas. It also follows from the above that Urban Green Acupuncture can become part of a strategy to increase urban resilience to a temperature change (Brázdová et all, 2020c).

Fig. 4 In urban environmental acupuncture it is not the size of the future location that is important, but the functionality of the used elements (picture made by E. Masala).

Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.

The term "Urban Environmental Acupuncture" was inspired by traditional Chinese medicine, in which acupuncture needles are inserted into the so-called acupuncture points of the patient in places of life energy. The term "Urban Environmental Acupuncture" refers to the creation of green spots in city centres, which after applying this method can become a place of real life.

Part 3: Method that Returns Natural Life to Cities

Urban Environmental Acupuncture focuses on places that are neglected, unmaintained, or have lost their original function. Ideally, they do not reach large size (up to 0.2 ha). The challenge lies in places that are considered "ulcers on the faces of cities" and are associated with a reduction in property prices in the area. (O'Brien et all, 2017)

Appropriately applied Urban Environmental Acupuncture then provides a number of ecosystems, sociological and socio-economic services.

A good example of Urban Environmental Acupuncture is the placement of several mobile green walls (Fig. 5) in the city centre for a relatively small amount of money (a lot of bang for the buck) (Brázdová et all, 2020a; Djedjig et all, 2017). In this case, with proper maintenance, the air can be improved, the temperature can be reduced immediately, rainwater management can be improved, and noise can be reduced (Wong et all, 2010; Zhang et all, 2019). Undoubtedly, the aesthetic function of the place will also increase and residents and visitors to the city centre will feel more at ease and safe (Leeuwen, 2006). This measure may also have an economic impact in the form of real estate improvements in the area (Wong et all, 2010; Zhang et all, 2019).

In the application of Urban Environmental Acupuncture, the participation of not only members of the community, who are often the main players, is extremely important. The municipality can create strategic plans and programmes in which the green acupuncture element appears, but only the general public can bring life there (it decides on the result) (Brázdová et all, 2020b). Integral parts are various experts, architects, garden and landscape engineers who are looking for the most suitable solution for the place (Radić et all, 2019). Of course, an intention could not be implemented without investors and their financial resources.

Fig. 5 Mobile green walls – simple, attractive and functional; Author: Adéla Brázdová

The Urban Environmental Acupuncture proceeds methodically according to key steps, which are based on the selection of a suitable area or localities that can be included in the placing greenery in the city programme.

It is always better if the public can actively participate in the creation or design, rather than passively accepting the results of Urban environmental acupuncture (Brázdová et all, 2020).

Summary

An urban space is evolving and undergoing a number of changes in its internal structure. It adapts to the requirements of the population and the needs of society. Urban green infrastructure can be considered as a set of management measures (green management). These measures increase the resilience of urban centres to overheating while taking advantage of the benefits offered by natural ecosystem services. Thanks to the city's green infrastructure, we can make natural conditions accessible to the inhabitants of the city.

Urban green infrastructure is important not only for human well-being, but also for biodiversity in urban areas (Susorova et all, 2013; Elsadek et all, 2019). Thanks to the appropriate location and subsequent maintenance of the green infrastructure, the conditions of urban environment can be improved. At the same time, thanks to the implementation of urban greenery, the value of a given locality may increase in the future. It can be said that urban green infrastructure also plays an important role for urban ecosystem services. The city's green infrastructure uses mainly artificial ecosystems with various combinations of artificial or natural elements. Green urban infrastructure, urban ecosystem services, and urban sustainability are closely linked concepts (Gartland, 2012; Elsadek et all, 2019).

The idea of Urban Environmental Acupuncture is based on the assumption that the current growth of cities with high population density no longer allows the placement of elements of green infrastructure in the form of larger green areas in the core of cities, such as parks or urban meadows. And it's definitely worth it!.

If you'd like to know more

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Videos

Paris agreement simplified: https://www.youtube.com/watch?v=1DdfNU5iATU

What are Nature-Based Solutions?
https://www.youtube.com/watch?v=FCwxzOPnBac

Nature-based Solutions to Cities:
https://www.youtube.com/watch?v=uALbrZXhyxw

Chapter 2 Soil Sealing and Soil Degradation Reduction by application of Urban Environmental Acupuncture solution

Authors: Anna Starzewska- Sikorska, Justyna Gorgoń, IETU - The Institute for Ecology of Industrial Areas

Learning targets

By studying this chapter, you will a get basic understanding of the potentials of urban green spaces to reduce soil sealing and soil degradation. You will also learn about the Instruments for Urban Intervention addressed to Sealed and Degraded Areas. Additionally, information will be provided on points to be considered when preparing an action plan for soil sealing and soil degradation reduction by urban environmental acupuncture.

Keywords

soil sealing, urban areas, urban environmental acupuncture

Part1: Soil Sealing in the EU policy

The general definition of soil sealing in the EU used in the EC documents describes soil sealing as the covering of the ground by an impermeable material. It is one of the main causes of soil degradation in the EU. Soil sealing often affects fertile agricultural land, puts biodiversity at risk, increases the risk of flooding and water scarcity and contributes to global warming. The scale of soil sealing in European cities causes the serious problem of soil loss and loss of fertility. According to the European Environment Agency, since the mid-1950s the total surface area of cities in the EU has increased by 78%, whereas the population has grown by only 33%.

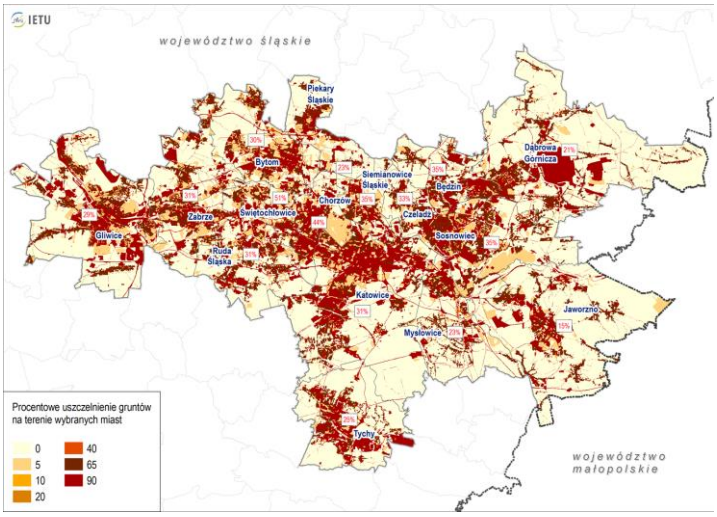

Fig. 1: Soil sealing in the Central Upper-Silesia region (Source: IETU, 2019)

The European Commission points out the need to develop best practices to mitigate the negative effects of sealing on soil functions. Furthermore, the Roadmap to a Resource Efficient Europe (COM (2011) 571) proposes that by 2020, EU policies take into account their impact on land use with the aim to achieve no net land take by 2050. In line with this, in 2011 the European Commission published the report Overview of Best Practices for Limiting Soil Sealing or Mitigating Its Effects in EU-27 presenting land take and soil sealing trends in the EU. The report contains an exhaustive overview of existing Member State policies and technical measures used to reduce and mitigate soil sealing.

On the basis of this report and with the help of national soil sealing experts, European Commission departments have prepared Guidelines on best practices to limit, mitigate, or compensate soil sealing (SWD (2012) 101 final/2). The guidelines collect examples of policies, legislation, funding schemes, local planning tools, information campaigns and many other best practices implemented throughout the EU. They are mainly addressed to competent authorities in Member States (at national, regional and local levels), professionals dealing with land planning and soil management, and stakeholders in general, but may also be of interest to individual citizens.

What steps should countries undertake to follow the EC Guidelines concerning soil sealing?

Part 2: Instruments for Urban Intervention addressed to Sealed and Degraded Areas

The most efficient planning instruments addressed to sealed and degraded areas are related to revitalization processes and urban renewal as well as those which introduce biodiversity in the urban space. De-sealing of sealed soil, as well as creation of new public space, with the application of pro-environmental solutions leads to the increase of biologically active land area, protection of city land, and in the long run, enhanced quality of the entire environment.

Introduction of innovative technical and technological solutions in de-sealing of sealed soil focused on enhancing the environmental comfort and supporting cities in the way of climate mitigation and adaptation to climate changes. Among selected solutions urban acupuncture seems to be one of the most interesting. In the context of urban soil sealing, selected and specific design intervention in the limited location (urban acupuncture) could solve the problems of sealed public squares, marketplaces, courtyards, streets and other public spaces.

Redevelopment and de-sealing of degraded urban land to perform new functions in the city is a good direction for the city and region, as regarding protection of city landscape and open green areas against investment pressure and processes of uncontrolled urban sprawl. This process support development of degraded and post-industrial space for the purposes of nature and recreation, which allows to develop ecosystem-related services and to strengthen biodiversity. These are activities intended to increase the comfort in urban environment and life quality of inhabitants as well as maintenance of biological diversity (Gorgoń, 2017).

Part 3: Ecosystem Services of Soil

It should be emphasized that reduction of soil sealing directly supports the enhancement of the ecosystem services of soil.

Soil is the foundation of terrestrial ecosystems, and the majority of ecosystem services needed for human survival arise from soil (Kibblewhite et al., 2008). Ecosystem services provided by soil can be supporting (e.g., primary production and biodiversity) or regulatory (e.g., erosion control, water infiltration, nutrient retention, atmospheric gas regulation and pest control). By definition, ecosystem services benefit human welfare and represent nature's capital (Costanza et al., 1997; Robinson et al., 2012). For example, the economic value of soil microbial metabolic pathways in removing greenhouse gases from the atmosphere, abating nutrients, eradicating pathogens and degrading organic pollutants has been estimated to be double that of the gross annual product (Guimaraes et al., 2010). Many ecosystem services inherently depend on soil health and biodiversity of the soil biota (Barrios, 2007; Brussaard, 2013). Soil health refers to the capacity of soil to function, to sustain or improve productivity and health of plants and higher trophic levels, as well as air and water quality in natural and managed ecosystems (Kibblewhite et al., 2008).

Soil is important in supporting ecosystem services such as: climate change effects reduction (open soil in urban areas), appropriate quality of soil can provide ecosystem services concerning food provision.

Part 3.2: Review of NBS in the SALUTE4CE project

One of the mitigating measures of soil sealing is de-sealing connected, among others, with providing for suitable areas of green space in urban regeneration activities.

Nature-based solutions (NBS) applied in implementation of urban environmental acupuncture (UEA) can directly have an impact on soil sealing reduction. Analysis of technical solutions in selected NBS indicates the use of soil on a site where an UEA intervention is to be applied. It is often connected with the necessity of de-sealing. The significant impact of these activities is visible in case of a dense distribution of UEA sites.

Further analysis of NBS proposed in the SALUTE4CE project as suitable ones for application in UEA shows that selection of NBS which can have a significant impact on reduction of soil sealing can be performed in two stages:

1. From the total of 30 NBS we can exclude these which consist in vertical solutions or solutions installed on roofs as these do not entail using soil on the ground which is connected with reduction of soil de-sealing.
2. From the remaining 18 NBS we mark out those which are connected with blue infrastructure development: rain gardens, road-side swales, linear wetlands.

3. A total of 15 NBS can be assessed as strongly, moderately, or weakly contributing to reduction of soil sealing. The table below shows the results of the assessment (the numbers are coherent with the project table of all NBS).

Table 1: Assessment of NBS impact on soil sealing reduction

NBS name	NBS definition	Impact		
		strong	me-dium	low
Urban meadows	Multi-species plant community of native herbaceous plants in the form of mesotrophic or dry meadow, created in urban space	x		
Verges/flower beds with native perennials	Roadside linear features (verges) or patches (flower beds) of green space of reduced maintenance activities, sown with a wildflower-rich grassland seed mix, to provide nectar and pollen to attract foraging insect pollinator species	x		
Ground cover plants	A patch of low vegetation usually one species (perennials or low shrubs), of reduced maintenance activities, tightly and permanently covering bare earth	x		
Lawn	An area of soil-covered land, planted with grasses, which are maintained at a short height and used for aesthetic and recreational purposes	x		
Green pavements	Pavement with soil-filled gaps, with filter properties and with specific creeping grass species with a short growing and minimum maintenance			X
Street trees	Trees grown and planted in a manner consistent with the standards for street trees	x		
Park trees	Trees planted in green (greened) areas other than traffic areas or town squares		x	
Fruit trees/ shrubs	Trees or shrubs grown for edible fruit or seeds		x	
Large shrubs	Shrub species / varieties growing up to a height exceeding 2 m		x	
Natural pollinators' modules	Terrestrial micro-habitat (10-20 m^2) designed to attract pollinators (and biodiversity in general), consisting of plants, water source, housing for biodiversity, and site furnishing			x
Hedges/hedgerows	A line of shrubs maintained to form a physical boundary (a hedge), in association with other flora and physical features (a hedgerow)		x	
Rockery	Small garden constructed with aesthetically arranged rocks / stones, with small gaps between in which small plants are rooted			x

NBS name	NBS definition	Impact		
		strong	me-dium	low
Herb spiral	Small garden constructed as a raised, cone-shaped spiral bed, incorporating multiple levels, designed to provide herbs with a variety of growing conditions.			x
Urban wilderness / succession area	A patch of vegetation in the urban tissue, where spontaneous but controlled succession takes place, and maintenance activities aim to ensure the sustainable provision of ecosystem services by a multi-species, self-supporting plant community	X		
Ground crops of vegetables / herbs	A small garden constructed for soil cultivation (patches, containers) of vegetables / herbs		X	

Summary

Soil sealing is becoming an increasingly serious problem in urbanized areas, as much of Europe can be categorized. Therefore, the problem of soil sealing has been indicated in many documents of the European Commission and numerous studies and scientific articles. The most efficient instruments addressing sealed and degraded areas are related to revitalization processes and urban renewal as well as those which introduce biodiversity in the urban space. De-sealing of sealed soil, as well as creation of new public spaces, with the application of pro-environmental solutions leads to the increase of the biologically active land area, protection of city land, and in the long run, enhanced quality of the entire urban environment and improvement of quality of life. In the context of urban soil sealing, urban acupuncture seems to be one of the most interesting solutions. Urban acupuncture is an excellent tool for activating local communities. Residents can join the processes of designing and arranging courtyards, inter-block spaces, and streets. In these small spaces solutions, such as pocket parks, green walls and roofs, city meadows, and many others can be used..

