IMPLEMENTATION OF GREEN INFRASTRUCTURE ELEMENTS TO MITIGATE CLIMATE CHANGE AND IMPROVE RECREATION IN THE MUNICIPALITY OF DRIENOV, SLOVAKIA

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https://doi.org/10.11118/978-80-7509-904-4-0106

Abstract
Green infrastructure, as an often-used term in several political documents and strategies of the European Commission dealing with the protection of biodiversity, adaptation to climate change, protection of water resources and flood prevention, serves as a tool to ensure ecological, environmental, economic, social and urbanistic benefits through natural solutions. From a sociological point of view, green areas represent a landscape element with recreational potential in a residential environment. The task of green infrastructure is to connect individual areas of greenery at the level of cities, municipalities and in the open country. Together with the blue infrastructure, it provides various forms of benefit for the population in urban settlements and improves the quality of life. Green and blue infrastructure solutions are particularly important in the urban environment, where more than 60% of the EU population (and approx. 53% of the Slovakia population) lives.
The contribution is focused on the design and subsequent implementation of green infrastructure elements in the village of Drienov, situated in the east of Slovakia in the Kosice Basin (Košická kotlina). The goal is to create infrastructure elements and objects that together will create a functional unit and improve the quality of life of people in the village. The goal can be fulfilled by creating several separate objects whose technical and social functions are interconnected. The results of this study are proposed elements as green areas made of semi-vegetated blocks, an underground tank, a rain garden in the exterior premises of the Drienov municipal office and a semi-vegetated retaining wall, which in the future would form a pleasant relaxation zone supplemented by trees, bushes, flowers and benches.

Key words: green areas, Kosice Basin, rain garden, retention tank, vegetation retaining wall

Introduction

Despite the fact that the term "green infrastructure" is used in several political documents and strategies of the European Commission dealing with the protection of biodiversity (EC 2020), adaptation to climate change (EC 2021), protection of water resources and flood protection, it is still a relatively new term in Slovakia (Hudeková et al. 2018). In the Nature and Landscape Protection Act (NC SR 2002), green infrastructure is defined as a network of natural and semi-natural elements, primarily green areas and water ecosystems, which is created and managed to provide a wide range of ecosystem services, with particular attention to ensuring biological diversity, ecological stability and favourable environment and the connection of the urbanized environment with the surrounding landscape. Green infrastructure is also understood as an effective measure to mitigate the effects of climate change mainly in urban areas and also to improve the quality of life in the context of recreation (Zeleňáková & Junáková 2022).
Through the natural retention and absorption capacity of vegetation and soil, green infrastructure can, for example, be used to reduce the amount of stormwater runoff into sewer systems and subsequently into lakes, rivers and streams. Increasing the sequestration of carbon, improving air quality, mitigating the urban heat island effect, creating additional habitats for wildlife and creating places for recreation (Junáková et al. 2020) could be among the benefits of green infrastructure in such a case. Green areas also contribute to the creation of a cultural and historical environment and determine the identity of cities, as well as the scenery of urban and suburban areas in which people live and work. Studies (Xu et al. 2019; De Sousa et al. 2012) show that green infrastructure solutions are less expensive than grey infrastructure solutions and provide a range of additional benefits for local economies, social sphere and the wider environment. However, in an urbanized landscape, green infrastructure can also be implemented by fusion with grey infrastructure (Balko et al. 2017).
Respect for nature on the part of human activity is important for the development of cities and residential areas, therefore the effective construction of green infrastructure according to valid standards is authoritative when implementing new urban areas.
The aim of the paper is to design and implement green infrastructure elements in the village of Drienov.

Material and methods

The village of Drienov is located in the east of Slovakia. It is located in the Košice basin in the valley of the Drienovský streams and its tributaries. It flows into the Torysa River. Administratively, the village belongs to the district of Prešov and the Prešov self-governing region. The cadastre of the village is located in the southern part of the district. The altitude of the village center is 219 m above sea level. The entire cadastral territory of the Drienov village is located in a moderately warm area with an average July temperature of 16 °C to 18 °C. The January temperature average ranges from -3 °C to -4 °C. The average annual temperatures in the moderately warm areas vary from 4° C to 8° C. The amount of precipitation in this area is around 600 to 700 mm per year, while its amount increases with altitude. On average, the month with the most precipitation is July, followed by June and August. December is the poorest month for rainfall.

In order to increase the ecological stability in the village of Drienov and improve the quality of people's life and the recreation potential of the village itself, elements and objects of green infrastructure were designed in the village, which together will create a functional unit.

General technical description of the proposed water retention measures

Several separate objects were designed, which technical and social functions are interconnected. The basic proposed elements are: green areas made of semi-vegetated blocks, an underground tank, a raingarden in the exterior premises of the Drienov municipal office and a semi-vegetated retaining wall, which in the future would form a pleasant relaxation zone supplemented by trees, bushes, flowers and benches.

