APPLICATION OF STRUCTURAL SUBSTRATE WITH BIOCHAR COMPONENT INTO THE URBAN WATER RETENTION MEASURES

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Abstract
The use of the structural substrate has the potential to be a valuable element in the planning and implementation of the blue-green infrastructure elements in the urban environment. The main objective of water retention measures in urban conditions includes absorption, sedimentation, infiltration, filtration, accumulation, and evaporation. The system of planting woody vegetation - the most important component of green infrastructure, into the structural substrate with biochar component shows the utilization of the filtering and absorbing capabilities of greenery and substrate itself in smaller rooting volumes. These parameters are essential in the environment with significant negative environmental conditions such as insufficient possibilities for the rooting system, urban heat islands, air and soil pollution associated with the immediate vicinity of the traffic communication, salination, lack of rainfall during the growing season. The paper presents methods focused on the utilization of structural substrates with a biochar component in the conditions of Slovakia.

Key words: blue – green infrastructure, sustainable landscape, urban planning

Introduction

The work explores the possibility of application of structural substrates to urban green infrastructures. Due to climate change, the incidence and intensity of extreme weather events are increasing. The technological use of the interconnection of blue and green infrastructure in the urban environment brings out the possibility of infiltration at the point of impact of precipitation, and thus imitates the natural hydrological regime. The benefit in the long run of blue-green infrastructure is the planned re-use of rainwater, compared to the classic drainage system and a unified sewer network. Also, microclimatic phenomena such as urban heat islands can be mitigated by measures associated with the level of development and the implementation of vegetation, water features, and permeable surfaces in the structure of green and blue infrastructure. The most demonstrable effect on the improvement of the micro and mesoclimate is woody vegetation elements, especially mature greenery. But due to the various stressors, it is often more difficult to create suitable long-term conditions for the growth of greenery in an urban environment, which provide space for short-term recreation space. This fact causes only a small percentage of planted trees to live through a period more than 10 years after planting.
The application of a structural substrate for new plantings in the urban environment creates many opportunities for the emergence of more resilient, adaptable cities in the future.

Material and methods

Soil sealing has a significant effect on the short hydrological cycle caused by residential, industrial, transport or energy infrastructures. Urbanized areas with a high degree of soil cover are characterized by large surface runoff. The high surface runoff is also covered by the reduced filtration function of the soil under the impermeable surface. Impermeable surfaces, therefore, contribute to the spread of pollution to more remote areas. The expansion of the built-up area and the construction of transport infrastructure also have a negative impact on the interconnections of natural habitats, biodiversity, and migration routes (Meli et al., 2017). Also, areas of the urban soils in residential areas with 60% of the built-up area are heavily polluted, since they have been less disturbed by anthropogenic activity, due to the high waste production and the concentration of smaller industrial parks, hospitals, and shopping centres with high energy intensity and transport infrastructure.
In Bratislava, the most risky areas in terms of soil quality are Nové Mesto, Ružinov, Nivy, Vrakuňa, Rača and partly Podunajské Biskupice. They represent sites that have a high risk of soil degradation from an environmental point of view due to the location of large industrial parks, environmental burdens, and waste management. Similarly, land corridors located near transport hubs represent unsuitable conditions. Sources of contamination are mainly carcinogenic substances (Cd), solid inorganic substances (Pb, Zn), gaseous inorganic substances, and salt contamination. Traffic lines are exposed to loads from exhaust emissions, which is reflected in the quality of the soils around them.

These pollution conditions increase the disintegration of the soil structure and have a limiting effect on the potential of nutrients absorption from the soils. Many urban areas do not provide soil conditions and flexibility for the growth of woody plants and especially trees, as most soils have an anthropogenically altered character. Such soils are characterized by a lack of nutrients, water, increased alkaline pH response, and compaction, which have a negative effect on nutrient absorption, absenting mycorrhizal fungi of root systems, and the overall health of vegetation in cities. Salt in combination with clayey soil causes the structure of the soil to collapse, minimizing pores leading to insufficient aeration, in addition to insufficient rooting volume. A functioning biota in the soil layer is essential for above-ground fauna and flora. Poor soil quality in urban areas lowers the standard of the environment, especially for housing and recreation. For this reason, increased protection measures that would at least partially eliminate the real and potential environmental hazards arising from the soil in this area are justified (Sobocká et al., 2020).

The network of green infrastructure elements is provided by elements of different scales and characters restoring ecological stability. Defining components could be applied both to the urban landscape and to the landscape. Examples of urban greenery components in conditions of Slovakia can be as follow (European Commission, 2013):

1. Green infrastructure areas connected with grey infrastructure – sustainable water management measures, street greenery, infiltration belts/areas, retention areas, vegetation based wastewater treatment plants, filter strips, swales,
2. Green areas infrastructure connected with blue infrastructure – greenery corridors of watercourses and water area (riparian vegetation), wetland vegetation, lakes/ponds, river/stream,
3. Green hubs – restored (semi)natural urban greenery areas with healthy functioning ecosystems, botanical gardens/arboretums/zoological gardens, urban green spaces (UGS), urban parks, cemetery and churchyard, green sports facility, urban forests, shrubland, abandoned and derelict area with patches of wilderness,
4. Greenery corridors next to the transport infrastructure – woody vegetation stripes, alleys,
5. Building greenery - green vertical systems (VGS) and roof greenery, atrium, green fences, green parking pavements, noise barriers,
6. Stepping stones/buffer zones - smaller landscaped areas, pocket parks, allotments, community gardens.