If you'd like to know more

See videos and a reference list below!

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Videos

More about soil:

https://www.youtube.com/watch?v=hbdsHOnd_gw

Chapter 3 Urban Environmental Acupuncture as One of the Solutions for Reduction of Heat Stress in Urban Space

Authors: Juliane Mathey, Jessica Hemingway, Leibniz Institute of Ecological Urban and Regional Development (IOER), Dresden

Learning targets

By studying this chapter, you will a get basic understanding of the potentials of urban green spaces to reduce urban heat stress. You will also learn about the cooling effects of different green space types in the course of the day. Additionally, information will be provided on points to be considered when preparing an action plan for heat stress reduction by urban environmental acupuncture.

Keywords

urban environmental acupuncture, urban heat stress, heat stress reduction, adaptation to climate change, urban adaptation strategies, green space planning, urban greening

Part 1: Introduction — Urban Heat Stress and Climate Change

Urban areas suffer from special climatic conditions: The phenomenon of the urban heat island (UHI) is characterized by dryness, heat, and lower wind strengths compared to the rural surroundings (Arnfield 2003). Densely built-up and sealed areas (Fig. 1) are heat stores emitting heat to their surroundings, which is especially notable at night with negative influences on human health (Lehmann et al. 2014).

In large cities, heat islands with “tropical nights” above 20°C make it difficult to have the necessary recovery from the heat stress of the day. The sleep can be affected negatively, which may pose health hazards (Höppe 1999). Vulnerable people such as elderly people, sick persons, and young infants (toddlers) are thus exposed to higher health hazards (Scherber et al. 2013). The urban heat island and extreme heat events can increase heat-related morbidity and mortality (Endlicher et al. 2016).

Have you ever thought about what this means for residents?

Perhaps you remember that the 2003 summer heat wave during August caused 35,000 heat-related deaths across Europe (Larsen 2006).

Fig. 1: Densely built-up district (Photo: R. Bendner)

It is expected that climate change will exacerbate these conditions, in particular heat waves with higher frequencies and duration (Endlicher et al. 2016, Baldwin et al. 2019) intensifying heat-related health problems (e.g. Pace et al. 2020). A sustainable urban development must deal with these foreseeable effects.

Part 2: Urban Environmental Acupuncture against Heat Stress

Part 2.1: Temperature Regulation by Urban Green Spaces

Urban green spaces (Fig. 2) are one option that can help to reduce heat stress in cities/FUA (Functional Urban Areas). They affect microclimate in a magnitude of ways. For example by regulating temperature, increasing humidity and improving air circulation (Gill et al. 2007, 2009, Bowler et al. 2010), they can positively influence the health and well-being of residents (Li & Mathey 2017). This is due to vegetative shade, evaporative cooling and low heat storage (from daytime irradiation) that they provide. The cooling effect of urban green spaces is much higher than that of their built-up surroundings, especially in the evening and at night (Mathey et al. 2011).

Fig. 2: Shade offered by trees (Photo: R. Bendner)

Perhaps you are now asking yourself: What can be done to reduce heat stress in urban areas?

Urban green spaces have beneficial cooling effects on the urban thermal environment (Bowler et al. 2010). Within tree-covered green areas the air humidity is 5-7% higher than in the surrounding area; in wooded areas and areas with larger plant stands it can increase by up to 30% compared to the open area up to a distance of 500 m (Pfützner in Greiner & Gelbrich 1972)! The wind speed in green areas tends to be reduced by an average of 0.8 m/s in comparison to built-up areas (Greiner & Gelbrich 1972). In the summer months, plant stands, especially leaves, can reduce wind speed by an average of 20-30% (Kuttler 1998).

Thus, their climate-regulating and positive bioclimatic effects offer important starting points for urban environmental acupuncture to reduce heat stress and for planning cities adapted to climate change (e.g. Rößler 2015). Vegetation can also play an important role in climate mitigation by acting as a temporary CO_2 sink to reduce greenhouse gases or by using shady trees, greened walls or roof-top greenery to help contain energy consumption by cooling buildings (Gill et al. 2007).

With regard to the climatically relevant functions of individual green spaces it is to be distinguished between effects within the area (PCI = Park Cool Island), their effects on the environment (Parkbreeze) and continuing wind-driven air mass transport (Bongardt 2006).

Part 2.2: Cooling Effects of Different Vegetation Structures

But green is not equal to green. Different types of green and green structures vary considerably in their impact on air temperature (Li & Mathey 2017, Jiang et al. 2020). The micro-climatic situation in green spaces (PCI) is largely determined by the proportion of sealed areas, the vegetation inventory, the proportion of green cover, the vegetation structure and the specific green volume (Cheng et al. 2015).

The results of micro-climate modelling indicate that on a hot summer's day the average cooling effect of small green spots of size 1 ha (at a height of 1.2 metres), compared to a fully sealed asphalted surface, ranges between 0.1 K and 2.1 K over the course of the day (Fig. 3). Whilst green sites featuring young trees and partly dense woodland can achieve an average cooling effect of up to 2.1 K (Fig. 3, type 3), large grassy areas provide only 1.0 K cooling (Fig. 3, type 1). However, healthy grassy areas are still better than dry lawns that provide a similar daytime climatic effect to that of sealed areas (Mathey et al. 2011).

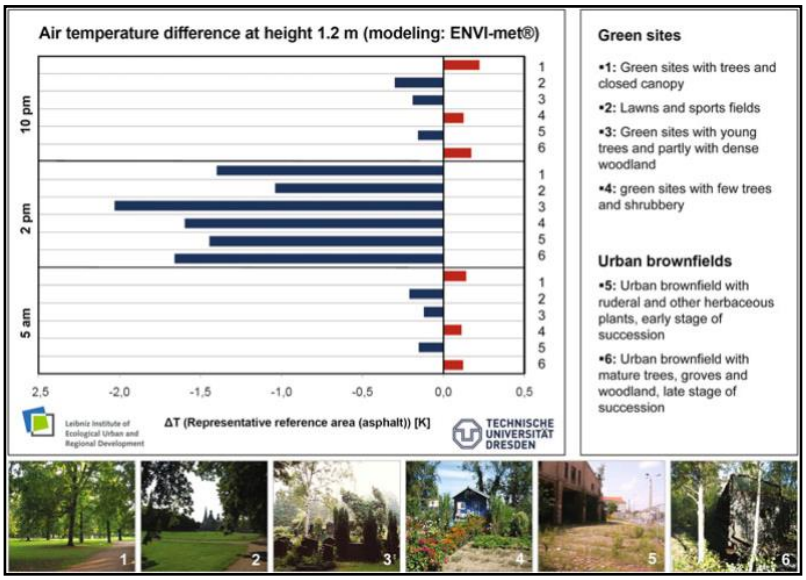

Fig. 3: Microclimatic effects of selected urban green space types in Dresden (Germany) at 5 am, 2 pm, and 10 pm (modelled by ENVI-met®, Bruse and Fleer 1998, modified after Mathey et al. 2015). © S. Rößler (Photo 1); R. Bendner (Photo 2, 4, 6); S. Stutzriemer (Photo 3); B. Kochan (Photo 5)

The regulative effects of various types of urban green spaces vary over the course of the day (Fig. 3). In the daytime, the lowering of temperatures in urban green spaces is especially perceptible in areas covered with trees. While open unsealed sites such as lawns and meadows (Fig. 3, type 2) generally have a high cooling potential during the night, dense woodland (Fig. 3, type 1) can prevent surface cooling after sundown (Mathey et al. 2011). Overheating additionally can be lowered by greened walls (Fig. 4) as well as by roof-top greenery/roof gardens, which have climate regulation effects and thus the potential to reduce energy consumptions by reducing the need for air conditioning (Mathey et al. 2017). The shade provided by trees along roads, cycle paths and footpaths (avenues) as well as by pergolas is very important in reducing heat stress and increasing the quality of life in public spaces.

Fig. 4: Green wall (Photo: R. Bendner)

Part 2.3: Proportion and Distribution of Green Spaces in the City/FUA

In addition to vegetation coverage and vegetation structure, the size of a single urban green space is of importance with regard to their potential for temperature reduction. Perceptible climatic effects are described for urban green spaces from a size of 1 ha (Stülpnagel in Gill et al. 2007). According to Sperber (2007), a measurable and perceptible area internal climate develops in a compact green area with a size of 2 ha, a maximum degree of soil sealing of 25 % and a grove-like population of old deciduous trees (crown cover of 60%) and shrub groups. Normally, large urban green spaces (over 40 ha) provide higher cooling effects than small ones. The doubling of the area causes a temperature reduction of 1 K; higher enlargement of the area can reduce the temperature between 1.5 K and 3 K. And the larger an individual green space, the longer the distances that can be overcome by the cooling effects. However, the climatic sphere of action of most urban green spaces ends, without influence of the topography, usually at distances of about 200–300 m (Stülpnagel 1987). Nonetheless the sphere of action of a green space does not grow proportionally to the size of the area. This explains why smaller green spaces (Fig. 5) are sometimes more effective than larger ones (Scherer 2007).

Fig. 5: Shade on small green spot (Photo: R. Bendner)

However, also individual trees can evaporate up to 500 litres of water per day, if provided with an appropriate water supply, thereby reducing the perceived temperature in its shade by 10°C to 15°C (Gillner et al. 2014). For example, a birch tree evaporates far more than 100 litres of water per day in high heat, a spruce only about 10 litres (Gretz & Prähofer 2019).

Generally speaking, tree species with low water requirements (e.g. rubies) cool better on hot days than tree species with dense leaf cover and high water requirements (e.g. lime trees), which cool more effectively on mild summer days (Trautmann 2019).

In most cities/FUAs, predominantly smaller green spaces (parks 5 to 15 ha) can be found (Bongardt 2006). Therefore, the well-known climatic effects of these smaller (inner) urban open spaces make them a key field of action for heat stress reduction and climate adaptation. The obvious advantage of large green spaces is put into perspective when one considers that smaller and well-distributed green

What do you think: Are there differences in cooling effects between tree species?

spaces can be reached more quickly and easily from neighbouring residential areas. This makes it easier for residents to avoid the heat stress by only walking short distances (Mathey 2011). **Keep in mind** that the vegetation within the built-up areas contributes to the provision of climatic regulation effects. In addition, the conservation of spontaneous vegetation and the greening of urban wastelands support heat reduction (Mathey et al. 2015). In this context, small green spots with as few sealed areas as possible and a diverse vegetation structure with varying shrub and tree heights can be assessed as microclimatically favourable (Mathey et al. 2011).

In addition to the effects of individual green spaces, the interaction of all green spaces in a city/FUA is also of climatological importance. The cooling effect of a green space system depends on the size, distribution and connectivity/interlinkage of green spaces (Mathey et al. 2011). The higher the proportion of vegetation-covered areas is in a city/FUA, the higher the green volume and consequently also the cooling effect (Fig. 6) (Mathey et al. 2011).

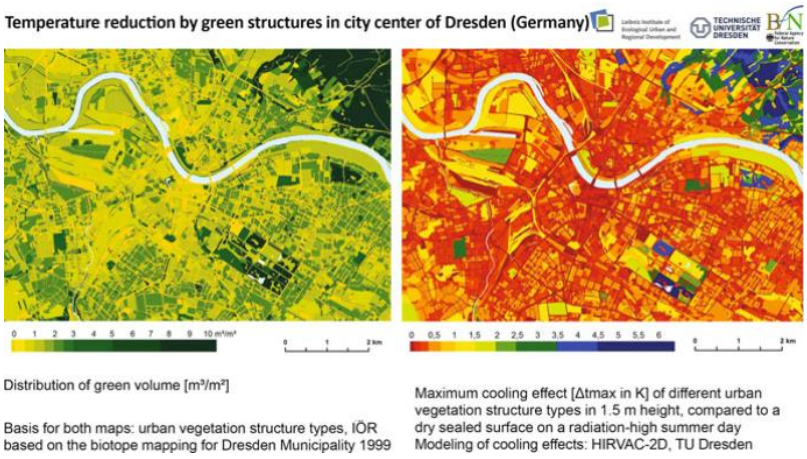

Fig. 6: Distribution of green volume (left) and maximal cooling effects (right) on a summer day with high radiation in Dresden (after Mathey et al. 2011, modified)

Part 2.4: Additional Things to Consider

Climate change will also have an impact on the biodiversity of urban areas, affecting the quality of green systems which may lead to changes in species composition and in vegetation structure, thereby undermining the vital role which such vegetation plays in providing those ecosystems services such as reducing heat stress (Roloff et al. 2007, Bowler et al. 2010).

The climatic impact is reduced if the green space is situated lower than the surrounding area, if it is bordered by walls or dense edge planting, or if it is surrounded by a dense building structure (Mathey et al. 2011).

Natural or artificial water bodies can be part of urban open spaces. The water surface, which is generally cooler than the surrounding area, leads to a so-called "oasis effect". The boundary effects of water bodies can be very different for example, lake banks rich in vegetation lead to an increase in humidity; riversides can carry water-near layers of air in the direction of flow. Making, larger rivers important in cold airways circulation within cities (Kuttler 1998).

That is why it makes sense to start with urban environmental acupuncture even on small spots in built-up areas.

What do you think: Are there differences in cooling effects between tree species?