Semi-vegetated blocks belong to important green alternatives for building paved areas. The block system is resistant to impacts, chemicals, UV radiation, high traffic loads and bacteria found in the ground. Their perforated surface creates a space for water absorption and they have very good properties for roads with medium loads (suitable for parking lots and driveways). They make it possible to transform paved areas into a green zone, and their great advantage is the possibility of use immediately after installation.

Other methods of reducing rainwater runoff from roofs are technically more demanding, but they also have much greater possibilities of using collected rainwater. An example is an ***underground collection tank*** buried below ground level, which enables the collection and subsequent use /retention/ of rainwater as service water in the building or for irrigation garden needs.

Raingarden, as another important green infrastructure element, serves to collect rainwater from reinforced impermeable surfaces, such as roofs, sidewalks, parking lots, driveways. The water should be retained in it for a maximum of 48 hours. The size of the rain garden will influence the depth and slopes. The ideal depth of a raingarden is between 15-30 cm. At a depth of 15 cm, the rain garden will need to be quite large to have enough capacity to accumulate the collected volume of rain. On the other hand, a rain garden deeper than 30 cm may retain rainwater for too long depending on the soil substrate. In general, raingarden slope gradients of more than 12% are not suitable. The installation of a rain garden is recommended in the lowest areas of the flat part of the plot. Determining the size (infiltration area) of a rain garden for well-draining sandy soil is recommended at a ratio of 5:1 (collection area to rain garden area). If the soils are of poorer quality and less permeable, then a ratio of 3:1 is recommended. The collection area is 150 m^2, the area of the raingarden is 30-40 m^2. If the floor plan area of the rain garden exceeds 30 m^2, it is recommended to divide the rain garden into several smaller gardens. The maximum area of the rain garden is 45 m^2.

Height differences in the terrain on the plot can be solved in several ways, but the technically simplest alternative is the construction of ***retaining walls***. It is a structure that is mainly used to separate height differences in the terrain, between buildings or between individual plots of land. Its function also consists in preventing landslides from the slope, it levels the terrain and often architecturally completes the garden and the environment by planting plants and bushes.

Results and discussion

Fig. 1 shows a situational drawing of the individual proposed objects of green infrastructure in the village of Drienov.

Fig. 1: Location of individual proposed objects of green infrastructure in the village of Drienov (SO.01 Main green semi-vegetated area, SO.02 Side green semi-vegetated area, SO.03 Underground retention tank, SO.04 Raingarden, SO.05 Vegetation retaining wall, SO.06 Belt of greenery)

Main green semi-vegetated area *(SO.01)* ***and side green semi-vegetated area*** *(SO.02): The* original surface is formed as a degraded asphalt-gravel layer and it needs to be replaced. The proposed semi-vegetated area will be made of concrete original prefabs 600x1500x15000 mm (15pcs – SO.01 and 11 pcs – SO.02) filled with soil compacted layer by layer from demolition works and subsequently as a reinforced road formed by layers of gravel embankment fr. 0-62mm of thickness 200 mm, mechanical reinforced aggregate fr. 16-32mm with a thickness of 150 mm and a bed layer fr. 4-8mm thickness 50mm. They need to be thoroughly compacted. Before laying the top layer formed by system perforated grass blocks 80 mm thick, it is necessary to lay a layer of geotextile, after laying the blocks it is necessary to backfill with crushed stone fraction 4-8 mm for their stabilization. A curb will be installed around the perimeter in a concrete bed made of plain concrete. It is necessary to observe a technological break. The total paved area is 211.50 m^2 for SO.01 and 172.00 m^2 for SO.02.
Underground retention tank *(SO.03): the* building of the municipal office will be drained using a drainage pipe under the ground and from there to a collection tank in the back part of the property in the green belt next to the sidewalk. The water inflow to the collection retention tank will be guided by gravity on the facade with an outlet to the collection tank with a volume of 5,000 L, through a Ø 150 pipe and treated by a filter unit in front of the tank. A pump will be installed in the collection tank for the possible use of rainwater for irrigation of the surroundings in drier months. The outflow of water in case of overfilling of the collection tank will flow through the overflow through a Ø 150 pipe and then into the raingarden. The capacity of the underground reservoir is determined on the basis of 5-year average of long-term precipitation totals for the Prešov district, runoff coefficient and area of the roof of the municipal office.
The central part of the territory can be used for the construction of a ***raingarden*** *(SO.04).* It would be a raingarden that would serve to retain water in the soil in the exterior premises of the municipal office. The inflow of water to the raingarden would be from the collection underground tank after its maximum volume filling, or drainage of the nearby retaining vegetation wall. The raingarden will have an irregular oval shape with an area of up to 40 m^2.
The vegetation retaining wall *(SO.05)* will be part of common outdoor spaces and serves to ensure height differences in the terrain and around paved areas. The height difference in studied area is variable according to the configuration of the terrain and reaches a height of approx. 2.10 m. The retaining wall is designed as a gravity wall, with original concrete prefabs loaded on one side by earth