Green infrastructure has many multidisciplinary functions and benefits: environmental - regulation of soil erosion and other slope processes, support of soil-forming processes, decomposition of harmful substances; ecological - promoting biodiversity, life cycles, and processes; microclimatic and hygienic - improving air quality and microclimate in the urban environment; mitigation and adaptation to climate change – positive influence of hydrological cycle and runoff conditions; economical; social and psychological function. An absence of trees is the biggest negative factor in urban structure. In addition to the aesthetic value, green areas have a positive effect on physical and mental health (Hunter et al., 2019). The support of urban green spaces is the most economical and effective strategy for increasing resilience in terms of climate change (Gillner et al., 2015).

Results

The importance of greenery in the urban has been proven, but it is necessary to provide suitable environmental conditions. The potential for improving the conditions for the development of tree growth and thus better opportunities for short-term recreation can be reached by using a structural substrate for vegetation in central urban areas, areas with high pollution, sustainable water management measures, green hubs or buffer zones. The structural substrate is more suitable for urban space than the classic substrate since the fractions of aggregate cant be compacted to the extent as the urban soils and the biochar component is responsible for the filtration of harmful substances, which offers a suitable environment for long-term tree growth. Therefore, the use of a structural substrate is more suitable for areas of short-term recreation in an urban environment. The used structural substrate model consists of a mixture of gravel aggregate, organic matter, and a biochar component in the planting area. The ratio can differ but the standard is about 3/4 of the volume of 4-8 mm fraction of aggregate, 1/8 of the organic part, and 1/8 of organic biochar. The use can be combined with drained semi-permeable street spaces, which will provide space for healthy growth, tree development and support of ecosystem services. The structural substrate provides many benefits associated with the prevention of subsoil compaction, the negative impact on nutrient absorption and surface permeability, the retention of rainwater, resulting in a higher tree survival rate, easier access to technical engineering networks, and, in the long run, financial costs and support.

The concept of "Ecosystem Services", makes it possible to assess the environmental consequences of climate change and its effects on society. Ecosystem services are related to habitat and biological conditions, and a particular ecosystem may provide several ecosystem services with different values and production. The value of biodiversity and ecosystems is not negligible, but it was necessary to evaluate ecosystem services to understand their relevance within society and in decision-making processes. Classification of ecosystem services can be divided into supply services, regulatory services, habitat services, and cultural services. Urban green spaces with the potential for short-term recreation in the urban environment offer several components of human well-being. Among the ones that result from the functional interconnection of blue-green infrastructure, we can include recreation, climate control, flood control, natural habitat for organisms, water pollution treatment, recreational function, mental health promotion, social function, mitigation of extreme, natural habitat for organisms, biodiversity conservation, stabilization and soil-forming function, aesthetic function and source of inspiration and education (Mader et al., 2011). The results of the importance of greenery in the urban environment confirmed the short-term benefits and enhancing effects of residential greenery on the psychological side of human vitality such as increased attentional capacity, reduced internal noise (van den Berg et al., 2010), and reflection, increased mental activity (Oguma a Shinoda-Tagawa, 2004), stress reduction. In the case of loss of greenery around human developed countries, a negative impact on health is detected. The results demonstrate the increased mortality associated with cardiovascular and respiratory diseases caused by the sudden loss of large areas of greenery caused by pests (Donovan et al., 2013). With a sufficient number of green areas in the urban structure, especially the woody vegetation in the scale of parks interconnected with pocket parks and buffer zones has been a significant increase in ecological stability and ecosystem services (Liu a Shen, 2014).

Discussion

Abroad, it is possible to see these connections and support systems of blue, green and grey infrastructure with new urban development entities and revitalizations of inefficient existing sites. The implementation of such projects in Slovakia is not common. In the example of Bratislava, we can see the efforts to transform a more sustainable city from the municipal office itself. The demands of the population for recreation began to increase in the middle of the 20th century as long term recreation, but since most of the population lives in urban areas, short-term recreation has become more and more sought after. Various measures have been implemented to increase the quality of short-term recreation in the urban environment for children and adults, and also in public greenery.

Conclusion

To ensure ecosystem services of an urban landscape, the application of sustainable modern urban development measures in areas with complex problems of each component of the local environment is the priority. The use of structural substrate is a potential solution to this goal. In the Slovakia region, mainly in Bratislava´s central urban area, problems have been defined and the process of planning and implementing initial projects are currently being worked on.

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Souhrn
Využití strukturálního substrátu má potenciál být cenným prvkem při plánování a realizaci prvků modrozelené infrastruktury v městském prostředí. Hlavním cílem opatření pro zadržování vody v městských podmínkách je absorpce, sedimentace, infiltrace, filtrace, akumulace a výpar. Systém výsadby dřevinné vegetace - nejdůležitější součásti zelené infrastruktury, do strukturního substrátu s biouhlovou složkou ukazuje využití filtračních a absorpčních schopností zeleně i samotného substrátu v menších kořenových objemech. Tyto parametry jsou zásadní v prostředí s výraznými negativními podmínkami prostředí, jako jsou nedostatečné možnosti kořenového systému, městské tepelné ostrovy, znečištění ovzduší a půdy spojené s bezprostřední blízkostí dopravní komunikace, zasolení, nedostatek srážek ve vegetačním období. Příspěvek představuje metody zaměřené na využití strukturních substrátů s komponentou biocharu v podmínkách Slovenska.

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