Part 3: Conclusions for Urban Environmental Acupuncture Concepts

Part 3.1: Planning Aspects

When developing urban environmental acupuncture concepts to combat heat stress in urban areas/FUAs the following should be taken into account (Mathey et al. 2011):

According to the planning goals consider what climatic effects are wanted at particular points in the urban fabric and whether the cooling effects are wanted by day or night. This will greatly depend on the function and use of each space. For example, the shade offered by vegetation is in high demand during hot summer days.

The distribution of green spaces across the city influences the effects that can be attained on the climate. A fine-grained, tightly knit and richly structured green-space system in the built-up area supplemented by open cold air corridors from peripheral areas can affect the microclimate of the entire city area/FUA. It is important that cold airways be kept free from higher vegetation or hedges and rows of trees should be arranged as parallel to the flow as possible, following the gradient.

The higher the proportion of strongly vegetated urban green space types in the urban area/FUA the better will be the impact on the urban climate.

The climatic effects of green spaces are directly related to the respective area sizes. The larger an area, the stronger usually is its area interior climate, but measurable temperature reductions within individual green spaces can already be observed in areas smaller than 1 ha.

However, for the potential reduction of heat stress, the structure of vegetation and the characteristics of each space are even more important than their size. The higher the green volume, the higher the cooling effect during the day. Please note, this must be considered in a differentiated way, since, for example, the vegetation structure (e.g. crown closure of trees) and the position in relation to the main wind direction also play a role in air exchange.

The impact of urban green spaces and vegetation structures on the climate depends on the time of day. The frequently encountered design of green spaces with a variety of trees, shrubs and large proportion of meadows or lawns usually causes both, cooling at night as well as reducing the heat load during the day (Pauleit 2011).

Trees along roads, cycle paths and footpaths as well as pergolas are very important for reducing heat stress and increasing the quality of life in public spaces. Overheating can also be reduced by greened walls and roof-top greenery/roof gardens.

In the future, it will be increasingly important to be careful selection of plants/trees according to their ability to cope with drought and high temperatures (Roloff et al. 2008, Gillner et al. 2014). Sometimes even non-native plants may be the suitable choice (GALK 2011).

What conclusions can you draw for your individual urban environmental acupuncture concept?

Of importance are also the management of green spaces. For example, ecological potential is closely linked to the availability of water. This must be assessed critically, especially in view of the expected water scarcity caused by climate change (Gill et al. 2007, Mathey et al. 2011).

And natural or artificial water bodies as well as rain gardens can contribute reducing heat stress.

Finally, the development of urban environmental acupuncture concepts must also be viewed in relation to other challenges of urban development. In addition to potential synergies, there exist sources of conflict regarding the aims of green space development in the city/FUA (Mathey et al. 2011). These can involve questions of mitigation and adaptation to climate change, sustainability and biodiversity (Wende et al. 2010).

On the basis of the above-mentioned points, you should decide at which point in the urban fabric (i.e. location)/UFA and which NBSs (Nature Based Solutions: e.g. urban meadows, green pergolas, vertical gardens, street trees, rain gardens) are suitable with consideration of the urban environmental acupuncture concept?

Part 3.2: Review of NBS in the SALUTE4CE project

Review of NBS in the SALUTE4CE project

In the SALUTE4CE project 30 nature based solutions (NBS) were found to be suitable for the implementation of urban environmental acupuncture (UEA). But green is not equal to green. Different types of green and green structures vary considerably in their impact on air temperature (see above). So all 30 NBS had been analysed concerning their respective cooling effects (reduction of urban heat stress), shown in table 1.

Table 1: Cooling effects of nature based solutions (NBS) suitable for urban environmental acupuncture (UEA)

NBS name	NBS definition	Impact		
		strong	me-dium	low
Urban meadows	Multi-species plant community of native herbaceous plants in the form of mesotrophic or dry meadow, created in urban space		X	
Verges/flower beds with native perennials	Roadside linear features (verges) or patches (flower beds) of green space of reduced maintenance activities, sown with a wildflower-rich grassland seed mix, to provide nectar and pollen to attract foraging insect pollinator species		X	
Ground cover plants	A patch of low vegetation usually one species (perennials or low shrubs), of reduced maintenance activities, tightly and permanently covering bare earth		X	
Lawn	An area of soil-covered land, planted with grasses, which are maintained at a short height and used for aesthetic and recreational purposes			X
Green pavements	Pavement with soil-filled gaps, with filter properties and with specific creeping grass species with a short growing and minimum maintenance			X

NBS name	NBS definition	Impact		
		strong	me-dium	low
Street trees	Trees grown and planted in a manner consistent with the standards for street trees	X		
Park trees	Trees planted in green (greened) areas other than traffic areas or town squares	X		
Fruit trees/ shrubs	Trees or shrubs grown for edible fruit or seeds	X		
Large shrubs	Shrub species / varieties growing up to a height exceeding 2 m	X		
Rain gardens (under-drained)	Shallow basin filled with porous soil mixture and covered with native vegetation capable of phytoremediation, designed for retention, treatment and infiltration of storm-water		X	
Road-side swales for retention and infiltration	Grassed open channel designed for reduction runoff volume as well as retention, treatment and infiltration of storm-water		X	
Linear wetlands for storm-water filtration	Shallow, linear basin with impervious bottom, filled with porous soil/gravel mixture and covered with native vegetation capable of phytoremediation. Designed for treatment and filtration of storm-water through surface and subsurface flow		X	
Natural pollinators' modules	Terrestrial micro-habitat (10-20 m^2) designed to attract pollinators (and biodiversity in general), consisting of plants, water source, housing for biodiversity, and site furnishing			X
Hedges/hedgerows	A line of shrubs maintained to form a physical boundary (a hedge), in association with other flora and physical features (a hedgerow)	X		
Rockery	Small garden constructed with aesthetically arranged rocks / stones, with small gaps between in which small plants are rooted			X
Herb spiral	Small garden constructed as a raised, cone-shaped spiral bed, incorporating multiple levels, designed to provide herbs with a variety of growing conditions.			X
Urban wilderness / succession area	A patch of vegetation in the urban tissue, where spontaneous but controlled succession takes place, and maintenance activities aim to ensure the sustainable provision of ecosystem services by a multi-species, self-supporting plant community	X		
Ground crops of vegetables / herbs	A small garden constructed for soil cultivation (patches, containers) of vegetables / herbs		X	

NBS name	NBS definition	Impact		
		strong	me-dium	low
Vegetated reinforced soil slopes with green fences	A fence out of wood, covered with climbers and shrubs, situated on vegetated reinforced soil slope (VRSS), functioning as both green safety elements and biodiversity habitat, separating the space for pedestrians or cyclists from the river / ditch.		X	
Green pergolas/ green arbours	A structure supporting vines or climbing plants, creating a shaded or semi-shaded space. It is identified by having two or more posts or columns and an open roof. Can be freestanding or attached to a building.	X		
Green facades with climbing plants	A wall completely or partially covered with greenery (twining or clinging self-climbers). It can use a trellis system to hold the plants that are rooted in the ground or containers.	X		
Wall-mounted living walls	Structures (continuous or modular) containing organic or inorganic growth media in which plants are rooted, attached to concrete walls. Water and nutrients are supplied using an automated irrigation system).		X	
Hydroponic mobile living walls/vertical gardens	Self-supporting constructive system based on metallic structure equipped with waterproof layer, hydroponic textile substrate for vegetation growth, water collection system and automated irrigation system.		X	
Vertical vegetable / herb gardens	Vertical free-standing or wall-mounted structures for growing vegetables or herbs outdoors		X	
Hanging wall planters (as green street furniture)	Baskets, flower pots, boxes, etc. with decorative perennials, hung on walls, posts, fences, sheds, balustrades, etc.			X
Compacted pollinators' module	Micro-habitat (4-5 m^2) created in a planter with impervious bottom, designed to attract pollinators (and biodiversity in general), consisting of plants, water source, housing for biodiversity, and site furnishing			X
Rain gardens in planter (=self-contained)	A crate/pot with impervious bottom, filled with porous soil mixture and covered with native vegetation capable of phytoremediation, designed for retention and filtration of storm-water			X
Street planters (as green street furniture)	Free standing planters of various shapes, sizes, made of various materials, e.g. wood, concrete, metal, recycled plastic, fiberglass. Not only perennials, but also bushes and trees can be planted in street planters			X

NBS name	NBS definition	Impact		
		strong	me-dium	low
Green covering shelters	Very light type of green roof covered with very light, thin substrate and small vegetation. Installed on small or big coverage infrastructures, like bus shelter or existing covering shelters.		X	
Green roof/ roof terrace	External upper covering of a building which the main objective is to favour the growth of vegetation. Consists of several layers ensuring water tightness and resistance to the penetration of roots as well as allowing the correct development of the vegetation	X		

Part 4: Good Practice Examples for Environmental Acupuncture Concepts

Part 4.1: HeatResilientCity (HRC – Heat resilient development of cities and urban districts – knowledge generation with a focus on local residents and implementation in Dresden and Erfurt) (Germany): Financed by the German Federal Ministry of Education and Research (BMBF) HRC develops and implements innovative, socially just and user accepted adaptation measures to reduce the summer heat load of people in buildings and open spaces. The research network analyses the existing conflicts, increases the acceptance of climate adaptation measures, reduce implementation barriers to make a contribution to sustainable urban development. Example quarters in Dresden and Erfurt serve as real-life laboratories (HRC o. J.).

Part 4.2: REGKLAM (Development and Testing of an Integrated Regional Climate Change Adaptation Program for the Model Region of Dresden) (Germany):

The German Federal Ministry of Education and Research (BMBF) supported seven regional projects via the federal KLIMZUG initiative. This has resulted in the creation of regional adaptation strategies throughout Germany. The IOER was head of the project called REGKLAM. Through REGKLAM many facets of climate change adaptation were examined including anticipated climate change in urban areas; impacts to social and industrial sectors as well as potential solutions, adaptation innovations and stakeholder involvement. For more information see REGKLAM (2013).

Summary

Urban green spaces assume a crucial role in view of its potential to regulate the urban climate. The impacts of urban vegetation include lowering temperatures, increasing atmospheric humidity, and influencing air circulation. But green is not equal to green. Different types of green and green structures vary considerably in their impact on air temperature. Their microclimatic regulation potentials are largely determined by the proportion of sealed areas, the vegetation inventory, the proportion of green cover, the vegetation structure and the specific green

volume. On a hot summer's day, the average cooling effect of small green spots of size 1 ha, compared to a fully sealed asphalted surface, ranges between 0.1 K and 2.1 K over the course of the day. Whilst green sites featuring young trees and partly dense woodland can achieve an average cooling effect of up to 2.1 K and large grassy areas provide only 1.0 K cooling. In the daytime, the cooling effect in urban green spaces is especially perceptible in areas covered with trees.

Consideration of different planning goals is important in deciding what climatic effects are required at particular points (i.e., locations) in the urban fabric/FUA and whether the cooling effects that can be achieved by day or night. This depends strongly on the functions and uses of the green spaces in question. The following theses can be formulated for urban environmental acupuncture (UEA) that takes adequate account of the need to reduce heat stress: (1) A richly structured green-space system in built-up areas supplemented by open cold air corridors from periphery can affect the micro-climate of the entire city/FUA. (2) The higher the proportion of strongly vegetated urban green spots the better will be the impact on the urban climate. (3) The larger a single area, the more distinctive the internal climate will generally be. Nonetheless areas smaller than 1 ha in size can measurably reduce the temperature. (4) The structure and specific nature of vegetation in a given green spot has a strong influence on the potential for climate regulation. (5) The highest cooling effects can be reached in green spots when the proportion of soil sealing is low and the vegetation structure is heterogeneous, featuring grassland, bushes, as well as small and high trees. (6) The impact of vegetation structures on the microclimate depends on the time of day. While open unsealed sites such as lawns and meadows generally have a high cooling potential during the night, dense woodland can prevent surface cooling after sundown. (7) Trees along roads, cycle paths and footpaths are very important for reducing heat stress and increasing the quality of life in public spaces. (8) Overheating can also be reduced by greened walls and roof-top greenery. Particular consideration has to be requirements in terms of maintenance.

The above-mentioned points shall help to decide at which point in the urban fabric/UFA which NBSs (Nature Based Solutions) are suitable in terms of an urban environmental acupuncture.

If you'd like to know more

See videos and a reference list below!

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Videos

Chicago Fights Extreme Urban Heat With Greener Ideas (i.e. roof gardens): https://www.youtube.com/watch?v=ukGN4PyeNoU

Esterhazypark: Cooling Park in Wien (Austria): https://www.facebook.com/w24TV/videos/wien-bekommt-ersten-cooling-park/816304518807715/ (in German only)

Urban Cooling in Canoga Park (several videos: mobility and green): https://altago.com/urbancooling/

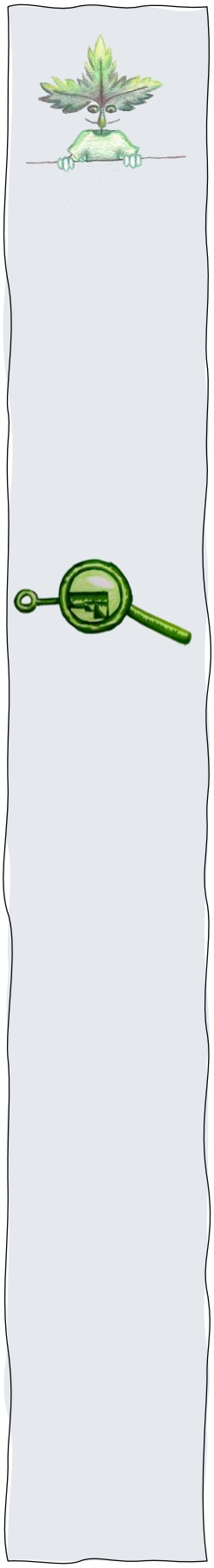
Singapore: biophilic city (green space, urban policy): https://www.youtube.com/watch?v=XMWOu9xIM_k

3 Cool Ways to Cool Our Cities (ideas for urban design): https://www.youtube.com/watch?v=V4Y7VYVVD68

Climate Watch Shorts: Urban Heat Island Effect: https://www.youtube.com/watch?v=EtO0qRiZcNA

Sponge City, Making Berlin Cooler: https://www.youtube.com/watch?v=_elnqk_GQgU

Chapter 4 Possibilities of application of Urban Environmental Acupuncture in Reducing Problems with Rainwater in the Urban Space



Authors: Barbara Vojvodikova, Božena Schejbalova, IURS - Institute for Sustainable Development of Settlements

Learning targets

This chapter focuses on the behaviour of storm water in an urban area. Students will learn basic information about the types of rainwater runoff. They will learn what happens to water in an urban space. And above all, they will learn about the possibilities of reducing storm water problems in the urban space, and how the Nature Based Solutions can be applied here.