pressure. Concrete prefabs are stored lying down. In the gaps formed by placing the panels lying down, there is a layer of soil, sand and substrate for planting suitable plants and bushes to improve the climate and supplemented with ecological system of vegetation retaining wall (ECObag), which will form the visible side of the retaining wall. After the plants are planted, the ECObags will over time become overgrown with vegetation, so they will not be visible and thus they create a green wall.
The elements of green infrastructure in the studied area will also be complemented by a ***green belt*** *(SO.06)* consisting of trees (2 pieces of Tilia tomentosa Silver Globe, 3 pieces of Prunus cerasifera Nigra), bushes (24 pieces of Berberis thunbergii) and beds of perennials.

Conclusion

Vegetation is an integral part of the urban structure of settlements and is often referred to as an essential naturalizing component of the environment in cities. In connection with global warming and climate change, the environmental aspects of building green infrastructure elements in cities are coming to the fore. In addition to having physical, psychological, emotional and socio-economic benefits for the individual and society, the elements of green infrastructure create opportunities to connect urban and rural areas and create pleasant places to live and work.
The paper summarizes the design and creation of possible elements and objects of green infrastructure in the village of Drienov (Slovakia) with the aim of mitigating the impacts of climate change in the urban environment. Green areas made of semi-vegetated blocks, an underground retention tank, a rain garden and a semi-vegetated retaining wall can be included among the important elements of green infrastructure, which are also applied in the studied area.

References

Balko, Z. et al. (2017). Construction of green infrastructure elements in Slovakia (in Slovak). Banská Bystrica, Slovakia: Slovak environment agency.
De Sousa, M.R., Montalto, F.A., Spatari, S. (2012). Using life cycle assessment to evaluate green and grey combined sewer overflow control strategies. J*. Ind. Ecol*, 16 (6): 901–913.
European Commission (2021). An EU Strategy on adaptation to climate change. Brussels, Belgium.
European Commission (2020). EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Brussels, Belgium.
Hudeková, Z. et al. (2018). Green infrastructure: A guide not only for municipalities (in Slovak). Bratislava, Slovakia: City District Bratislava-Karlova Ves.
Junáková, N., Zeleňáková, M., Mihaľová, N. (2020). Recreational potential of the Lower Zemplín region in the Bodrog river basin. In: J. Fialová (Ed.). Public recreation and landscape protection – with nature hand in hand? Conference proceeding. Brno, Czech Republic: Mendel University in Brno, 2020: 397-400.
NC SR - National Council of the Slovak Republic (2002). Act No. 543/2002 on Nature and Landscape Protection. Bratislava, Slovakia.
Xu, C., Tang, T., Jia, H., Xu, M., Xu, T., Liu, Z., Long, Y., Zhang, R. (2019). Benefits of coupled green and grey infrastructure systems: Evidence based on analytic hierarchy process and life cycle costing. *Resour. Conserv. Recycl.,* 151:104478.
Zeleňáková, M., Junáková, N. (2022). Water retention measures as an element of adaptive measures to tackle the climate change in the city of Trebišov, Slovakia In: J. Fialová (Ed.). Public recreation and landscape protection – with Environment Hand in Hand… Conference proceeding. Brno: Mendel University in Brno, 2022: 446-449.

Acknowledgement

The authors are grateful to the projects HUSKROUA/1702/6.1/0072, HUSKROUA/1901/8.1/0088 VEGA 1/0308/20 and 011TUKE-2-1/2021 for financial support of this work.

Souhrn

Vegetace je nedílnou součástí urbánní struktury sídel a bývá označována za nezbytnou naturalizační složku prostředí ve městech. V souvislosti s globálním oteplováním a klimatickými změnami vystupují do popředí ekologické aspekty budování prvků zelené infrastruktury ve městech. Kromě fyzického, psychologického, emocionálního a socioekonomického přínosu pro jednotlivce a společnost, vytvářejí prvky zelené infrastruktury příležitosti pro propojení městských a venkovských oblastí a vytvoření příjemných míst pro život a práci. Příspěvek shrnuje návrh a tvorbu možných prvků a objektů zelené infrastruktury v obci Drienov (Slovensko) s cílem zmírnit dopady změny klimatu na městské prostředí. Mezi významné prvky zelené infrastruktury, které se uplatňují i ve studovaném území, lze zařadit

plochy zeleně z polovegetačních tvárnic, podzemní retenční nádrž, dešťovou zahradu a polovegetační opěrnou zeď.

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