Keywords

runoff, infiltration, retention, evaporation

Introduction

Urban development was inextricably linked to water. Drinking water is essential for life; water and watercourses are used for propulsion or in a sewerage system; rivers form a transport system, and water can also form a defensive wall. Water can also be the destroyer and destroy everything. "Water is an irreplaceable helper, but a bad master." Water in an urban environment must be taken care of, all the more so because people have changed its natural state.

Part 1: A Little Theory about the Behaviour of Rainwater

Runoff refers to fast runoff components. It consists of surface and mostly hypodermic runoff. Direct runoff is often defined as that part of the precipitation or melting of snow which flows relatively quickly from the surface or subsurface into a stream. (Garvin et al. 2007)

It consists of two components:

- surface runoff;
- hypodermic outflow (interflow / subsurface runoff).

Hypodermic runoff is a component of runoff that represents the outflow of seeping gravitational water in the upper subsurface layer of soil or subsoil into a stream without reaching the groundwater level.

Surface runoff has two different types, depending on the conditions under which it arises (see Fig.1):

a) Exceeding of the infiltration capacity occurs in conditions where the soil is not yet saturated. The water content of the soil is not significant here – the soil can be very dry. Crucially, the intensity of precipitation or melting snow exceeds the rate of water infiltration. Exceeding soil infiltration capacity (Horton runoff).

Horton runoff occurs when the intensity of rain exceeds the infiltration capacity of the soil. A thin layer of water forms on the surface followed by the movement of water down the slope. At this point, it is necessary to create the possibility of retention to slow down and possibly weaken the effect. Running water naturally accumulates in surface depressions. If we create these depressions, we intensify the positive effects. After filling the retention points, overflow occurs. In the landscape, the surface runoff passes into grooves and streams, which merge into other streams; the runoff accelerates, and the level in the recipient increases rapidly. In an urban environment, water can flow into buildings and cellars, and flood roads.

b) Achieving the saturation state means filling the entire free space for water in the upper soil profile. The water has nowhere to infiltrate and flows down the surface. Surface runoff in such situations can occur even in soils infiltration capacity of which is very high.

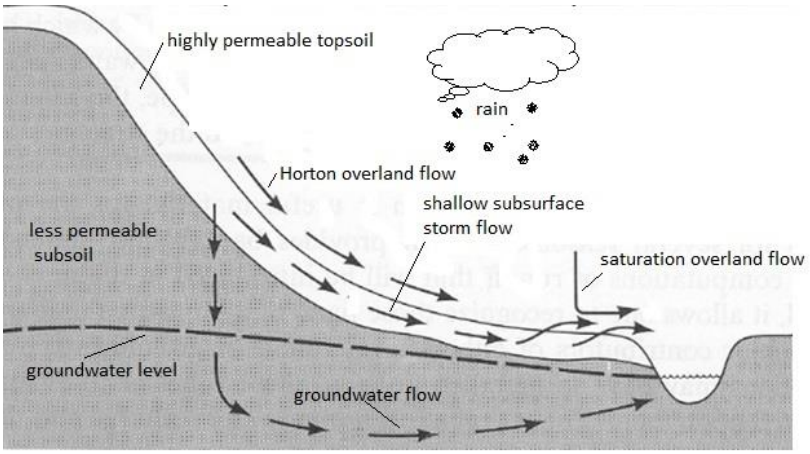


Fig.1: Outflow from the surface at the time of precipitation (on the background of figure from Water in Environmental Planning, Dunne and Leopold, 1978 modified by B. Vojvodíková)

Infiltration is the movement of water in the direction of the earth, which takes place in the upper part of the earth's surface (mostly soil). It is a complex process in which water permeates not only the soil pores, but above all uses various gaps and cracks in the earth's surface (so-called preferential paths). (Ferré and Warrick, 2005).

Infiltration intensity is the amount of water that infiltrates from the surface into the soil over time. It is expressed as the height of the water column over a period of time

Infiltration capacity is given by the maximum possible intensity of infiltration and percolation. It is expressed as the height of the water column over a period of time.

If the intensity of precipitation is less than or equal to the infiltration capacity,

Why infiltration is important to us?

Do you know why water can run off the surface even when dry?

there is no surface runoff.

If the intensity of precipitation is greater than the infiltration capacity, surface runoff will occur.

Surface runoff is equal to the difference between the intensity of rain (snow melting) and infiltration capacity.

During rainfall, the behaviour of water changes depends on many factors. On the one hand, it is the actual rain intensity. On the other, it is the rain length and how the soil was saturated before the start of rain. (Biswas and Uitto,1999).

Part 1.1: Runoff Processes in Urban Areas

In an urban environment, surface treatment changes the type and size of runoff processes during urbanization. Covering parts of the soil with impermeable layers increase the volume and velocity of Horton's ground flow. Gutters and storm-drains quickly drain water into sewers. Thanks to the straightening of watercourses and the smoothing of riverbeds, the flow is accelerated. However, this can lead to rapid drainage of water from the city and reduce the possibility of infiltration, but also to overloading bridges and culverts. (Odtokové procesy (Run off processes)

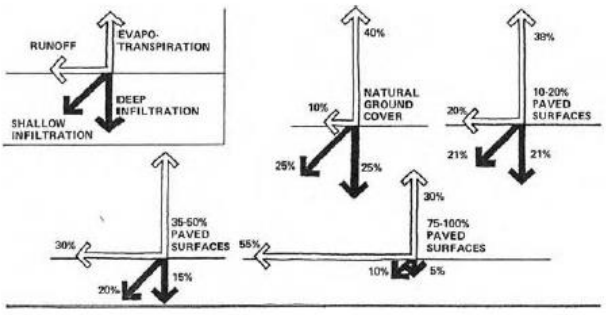


Fig. 2: Typical hydrogram of change due to an increase of impermeable surfaces (Source: Tourbier and White, 2007)

In the natural landscape (Fig. 2), 50% of water is infiltrated and part of it also subsidizes the saturated zone. Water from the saturated zone can also be used to supply wells. In a densely built-up area, only 15% of water is absorbed, which can also lead to a decrease in the groundwater level. The evaporation decreased from 40% to 30%. Runoff increased from 10% to 55%. (Tourbier and White, 2007)

We have three main tasks: To strengthen infiltration to improve evaporation, to slow down and ensure retention of water flowing off the surface.

Part 2: What We Can Do with Rainwater in an Urban

Environment — Infiltration and Retention

Today, the drainage by rain into a (uniform) sewerage system is often used - we quickly drain water out of the territory. As a result of such a solution, during heavy rains, the sewerage capacity is exceeded; the waste-water treatment plants are overloaded. Therefore, our task is to retain water in the area and slow down the outflow. (Biswas and Uitto,1999) A possible solution is therefore to create storage tanks. From those tanks, water can be used for other uses. We can also build a tank with the possibility of infiltration.

We build these tanks as underground or above-ground.

Tanks for further use are equipped with dirt filters, overflow into sewers, and are impermeable. For further use of water, they are equipped with pumps and connected to the building. When building these devices, it is necessary to pay attention to the technical design and prevention of uncontrollable movement of water towards the building and thus its possible damage. Furthermore, when using water for internal distribution, rainwater must be separated from the drinking water supply system.

Tanks for subsequent infiltration are very suitable, for example, in a heavily built-up area. They address both the temporary accumulation of rainwater and infiltration. Rain gutters equipped with mechanical dirt filters open into the underground seepage tank. In the case of drains from a parking lot, it is possible to precede oil separators – from rainwater and wastewater. These storage tanks must allow gradual infiltration. The tank is maintenance- and cost-free. The tanks can be equipped with an overflow into the sewer to ensure safety. (Demiroğlu, 2016)

Due to the primary focus of this course on nature-based solutions, we will focus primarily on surface storage tanks.

We distinguish these basic types:

“Vegetated swales” (“bioswales”). The main function of these swales is the short-term accumulation of rainwater and thus the protection of the surroundings. They help with infiltration, purification, and drainage of rainwater. The designs can be different from simple modelling of the terrain and creation of a depression (Fig.3 – this solution is the least costly, but the overall efficiency is lower.) or they can be constructed of several permeable layers, thereby increasing retention, increasing infiltration and overall efficiency (Fig. 4). (Dinič et al. 2018). But the costs are higher. Simple swales are often built near roads, where water can flow through the entire edge or through individual holes between curbs (storm water curb extension – vegetation strips connected to the sidewalk. Curbs are locally lowered so that rainwater can flow from the road).

Fig. 3: Simple swales used to accumulate water from the pavement (Photo: B. Vojvodiková)

Fig. 4: A low-height swale equipped with retention layers (Photo: B. Vojvodiková)

Where in your neighbourhood would it be possible to build a simple swale??

Linear wetlands for rainwater filtration. There are shallow, linear tanks with a low permeability bottom. Tanks designed for rainwater accumulation. They are filled with a porous mixture of soil and gravel and covered with the original vegetation capable of phytoremediation. This is the main difference from bio swale. These places are designed for longer-term water accumulation; support the development of wetland communities. They are also designed for the treatment and filtration of rainwater by surface and subsurface flow.

"Rain garden" is formed by a terrain depression (natural or created) such as a ditch, where rainwater is captured, infiltrated or evaporated (Fig. 5). Tanks must be situated on soils that lack adequate percolation rates. The implementation is carried out in larger paved areas or roofs. In addition to water management functions, it can also have a high aesthetic effect. Installing a rain garden requires more preparation than swales. It is necessary to remove all the original plants. It is necessary to choose suitable plants so that they tolerate drought well, in the case of okra, and moisture in the middle part. The garden needs to be cared for. Water does not naturally flow out to the site or is directed toward the building foundation.

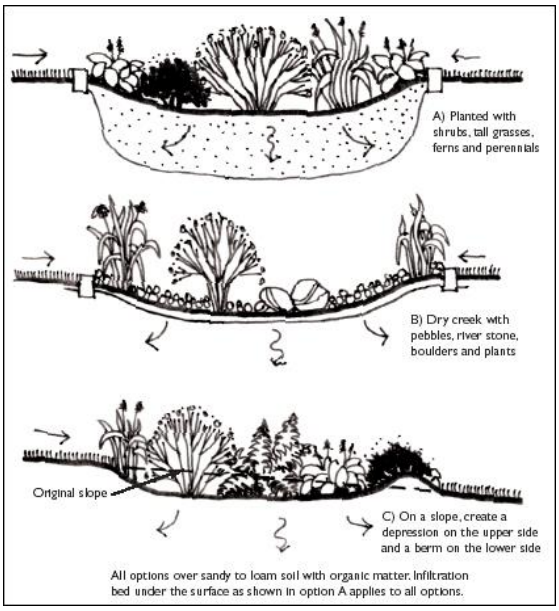


Fig. 5: A rain garden source (https://fuzeus.wordpress.com/2012/09/04/a-beautiful-rain-garden-at-absolutely-no-cost-for-any-la-residents/

)

Green sidewalks can be used for water infiltration without retention (see Fig. 6).

Fig. 6 Green sidewalks (Photo: B. Vojvodiková)

Part 2: What We Can Do about Rainwater in an Urban Environment — Evaporation

An integral part of the hydrological cycle is Evaporation.

We can divide it into:

- Evaporation from the free surface
- Evaporation from vegetation

Evaporation from the free surface is related to the creation of surface storage tanks as well as suitable water elements (Fig. 7). This solution is possible where we have a large enough area suitable for creating a pond or polder. Accumulation tanks at car parks or on large roads are part of the mitigation measures

Fig. 7: Water element (Photo: B. Vojvodiková)

Evaporation from vegetation can take place in virtually any nature-based solution.

Green roofs are particularly specific. They have both evaporation and water storage functions.

Extensive green roofs are based on small layers of substrate, with undemanding plants resistant to and tolerant of extreme conditions, with the ability to grow in the area. They protect the roof structure from sunlight and temperature fluctuations, which are considerable on an unprotected roof. Rainfall is retained here, and gradual evaporation humidifies the air in its surroundings. It also protects attics and reduces the possibility of fires. These roofs are unsuitable for a large number of people. The function is rather aesthetic and microclimatic (Fig. 8).

Fig. 8 Green roof (Photo: B. Vojvodiková)

Intense green roofs. They usually represent a set of compositional technical and vegetation elements. They are divided into simple intensive roof gardens and demanding intensive roof gardens. Simple gardens usually consist of lawns, perennials, and woody plants. Acquisition costs are lower, and aftercare is less demanding compared to a demanding intensive garden type. Demanding intensive roof gardens have high demands on the soil profile structure and regular water supply. A special element is a water garden – the roof is constantly flooded with water during the growing season. Aquatic plants are used in these gardens

Summary

Water is an integral part of urban life. Therefore, it is essential to respect water and to set up water management as efficiently as possible. (Morris and Thérivel, 1995) A number of legislative steps are already helping to initiate investors to include elements improving water management as part of projects. For example Czech legislation (Act. 501/2006 Coll. on general requirements for the use of the territory) include part deals with the management of rainwater. The infiltration of rainwater on the land of residential buildings is met if the ratio of the area of the part of the land capable of infiltration of rainwater to the total area of the land is in the case of:

- detached family house and a building for family recreation at least 0.4;
- terraced house and an apartment house 0.3.

Similar regulations exist in other EU countries. Rain gardens and green roofs are great tools for rainwater management, but when applying them, it is also necessary to pay attention to the quality of construction. It is necessary to prevent leakage into the roof structure. Also, water from the rain garden does not infiltrate into the foundations. It is also necessary to avoid the risks of possible groundwater pollution. For each infiltration system, it is advisable to seek the opinion of a hydrogeologist, who will assess the possibilities or possible problems that could arise by infiltration.

If you'd like to know more

Rain Gardens - Your personal contribution to cleaner water

https://www.chicagobotanic.org/downloads/wed/WI_DNR_homeowners.pdf

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Videos

Horton run off

http://portal.chmi.cz/files/portal/docs/poboc/CB/runoff_cz/navmenu.php_tab_1_page_2.2.0.htm

http://portal.chmi.cz/files/portal/docs/poboc/CB/runoff_cz/media/flash/infilt_runoff_hvyrain.swf

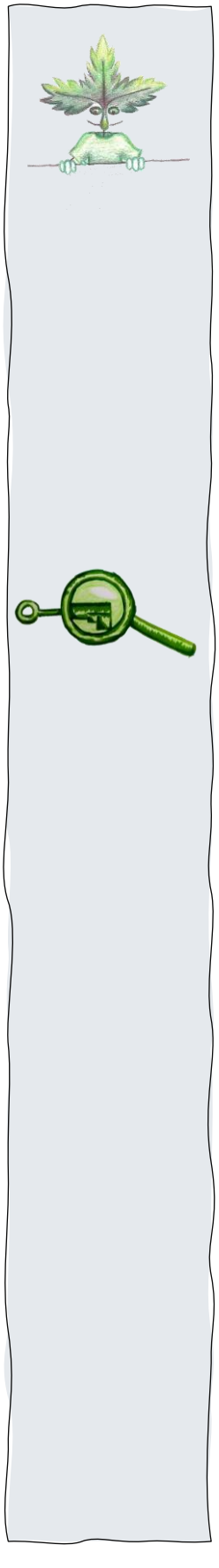
http://portal.chmi.cz/files/portal/docs/poboc/CB/runoff_cz/media/flash/infilt_runoff_ltrain.swf

Climate Resilient Cities - https://www.youtube.com/watch?v=OOd4vOKPzEg

Nature-based solutions for water quality improvements -
https://www.youtube.com/watch?v=2FD7Bg5tNTw

Applying nature-based solutions for a climate resilient Rotterdam
https://www.youtube.com/watch?v=IqC70VZOPnw

Chapter 5 Urban Environmental Acupuncture for Increasing Air Quality



Authors: Matteo Tabasso, Elena Masala, LINKS Foundation

Learning targets

This chapter provides an overview on the correlation between green infrastructures and air quality and identifies the most effective green infrastructures in improving air quality through urban environmental acupuncture.

Keywords

air pollution, green infrastructure, air quality

Air pollution represents a huge problem in our cities, as about 3.8 million premature deaths annually are attributed to outdoor air pollution. According to the World Health Organisation, it represents “the single largest environmental health risk in Europe”, while the European Environment Agency (EEA) has warned that, in our continent, air pollution causes between 400,0000 and 500,000 premature deaths every year (Air quality in Europe - 2015 report).

Indeed, air pollution is currently the most important environmental risk to human health in Europe, and is perceived as the second biggest environmental concern for Europeans, after climate change (European Commission, 2017a).

A systematic review financed by the David Suzuki Foundation (Zupancic, 2015) provided an analysis of the impact of green space on heat and air pollution in urban communities and identifies the most common air pollutants: particulate matter (PM), sulphur dioxide (SO2), ground-level ozone (O3), nitrogen dioxide (NO2) and carbon monoxide (CO).

Different air pollutants have different adverse health effects, and the World Health Organisation estimates that, in particular “PM contributes to approximately 800,000 premature deaths each year and 6.4 million lost years of healthy life in cities” (Brauer, 2012). Exposure to sulphur dioxide (SO2) was associated with pre-term births, while exposure to PM 2.5 can produce problems of low birth weights and pre-term births (Bekkar, 2020). Furthermore, ozone exposure may have negative effects on birth weight and neurodevelopment. According to Canadian studies, NO2 exposure is linked to an increased risk of ischemic heart disease (Crouse, 2015).

Obviously, the most effective intervention to reduce air pollution would be the reduction of emissions but this is often difficult and green infrastructure cannot play any role in that. Another way to reduce human exposure to pollutants is extending the distance between sources and receptors. This can be achieved, for instance, by increasing the distance between road vehicles and pedestrians, or by

placing “barriers” between sources and receptors, placed in different configurations. Green infrastructure such as trees and hedges can provide semi-permeable obstacles to the airflows, virtually extending the distance thus reducing the negative effects for the receptors. This kind of barrier is effective where deposition can be enhanced by holding air thanks to dense vegetation. The space domains in which green infrastructure is likely to be effective are different and range from a small “green oasis” such as a bench surrounded by green hedges to a dense urban woodland. In many cases, green infrastructure, which represent the heart of nature-based solutions policies, are a very effective solution to recover natural processes (ecosystem services) within urban contexts.

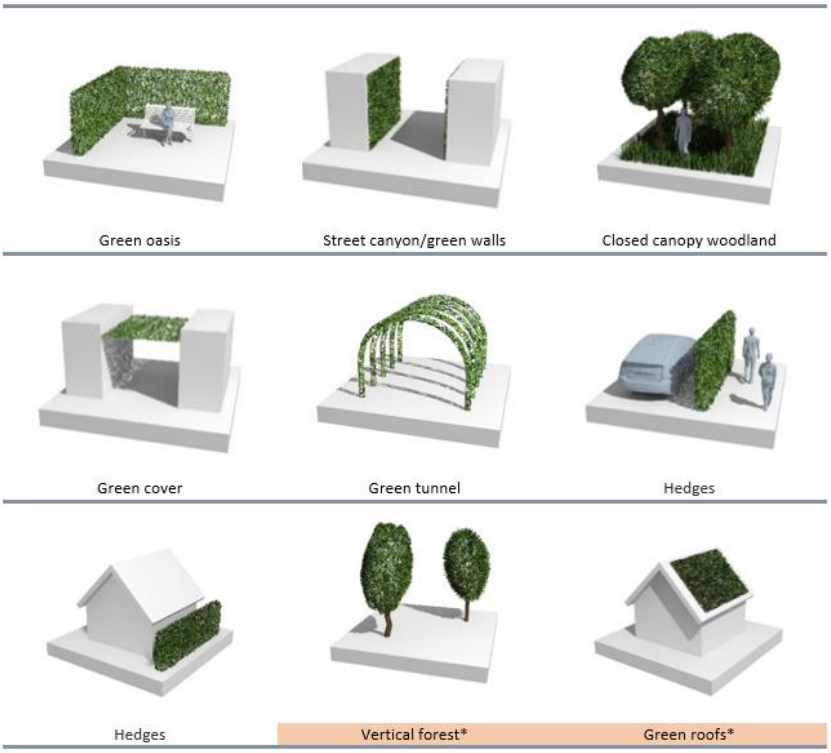
It is obviously unthinkable that green infrastructures alone can solve the problem of air pollution, anyway several studies demonstrated the contribution they can provide to this end.

In a recent study research, Hewitt et al. (2019) emphasize the role of some specific interventions in improving air quality. The previously mentioned report from the Suzuki Foundation (Zupancic, 2015) analysed different types and scales of green space in cities and found that urban green space often produces cooler and cleaner air at different scales (site, neighbourhood and city). The study also found that “closely spaced and connected smaller green spaces can provide greater cooling effects to adjacent urban areas than large individual parks with open grass areas”. Green infrastructure allows the introduction of vegetation into the urban landscape, which work on the principle that “pollutants deposit more efficiently onto vegetation than onto smoother, impervious, artificial surfaces”.

There are several examples of specific green infrastructure, such as benches closely surrounded by green hedges, extensive green walls in a street canyon, tunnels or canopies of dense vegetation to protect pedestrians, city parks or woodlands with dense trees, and so on.

Numerous studies agree on the fact that the introduction of green infrastructure can help improve urban air quality, but empirical evidence is scarce on this topic (Hewitt 2019). In urban contexts, pollutant concentrations change rapidly and the evaluation of small changes due to the introduction of green infrastructure is very difficult. For this reason, decisions on green infrastructure are mainly based on prediction models and it is fundamental to know what, where, and how to plant in order to avoid unexpected (health) impacts and reduced resilience.

In fact, the effectiveness of green infrastructure changes depending on the typology: for example, horizontal green infrastructure is effective only on deposing pollutants, while vertical green infrastructure work on both deposition and mixing, thus increasing its level of efficiency.



*Those kinds of green infrastructure are indicated as ineffective for air quality improvement, but effective for other ecosystem services, because…

- **VERTICAL FORESTS**
  have modest horizontal extent and very large aspect ratios but will be ineffective for air quality because they do not produce either a closed canopy or an open top green oasis.

- **GREEN ROOFS**

  enhance the deposition of pollutants from the atmosphere by increasing the available surface area (Yang et al. 2008; Treeconomics 2015) and are unlikely to make an appreciable difference to ground-level pollutant concentrations since they act on the very large volume of air above the urban canopy (Pugh et al. 2012).

Fields, parks, abandoned plots can be important because areas not sealed by concrete ensure cooler temperatures and help to keep the air clean, but other kinds of actions involving green infrastructure could also damage air quality (e.g., introducing trees into a street canyon, which may increase canopy closure and reduce ventilation rates), or may have no clear effects on it (e.g., building green roofs).

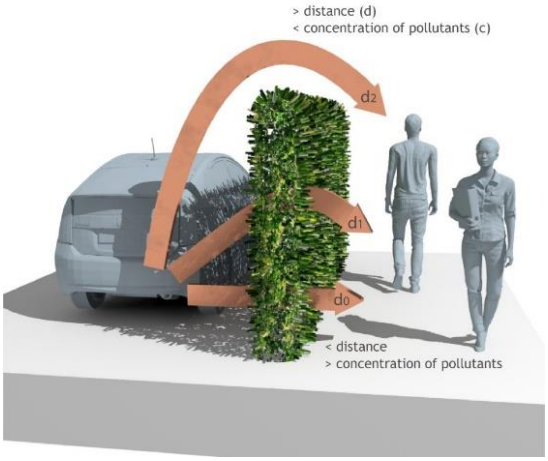


Fig. 1: Effect of a permeable linear barrier or hedge on pollutant concentrations (elaborated from the author, retrieved and adapted from based on Hewitt, 2016)

Along paths d1 and d2, pollutant concentrations are diluted by mixing and deposition. Deposition dominates for d1, mixing dominates for d2, with c2 decreasing approximately exponentially. In the absence of the linear barrier, the receptor experiences higher concentration, c0, diluted over shorter distance, d0, and not subject to enhanced deposition to vegetation.

According to the GI4AQ methodology, green infrastructure can be effective over a range of horizontal and vertical spatial scales, but it is important to consider any intervention in terms of its characteristic horizontal scale and its height-to-width aspect ratio.

Fig. 2: Efficiency of Green Infrastructures in absorption of pollutants (elaborated from the author retrieved and adapted from Hewitt, 2016)

The common idea that increasing the amount of vegetation reduces ground-level pollutant concentrations linearly (i.e., that doubling leaf area will half pollutant concentrations) can prove to be fallacious. “The vegetation deposition sink is at a distance from the pollutant emission source, so atmospheric concentrations will be always a non-zero, positive-definite, balance of emissions, advection, deposition, and reaction. Not accounting for other aspects in the budget leads to an over-estimation of the efficacy of green roofs and other forms of green infrastructure on air quality, to the detriment of rational decision making” (Hewitt 2020).

The way vegetation interacts with airflows, and consequently with air quality, is influenced by different factors such as plant typology, height, morphology, etc. (Baldauf 2017). Furthermore, not all types of vegetation are suitable for improving air quality and, above all, it is demonstrated that sometimes, using the right types of plants, a smaller green area is enough to be a good deterrent against air pollution.

The three main characteristics that influence the efficiency of plants to reduce air pollution are density, plant height, and the intrinsic characteristics of the leaves.

Numerous studies have confirmed the theory that increased tree cover is positively associated with increased mitigation of PM, O3, NO2 and SO2. Likewise, it was found that younger and, therefore, smaller trees have good effectiveness in removing PM10, as they have much denser foliage (Zupancic 2015).

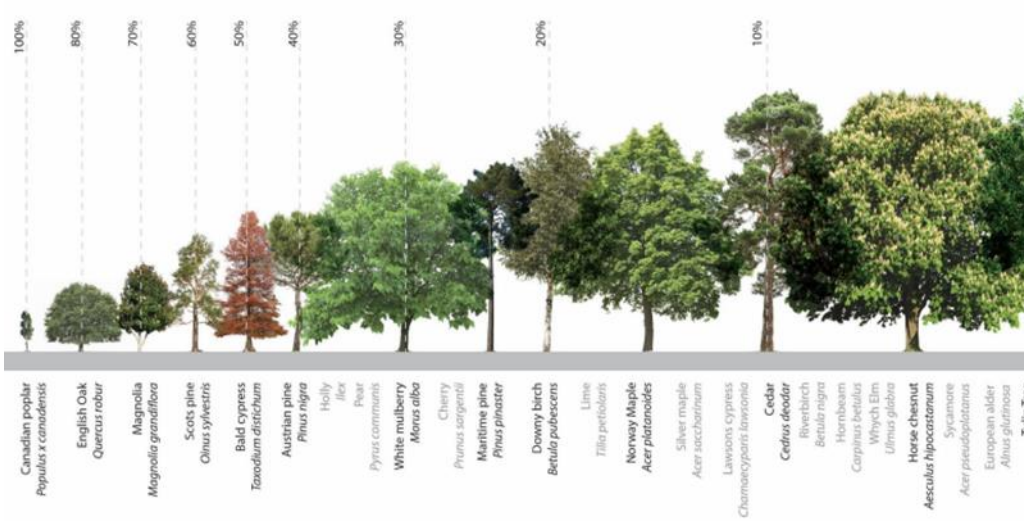


Fig. 3: The worst and the best plant for air quality (retrieved from: Churchman Landscape Architects 2018)

http://epapers.bham.ac.uk/3104/1/Churchman_GI4AQ_does_it_add_up.pdf).

The height of the plants is a very important factor, as several authors have shown that a lower tree does not necessarily negatively influence the uptake of pollution. In fact, there is evidence that compact trees and shrubs growing low to the ground are more effective at capturing PM than large-branched trees. (Beckett 2020).

Several authors agree on the importance of plant leaf traits on the mitigation of PM, in particular when the density of leaf is higher while the surface of leaves seems not to be particularly significant to PM accumulation (Sæbø, 2012).

The table below reports the 6 policy interventions (PI) envisaged by the GI4AQ model

PI1	Carry out modelling (probably using computational fluid dynamics) to identify causes of reduced ventilation in streets with closed tree canopies where emission reductions have not been sufficient to achieve acceptable air quality. Modify canopy to increase street canyon ventilation accordingly
PI2	Introduce hedges (and other linear barriers) between traffic and pedestrians. Choose barrier height, porosity, and length to maximise benefits. This may require dispersion or computational fluid dynamics modelling
PI3	Provide long-term effective management of green infrastructure to ensure continuation and maximisation of the ecosystem service of enhanced pollutant deposition
PI4	Introduce and maximise areas of green walls in street canyons
PI5	Create “green oases”, i.e., slowly ventilated zones containing or surrounded by GI but with no internal pollution sources. Green oases may range in size from a bench closely surrounded by high hedges to a city park with a dense tree canopy
PI6	When planning to increase or change the urban tree population by more than ~ 10% at the city-wide scale, assess the impact on ground-level ozone and choose low VOC-emitting tree species to minimise any increases in down-wind ozone pollution

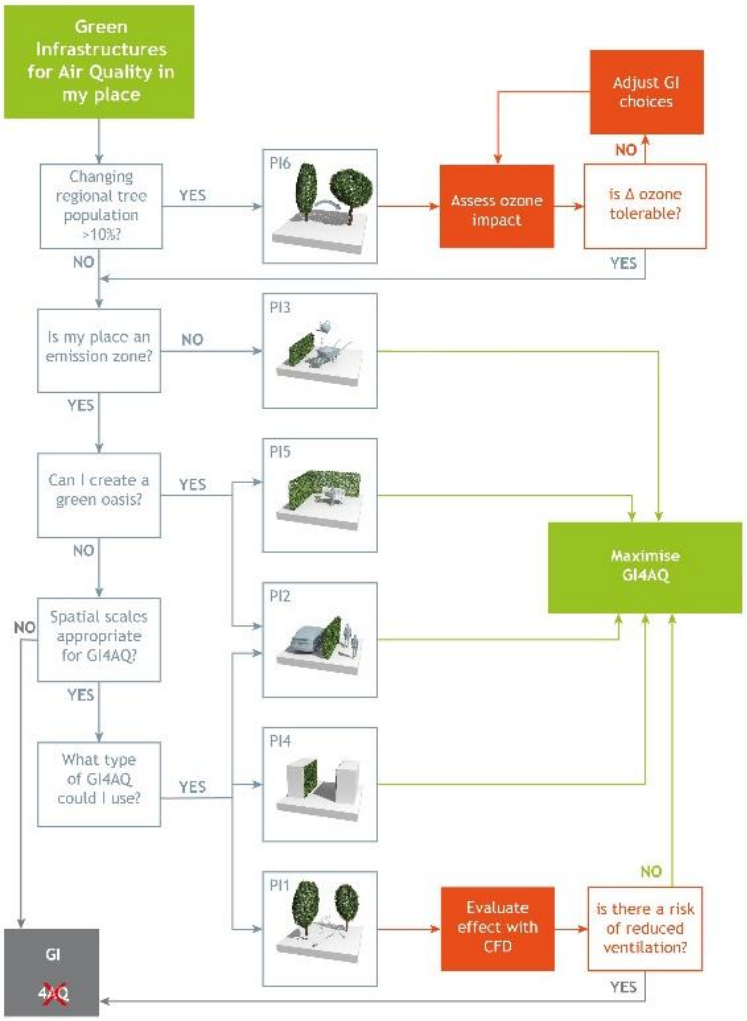


Fig. 4: Flow chart to aid Green Infrastructure for Air Quality (GI4AQ) decision making

Retrieved and adapted from Chris Churchman, Churchman Landscape Architects, "GI4AQ (Green Infrastructure for Air Quality): Does it all add up?"

Summary

Green Infrastructure is effective in reducing air pollution when deposition can be enhanced by holding air for long time near vegetation. Even considering the complexity of modern cities, the conceptual framework proposed within the GI4AQ methodology represent a useful guidance to policy makers on the implementation of green infrastructure and their effects on urban air quality.

Usually green spaces, and in particular green infrastructure, have a positive effect mitigation measures to counteract air pollution, however, the design process of the spaces must take into account many factors and variables that, if not considered, may not be effective in reducing toxic substances in the urban context. Therefore, proper considerations regarding the context are fundamental in order to identify if and how to employ green infrastructure to improve air quality.

If you'd like to know more

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Videos

https://www.interreg-central.eu/Content.Node/Salute4CE-ProjectPresentation.mp4

Chapter 6 Selection of suitable, sustainable, native, and country-specific native plants

Authors: Leszek Trząski, Katarzyna Galej-Ciwiś, Silesian Botanical Garden

Learning targets

The purpose of this chapter is to make you familiar with the right selection of the species and varieties of plants to be planted in greenspots. You will also learn at what stage of designing a list of plants to be planted this plant selection should be made and on which websites to look for information. In this chapter, you will also learn what mistakes to avoid and how to adjust plants in terms of their biogeography and history.

Keywords

Plant selection recommendations, country-specific plants, native plants, naturalized plants, indigenous species, straight species, cultivated varieties, invasive plants, greenspot design, biogeografic criterion

Part 1: The most general principle of selecting plants for UEA

Selection of plant species and varieties, and their combinations, must be consistent with the environmental conditions of the FUA (Functional Urban Area) as well as with the specifics of the site, and adjusted to the type of intervention - i.e., the type of greenspot and types of NBS.

You also need to be sure that there is no risk of expansion in the urban ecosystem and, in the case of biogeographically alien species, no risk of invasion of wildlife. From the regulation entitled, to apply in the UEA without major reservations, only native species or naturalized species are recommended (the meaning of the terms is explained in the subchapters).

The selection of species should be made by a TEAM, which is formed by thorough knowledge of the site conditions and knowledge of the expectations of local stakeholders with practical knowledge of the specificity of a given NBS, practical knowledge of gardening, and competence in the field of landscape architecture.

Part 2: At what stage in the design of a greenspot should plant species be selected?

In each FUA and for each greenspot, the selection of plants should be considered from the earliest stages of design. We recommend that the development of an initial, comprehensive list of life forms and species should follow the initial vision of the greenspot as understood in our Deliverable 1.2.1 (interreg-central.eu) on page 13. Later, as the target vision of the greenspot has been created (this stage of greenspot planning is discussed in Deliverable 1.2.1 on page 23), the list of plants shall be specified in relation to the selection of specific NBS.

It should always be remembered that even the most beautiful vision of a greenspot may collapse in the face of hard market realities, e.g., it turns out that plant material with the desired characteristics is unavailable or its acquisition or use exceeds financial or logistical possibilities. Therefore, even before starting a specific green design, it is worth analysing the supply of plant material on the local market.

It is also worth realizing that the future user of this greenspot is not interested in the list of NBS used; for them the key is to answer the question of how the user will be able to use this place and what the quality of their stay will be like. The aesthetic values and the symbolism associated with specific plant species are also very important. The choice of this species over another may also be determined by the elements of the identity of a place and may be affected — positively or negatively — by people's emotions. All this means that in some cases the presence of a given species or variety may be a foregone conclusion at the time of making a decision to transform a given site into a greenspot (the site selection procedure is described in detail in Deliverable 1.1.1) (interreg-central.eu).

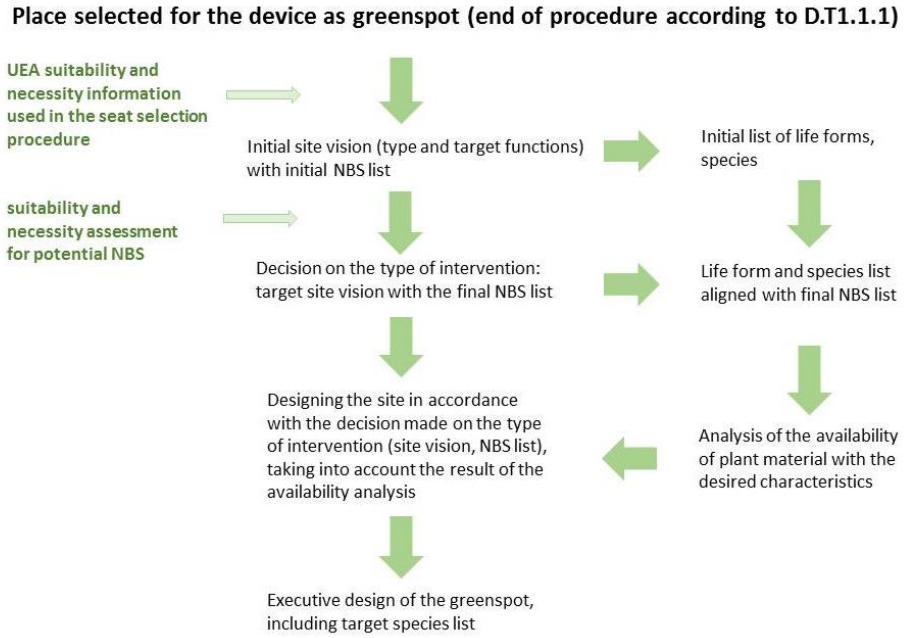

Fig. 1: shows the proposed logic for selecting plant material in correlation with the background of the greenspot planning and design procedure; Author's own source

When selecting plants for UEA, you cannot afford to experiment! The origin of a specific seedling and the history of the species in the context of a specific place must be well documented.

We only choose the best quality material. If there is a green standard in a given city, the quality of the material must at least meet this standard. If there is no such - let's look for a nearby town.

If we have a choice between the wild form and the cultivar, we should always choose the wild one.

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Part 3: Plants recommended for use in UEA according to the biogeographic and historical criterion – native species and country-specific species

Generally speaking, we recommend that native species of trees, shrubs, and perennials should be preferred in UEA. The simplest justification for such an approach is contained in the sentence below:

"Native (…) plants are adapted to our local pests and climate and will require less maintenance in the long run than most ornamentals. Planting natives in an urban situation also provides wildlife habitat where it is often scarce or degraded. This list emphasizes smaller trees to remain in proportion with the urban surroundings and lessen interference with power lines and buildings" (soundnativeplants.com).

There are many definitions of "native species"; some of them are cited at wildflower.org and at foxleas.com. Similarly, the terms "naturalized" and "country-specific" have different meanings. Without getting into unnecessary definitional disputes, we explain the meaning of all these concepts adopted in this manual for purely practical reasons.

Part 3.1: Native species

This manual is written primarily for Central European (CE) city practitioners, and we therefore assume here that "native" means that the plant is native to anywhere in CE. We reserve that Central Europe is an area defined not only by the administrative borders of the CE Programme, but also as an area where several biogeographic zones of Europe meet. "Native" in this manual is defined as a species that meets two conditions: it comes from the continental, Alpine or Pannonian biogeographical region of Europe, and at the same time its natural range extends to the administratively understood CE region. We define biogeographical regions according to the European Environment Agency (eea.europa.eu). Thus, within the meaning of this manual, the "native" category does not include, for example, a species originating in southern Italy or the Adriatic coast of Croatia (Mediterranean zone) or western Germany (Atlantic zone).

A particular subcategory of native plants is indigenous species. Such a species is native to a particular area, such a particular region of the country.

It is not difficult to check the natural range of a given plant species in Europe. We suggest using studies made available on public servers, e.g.,:

- KEW Royal Botanic Gardens (plantsoftheworldonline.org)
- European Commission Service Web Site (ies-ows.jrc.ec.europa.eu) (only links to a given species for example Acer platanoides)
- Flora Europea (eunis.eea.europa.eu)

Even the native species may turn out to be expansive. Remember that when designing a greenspot, you also have to take into account the risk that expansion will occur.

We recommend that for UEA, species should be mainly used that fall into the category of "native species" extended to "naturalized" species (see Fig. 1 - boxes with a green background), with a preference for the former.

Part 3.2: Naturalized species

For the purposes of UEA, as "naturalized" we define a non-native species, that is, originating — in the biogeographical sense — from outside Central Europe, but at the same time meeting all the following conditions:

- it is a permanent (for two or more centuries), desired element of the landscape of Central European cities;
- in the CE area, it does not penetrate from urban plantings to extra-urban ecosystems;
- possible expansion to areas adjacent to urban plantings, and even if it happens, it is easy to control and stop;
- it provides well-documented benefits for urban biodiversity (e.g., good for insects, provides food for birds, is highly soil-forming, etc.).

As in the case of native species, within the meaning of this manual, the category of "naturalized" does not include, for example, non-CE species whose traditional settlement in cities is limited to the southern Italian or Adriatic coast of Croatia (Mediterranean zone) or western Germany (Atlantic zone).

Part 3.3: Country-specific species

A "country-specific" (as defined in this manual) is a plant species whose natural range or area of traditional settlement in cities (naturalization) covers fully or partially, a given country within the CE Program area. In the case of a species naturalized in a given country (it means outside its natural range), however, all the conditions below must be met:

- it is a permanent (for at least two centuries) element of the landscape of cities in a given country;
- it is not listed on the national or regional invasive plant list;
- it is well adapted to the specificity of the urban climate and tolerates well the climate changes occurring in a given country / region.

Thus, a "country-specific" species is one that is a permanent element of urban ecosystems in the region to which a given FUA belongs.

Recommendations for the selection of plant species for UEA according to the biogeographic key, taking into account the history of cultivation in cities, are presented in Fig. 2.

We also recommend that in a given FUA, at least some of the native species used for UEA should be both "country specific" and "indigenous".

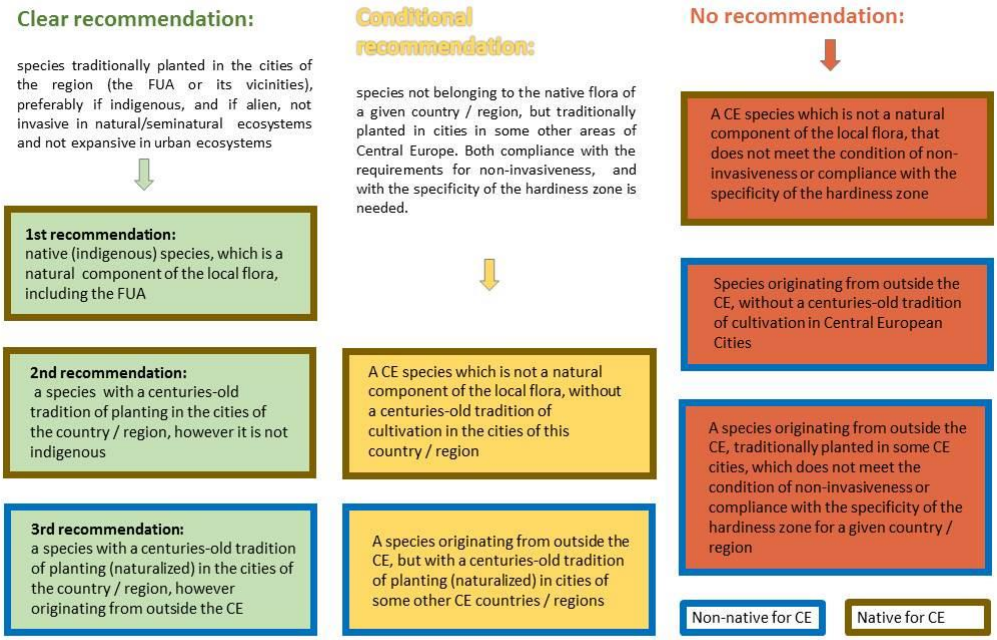

Fig. 2 Biogeographic recommendations for the selection of plant species for UEA in Central European cities; Author's own source

Part 4: Plant species that cannot be used in UEA

In UEA, it is not allowed to use invasive plant species defined by the definition of Invasive Alien Species (IAS) valid in the European Union:

"Invasive alien species (IAS) are non-native species that are deliberately or unintentionally introduced by human action outside their natural habitats where they establish, proliferate and spread in ways that cause damage to biological diversity" (ec.europa.eu). These are, in particular, species included in the Invasive Alien Species of Union concern (union list) (ec.europa.eu).

When considering the selection of plants for UEA to be used in a given FUA, one should also completely abandon species listed on official or semi-official, country-specific / regional lists of alien invasive species. For example, in Poland, the list is published within the legal document at (prawo.sejm.gov.pl) and at (projekty.gdos.gov.pl). For further information on individual species see atlas-roslin.pl (Snowarski, 2021).

The official list of invasive plants for Slovakia can be found at (minzp.sk).

Systematized information about Slovakia is also included in the studies available at sopsr.sk (Gojdičová).

In Thuringia, similar information is available at (tlubn.thueringen.de)

We cannot recommend invasive species from regional lists, according to the European NOBANIS database (nobanis.org).

There are also plant species whose natural range extends over the continental zone of Europe, but they are highly invasive and therefore are included in the national lists of invasive plants in Central Europe (e.g., Ulex europeus on the Polish list). We do not recommend such species for use in UEA in any FUA in Central Europe.

We also warn against "experimenting" within UEA, involving the use of species of foreign origin, with a wide range of tolerance to environmental conditions (especially those recently imported from other regions of the world), the invasiveness of which in Central Europe has not yet been tested.

Part 5: Plant species, including aliens, the possible use of which requires special care in UEA

Any decision to introduce a species of foreign origin (including a species naturalized in CE cities) should be preceded by checking the information on its possible (potential) invasiveness. Any decision to use non-native species not included in the official lists of invasive plants — whether in the EU, or in a given country or region — should therefore be preceded by analysis of scientific databases dedicated to invasive species, e.g., the CAB International (cabi.org). If the species is listed in a specialized database of this type, its use in UEA requires special care and the decision should be preceded by analysis including:

- assessment of information on invasiveness and/or expansion as derived from the content of databases
- assessment of closer and further surroundings of the planned UEA site, in the context of possible threats to biodiversity of neighbouring urban or suburban areas
- reference to the practical knowledge of city gardeners, foresters and botanists about the biology of a given species.

There is quite a large quantity of plant species with a wide range of tolerance to habitat requirements, including those traditionally grown in cities, with a proven potential for being invasive or expansive, but not on European, national or local invasive species lists.

Information on the potential invasiveness or expansion of alien species not officially listed as invasive plants should be obtained from all available country-specific or regional-specific sources. For example, for Poland, such information can be found at gdos.gov.pl (Tokarska et al., 2012).

Similar information can be easily found for most countries and regions, for example for the northern part of Italy (Galasso et al., 2018).

Information on potentially invasive species relevant to Thuringia can be found at tlubn.thueringen.de.

It should also be checked whether new reports on plant invasiveness have appeared in the professional literature, which may refer to the CE area, a given country or even a given FUA. It may be especially useful to consult the international database of invasive species (griis.org).

Part 6: The dilemma, not fully determinable, of selecting plant species for UEA: native species or species “ideally” adapted to the difficult conditions of the urban environment?

In practice, the application of a biogeographic criterion in the selection of plant species for UEA is not as simple as it might seem. The biogeographic criterion is very important, but too orthodox an application of it should be avoided. The fact is that in a highly urbanized space, the living conditions of plants differ significantly from those in the non-urban areas of the same region. For example, the UHI phenomenon makes plants particularly vulnerable to high temperatures and water deficits in the soil in a full-growth season. Moreover, winter temperature drops are milder than in non-urban space. In addition to the UHI phenomenon, degraded soils are part of the urban specificity – they are usually compact, without proper structure, with a small water holding capacity, and often also saline. Instead of real soil in cities, we often deal with anthropogenic soil with a very heterogeneous structure, unbalanced in terms of available minerals and organic components. These factors mean that not all native species of trees, shrubs and perennials are suitable for use in UEA. It therefore seems that it is worth formulating an unequivocal recommendation to select plants for UEA from drier and slightly warmer zones compared to presenting the location of a given FUA on the map of Europe. However, such proposal also appears unreliable. The thing is that the vegetation period in the city begins earlier than in non-urban areas, sometimes even by a dozen or so days. In the Central European climate, spring frosts following a series of warm days, not omitting city centres, are no surprise. Numerous plant species from a slightly warmer climatic zone turn out to be sensitive to the effects of such phenomena if they have already started their spring activity. In this case, a difference is revealed between the full-frost resistance during the dormant period and the sensitivity to cold during the activity period. From the above, the conclusion can be drawn that despite the specificity of the urban climate, in selecting species for UEA it is worth following compliance with the hardiness zone assigned to a given region.

Several features of a plant "ideally suited" to the conditions prevailing in a highly urbanized space can be defined. For example, it could be:

- Ease of introduction into the urban environment and ease of settling in the first period after planting.
- Quick achievement of the assumed effect (e.g., fast growth rate, strong rooting, quick ground coverage).
- Resistance to pathogens present in the urban environment and to allelopathic effects from other plants.
- Ability to create a durable, self-sustaining plant community in difficult urban conditions (self-propagation, high regeneration capacity, low maintenance requirements, or even no such requirements).

- High resistance to extreme weather phenomena (extremely high or extremely low temperatures, rainless periods, torrential rains, late spring frosts, air pollution).
- Low soil requirements, including the ability to develop on compacted, dry, saline, acidified soils, and even on soilless anthropogenic areas.
- A wide range of tolerances in terms of light conditions (from shade to full sun).

Unfortunately, it is quite difficult to identify such a native tree, shrub, or perennial species that would be characterized by the full set of these features. Paradoxically, this set very well illustrates the features of the invasive species, therefore one that cannot be recommended for use in UEA under any circumstances!

In practice, the choice of plant species for a given greenspot will usually be a compromise between the recommendation to prefer native species, the recommendation to use the species best suited to the specifics of the urban environment (often they will be species of foreign origin), and the need to adapt your choice to the specific conditions of the site. If we are to decide to use an alien species, we must be sure that it will be easy to prevent, contain and remove the effects of possible plant expansion within the greenspot and to other areas. In addition, we should only choose species for which we are sure that their introduction in a given point of the city will not pose a threat to the nearby areas of natural value, not only those under legal protection (e.g., suburban nature reserves), but also forests, meadows, old parks, gardens, trees accompanying river valleys, etc.)

Part 7: What to prefer – straight species or cultivated varieties / forms?

Plants significantly different from the wild-type of a given species, as well as interspecies hybrids are widely available on the market. Commonly used terms are wild-type (= straight species), variety, clone, cultivar, nativar, hybrid. In this manual, we understand these concepts as proposed at (Content.yardmap.org, (2021). This classification clearly defines, sufficiently for practitioners, when we are dealing with a natural subspecies or a variety found in wildlife and propagated from seeds, and when, for example, with a cultivar, i.e., a plant obtained by cloning.

The ability to distinguish between wild-type plants and cultivated varieties/forms that are altered and/or grown differently than from seeds is important for a number of reasons. First, the environmental requirements of cultivated varieties/forms often differ significantly from those of wild-type plants of the same species. The rate of growth and the target size are also different, as well as altered longevity and hardiness. Moreover, there is a growing body of scientific evidence that "altered" plants provide less benefit to the urban ecosystem than wild-type plants. For example, it is known that in the case of trees and shrubs,

varieties (including nativars) with discoloured leaves are not preferred by insects. It is also known that in the case of perennials, pollinators do not always visit a nativar as eagerly as a wild form, although it is species-dependent, both for nativars and for insects.

Our recommendations regarding the choice between straight species and plants changed in such a different way are presented in Fig. 3. In accordance with these recommendations, if there is a choice between straight species and nativar of a given species, we choose a wild form, especially if it is to be of benefit to the city's biodiversity.

We generally do not recommend for UEA to use clones, cultivars other than nativars, or cross-species hybrids, especially if their impact on the city's biodiversity is unknown or their environmental requirements are not well understood. We especially do not recommend selecting showy plants with an unclear taxonomic status.

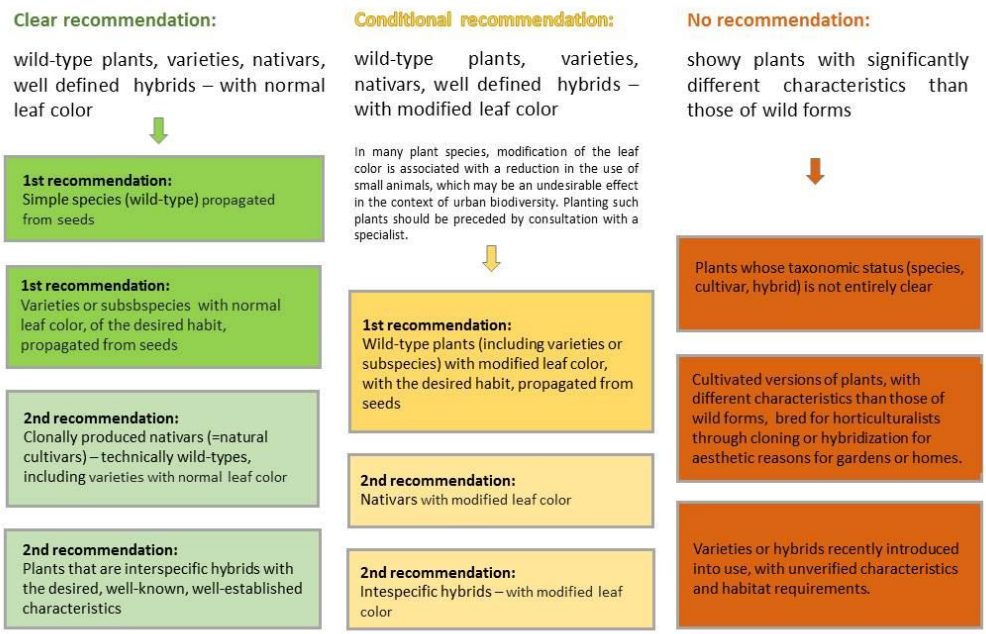

Fig. 3 Recommendations regarding the choice between straight species and plants changed in such a different way; Author's own source

Part 8: General requirements that should always be met in order for a given plant species to be selected for UEA

Extensive recommendations on the selection of species for UEA, going far beyond the biogeographic and historical criteria, are presented in Deliverable 1.1.2. At this point, we limit ourselves to providing a checklist of general requirements that must be met for a given greenspot. Those are:

Matching environmental conditions, including also compliance with a hardiness zone (completely sufficient information about a city's affiliation to the hardiness zone is available at Plantmaps.com, (2021).

- Providing major benefits in terms of regulative ecosystem services (ES).
- Compliance with the needs of protecting and strengthening biodiversity.
- Promoting expected social benefits.
- Conflict/risk avoidance.
- Facilitating further maintenance of the UEA site after actual implementation.

Summary

Selection of plant species and varieties, and their combinations must be consistent with the environmental conditions of the Functional Urban Area (FUA) as well as with the specifics of the site, and adjusted to the type of intervention, i.e., the type of greenspot and types of Nature Base Solution (NBS).

If you'd like to know more

See the video and reference list below. It is also worth looking for websites dedicated to countries that did not participate in the SALUTE4CE project.

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Chapter 7 Action Planning for Urban Environmental Acupuncture (Small Green Space)

Authors: Jessica Hemingway, Juliane Mathey and Peter Wirth, Leibniz Institute of Ecological Urban and Regional Development (IOER), Dresden

Learning targets

In this chapter you will become familiar with action planning specifically as related to urban environmental acupuncture (UEA). This chapter was written based on the "transnational concept of action plans" developed for the SALUTE4CE project (Hemingway et al. 2020). You should be able to answer the following questions at the conclusion of the chapter:

- What is action planning?
- What does the process of action planning for UEA entail.

What is an action plan?

Keywords

action planning, importance of action planning, steps and process of action planning

Part1: Introduction to Action Planning

The process of action planning and the product, the action, plan can help you to be well prepared with the necessary tools and resources to save time and energy. By going through the motions of action planning you are lining all your ducks in a row to accomplish your planning goals. An action plan is important because it serves as a guide in making the goals of your community a reality.

An action plan is a written document outlining how project implementation will be accomplished. An action plan contains different elements which typically occur in chronological order (discussed below). As described by Coyle (2011), a sustainable action planning expert, "It [an action plan] should be used to identify the specific tasks, timelines, and resources necessary for implementation. It will activate the community's vision by enabling the desired outcomes appropriate to the people and place, including the protection of natural landscapes."

In our case, we are dealing with action planning in the context of urban environmental acupuncture (UEA). Consequently, we must consider the tasks, timelines, and resources necessary for creating a UEA concept with local actors in a functional urban area (FUA), City or district.

Part 2: The Process of Action Planning

Problem statement and goal formulation

Photo: Microsoft Word Archive, 2021

How do I start the planning process?

Begin the action planning process with general considerations relating to UEA. Identify the need or reason for using UEA (see chapter 1 of this manual). Is there a lack of large open space and thus a need to utilize small, underutilized plots for use as green space? Consider whether UEA is suitable in your FUA, city, or district in relation to its advantages and potentials for instance, the low budget and fast implementation character, as well as the opportunities of citizen involvement. Identify and describe the potential of UEA to contribute and or relate to current and future planning policies (local, state, or regional)? In general, how could UEA help to address current planning challenges you are facing?

Creating a local action plan

How do I start the process of creating an action plan?

Identify the areas of your planning jurisdiction that have the potential to benefit from UEA. Example challenges addressed within the SALUTE4CE pilot projects include extreme heat, lack of vegetation, social dissidence, and a lack of biodiversity. Details on the identification of problem areas and potential interventions were presented in Chapter 1 of this manual, “What is green acupuncture? Description of methods of selection of green acupuncture spots by IURS”.

After identification of possible acupuncture points and interventions, you will proceed through three main phases.

Phase one - the preparation phase (preliminary activities):

Deciding on responsible parties (e.g., forming an action planning team)

In the preparation phase a planning team that will be responsible for action planning needs to be assembled. This is dependent upon the needs of your project; however, some pointers are provided here. Firstly, an internal coordinator should be selected; this is the person in charge of leading the implementation of the plan. In addition, three to five core action planning team members should be designated. Within this team a contact person for citizen and resident concerns should be chosen; this can be the coordinator or an additional individual. Other potential members of the action planning team include individuals from municipality departments (e.g., planning, environment, parks, and gardens) as well as other relevant institutions or organizations that possess applicable expertise and interest in terms of green infrastructure (e.g., environmental organizations). The action planning team should consider whether an external moderator – outside of the core members (i.e., a neutral person who is not a formal member of the planning team or project) or someone from a planning office should be involved. An external moderator is not required; this is the decision of the action planning team. It is important that the action planning team possess the skills, competency, and authority necessary to carry out tasks of the analysis and implementation phases. Considering the balance of skills within the core group is also important. It is useful to have Individuals on the action planning team that are influential and valuable in the process of planning for the UEA sites, they should also be motivated and have the time to contribute to the process (GreenKeys Team 2008).

Who should make up the action planning team? What kinds of expertise are necessary and how many people should be included?

The tasks of the action planning team include defining responsibility, creating pilot project visions and goals, organizing living labs, public relations, collecting data and external expert outreach among others. It will be necessary to create a working plan with deadlines for the team to ensure that goals are met. Specifying who is responsible for which task and by when. Also important is identifying required formal (legal) procedures which need to be considered as part of the planning and implementation process (GreenKeys Team 2008). In addition to identifying individuals and assigning roles, the action planning team will be responsible for initiating the planning process, coordinating implementation and citizen involvement. The latter can be realised with a press release, an information note in the local official gazette and/or a post in social media. Having additional support for your UEA project is essential to ensure success in all phases of the planning process.

What types of activities does an action planning team carry out?

Public, political, and financial support play an important role in UEA planning, it is important to win support for your project in the preparation phase:

- Gaining support for the pilot project

What kind of support is needed locally to ensure success of my UEA project?

Public support

Photo: Microsoft Word Archive, 2021

Public support may include residents, interest groups and relevant experts and stakeholders. This is particularly important where the community should be involved in planning, building, maintaining, or monitoring UEA sites. The public should be included throughout the planning process; and be kept up to date about the progress of planning, including the development of planning procedures. Additionally, the public can contribute to building visions by making the needs of the community known. By getting to know residents or the future potential users of the respective small green spot, one can gain knowledge concerning the local situation and the needs of various groups and their expectations (i.e., what ecosystem services are particularly needed). The public can participate in UEA action planning in a variety of ways including both formal and informal collaboration (e.g., living labs, public events, goal-oriented workshops, or PR campaigns (GreenKeys Team 2008)).

Political support

In the best-case political support should be had at the beginning stages of planning and steadily improved upon throughout the planning process. Local political support should be obtained from the mayor or city council in the form of an approval letter or resolution. Political support is especially important when challenges arise in the planning process (implementation of tasks and actions) and can be important when presenting results of the pilot projects. Additionally, visions, goals and targets need to be accepted and confirmed by local representatives. The political support gained early in the planning process will prove to be vital in the planning process in later. In order to maintain a dialog, the action planning team is recommended to inform the city council and mayor of the planning process and the potential of the pilot projects to improve green infrastructure or quality of life within the respective FUA, City or district (GreenKeys Team 2008).

Financial support

Within the framework of the SALUTE4CE project it was necessary for pilot project partners to obtain additional financial support outside of the project funding to implement UEA sites. In most cases it may be necessary to pool financial resources from several origins to create, implement and maintain UEA sites. Potential sources of financing include but are not limited to citizen donations related to city greening initiatives, a commitment from the mayor through the city budget, European Union funding or federal or state funds allocated to support biodiversity or climate change adaptation. Or other sources of funding that are less conventional such as funds collected as part of a lottery (GreenKeys Team 2008).

Phase two - the analytical phase (gather and evaluate information):

What information needs to be collected?

You will need to compile information about your FUA, city or district referred to as a profile and information concerning the physical conditions as related to greenspace.

Photo: Microsoft Word Archive, 2021

Create a Profile

The purpose of the description of general conditions should result in background information necessary to understand how UEA sites fit into the bigger picture and may contribute to green infrastructure within your FUA, city or district. The focus of this section should be on demographics (i.e., population size and characteristics), the planning framework (i.e., relevant local administrative organizations, planning and legislative context, and national and international concepts and strategies relevant to small green space) and economic and financial circumstances (i.e., financial standing of your FUA, city or district, financing possibilities). Documents that may aid in creation of your profile include landscape, land use, strategic and comprehensive strategies, and plans.

Pre-selection of UEA sites

The collection of information concerning potential UEA sites will result in understanding the main physical conditions of your FUA and potential UEA sites. This will help to identify the key problems and the spatial hot spots. The characteristics of the physical conditions may include but are not limited to the quantity of greenspace/green infrastructure in the FUA, city, or district information concerning areas selected for a potential green space (soil properties, plant and animal species, environmental hazards, etc.), green networks/human resources (complimentary initiatives for potential cooperation) and number of residents within walking distance of UEA sites. For the selection of potential UEA sites, the involvement of the local population is crucial. Often local people have a good knowledge about their neighbourhood and can enrich the analyses. A press campaign could support these activities and award the best proposals. The process of selecting the UEA sites in the analysis phase includes selecting the relevant intervention areas of your FUA or city, identifying potential sites within these areas, and analysing the potential sites in preparation for the final selection.

Data collection & generation if necessary

If some of the required data is not available, it may have to be self-generated via templates or surveys, or procured from an organization possessing the skills and tools. The process of generating data is a separate process from living labs. Keep in mind that the data collected or generated should be reliable and up to date to support proper decision-making and planning in the developmental phase.

Phase three - developmental phase (decide and plan actions):

To decide and plan actions in this phase you will conduct three activities, the final selection of UEA sites, defining plan measures and conducting a living lab to gain final input on the selected measures.

Final selection of UEA sites

Based on results of the analytical phase a short list of potential UEA sites has been created. Subsequently, selection of the green spot type and assessment of NBS applicability will be conducted resulting in a final selection of NBS. Selection of the type of green spot to be implemented is based on the type of site that one is working with such as: traffic areas, multifunctional public areas, areas for peace/reflection, semi-public areas, or fallow (vacant) areas. It must be decided whether the original function of the site will remain the same, be changed or if it is at all possible to transform the site into a certain type of UEA site (e.g., urban orchard, green roof, community garden, etc.). For further description of the technical features of UEA solution types see module 1, chapter 1 of this manual.

Defining plan measures

Based on the NBS selected, the action planning team will have to select actions necessary to implement the pilot projects. This includes targets or goals of the pilot project, that is, what is the purpose of your UEA sites? Which NBS have been selected and what must be constructed? This should include planting greenery such as, trees, bushes, climbing plants and grass, and where pertinent benches, small architecture, or gaming tables (For more information see: module 2, chapter 6 of this manual). Your action planning team can further consider what restrictions exist after the UEA sites have been selected (i.e., whether certain features are permitted such as greenery or flowers requiring care or large trees).

How do I decide and plan actions in this phase?

Who should make up the action planning team?"

What kinds of expertise are necessary and how many people should be included?"

Public feedback on the planning process - living labs

Photo: Microsoft Word Archive, 2021

Living labs are to be conducted in the FUA, city, or district with local inhabitants and stakeholders. Workshops should be organized locally together with project partners and other professionals. Living labs should consist of a guided discussion (e.g., round tables) and workshops to develop action plans for the UEA sites. This includes local and regional public authorities. The goals of the living labs should be to aid in criteria for selection of UEA sites, setting priorities and gaining knowledge from local stakeholders (SALUTE4CE, 2019). Conducting a living lab before you begin plan implementation may help to avoid any unnecessary conflicts or help to remind stakeholders of the tasks that they agreed on doing. The action plan should be finished at the conclusion of the developmental phase as it will guide implementation to create your small green spaces.

Part 3: Plan Implementation

The actions have already been defined as specific targets and measures identified in the developmental stage. This includes the task, date of completion and individuals responsible for carrying out the task. You should proceed after the developmental phase with plan implementation based on pre-determined actions. After, implementation maintenance and management plans can be created to ensure that pilot projects are maintained in the future. What's more, monitoring and evaluation of the implemented UEA sites can be conducted to measure the impact of UEA site creation. This is based on a set of indicators selected by the action planning team. Finally, a summary of the outlook and future perspectives for your pilot projects is recommended.

Table 1: The process of action planning for urban environmental acupuncture

Steps of the Process	Task Description
Problem statement – Goal formulation	
Step 1: Preparation Phase (preliminary activities)	-Deciding on responsible parties (e.g. forming an action planning team) -Gaining support for the pilot project (e.g. public, political & financial) -Defining planning procedures (e.g. Set milestones, work program, timetable)
Step 2: Analytical Phase (gather information, evaluation)	-Creation of a profile of your city/municipality (i.e. knowledge concerning general conditions and the local situation) -Pre-selection of UEA sites -Data collection & generation if necessary
Step 3: Developmental Phase (formation of action plan)	-Final selection of UEA sites -Defining plan targets and measures -Public feedback on planning process and concept to improve the action plan (i.e. living labs)
Plan Implementation	

Source: Authors' Illustration, 2021

How to continue once the plan is finished?

Summary

An important part of being successful at implementing urban environmental acupuncture is good preparation beforehand. This chapter has presented the basics of action planning and the process of creating an action plan. After action planning has been completed, you and your team should be well equipped to implement green space using the concept of urban environmental acupuncture. With an action plan in hand, you will have collected the required information to implement micro green space in your city. Including, the purpose of the action plan specific to your city as well as advantages and potentials of urban environmental acupuncture in addressing pressing urban challenges, identification of those responsible for specific tasks, visions and goals of your community, public, political, and financial support, data collection and analysis used to select UEA sites and project types, maintenance and management plans, and finally, monitoring and evaluation concepts to ensure that your UEA sites are both being maintained in the future and are producing the results that you and your team intended.

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