WATER RETENTION MEASURES AS AN ELEMENT OF ADAPTIVE MEASURES TO TACKLE THE CLIMATE CHANGE IN THE CITY OF TREBIŠOV, SLOVAKIA

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Abstract
Many countries are currently facing environmental problems related to climate change. Adaptive measures that reduce landscape vulnerability and increase the adaptive capacity of natural and man-made ecosystems to the current or expected negative effects of climate change are a response to the demand for its mitigation. Selected adaptation measures can be implemented as a system of measures aimed at improving the hydroclimatic conditions of the landscape, especially by influencing its water retention function.
The paper focuses on the design of water retention measures in the area of the secondary school in the town of Trebišov, located in the Lower Zemplín region in Slovakia. The proposed water retention measures are implemented by retaining and draining rainwater during heavy rainfall from paved areas and collecting areas of roofs. The results of this study are newly built drainage pipe systems with the creation of retention structures of rain gardens, infiltration trenches, vegetation walls and rainwater collection tanks for watering, including permeable areas of vegetation blocks.

Key words: rainfall, vegetation wall, Lower Zemplín, rain garden

Introduction
Climate change, as a phenomenon of the 21st century, is becoming one of the biggest challenges of environmental policy (WEF 2018). Although the signs of climate change vary around the world and in the regions, its adverse effects on socio-economic and natural systems are increasingly significant and require an active solution (ME SR 2018). They are most pronounced in urban settlements, which are characterized by impermeable surfaces with a high concentration of human activities (Zeleňáková et al. 2015). This leads to a significant increase in air and surface temperature (ME SR 2018). Currently, more than half of Slovakia's population (approx. 53% of the total population) lives in cities (SO SR 2021). A solution that should ultimately prevent, or at least minimize the risks and negative consequences of climate change, is to combine mitigation measures (measures to reduce greenhouse gas emissions) with measures that reduce vulnerability and enable the adaptation of humans and ecosystems through lower economic, environmental and social costs (Andrejčinová et al. 2018).
Great emphasis is placed on the application of elements of green and blue infrastructure in the urban environment, which preserve the values and functions of native and nature-friendly ecosystems. Thus, individual settlements urgently need to plan and implement measures to mitigate impacts and adapt to climate change. There is a growing interest in natural water retention measures (Strosser et al. 2015), which can contribute to achieving the objectives of various European Union policies, e.g. EU Strategy on Adaptation to Climate Change, EU Biodiversity Strategy for 2030, EU Action on Water Scarcity and Drought, etc.
According to (Tešliar et al. 2020), the city of Trebišov also belongs to one of the cities in eastern Slovakia, which is included in the group of municipalities endangered due to the significant impact of climate change. It is assumed that in the future the most serious problems in the town of Trebišov will include heat waves, droughts, drinking water scarcity, floods, and loss of soil organic matter due to conventional land management. To mitigate these negative consequences, it is necessary to take partial steps in the city.
The aim of the paper is to design new, or to revitalize the existing water retention measures in the individual premises of the secondary vocational school in the town of Trebišov.

Material and methods
The town of Trebišov as the center of the Lower Zemplín region lies in the southwestern part of the East Slovakian lowlands. It is located at an altitude of 109 m above sea level, mostly on the right bank of the Trnávka stream, a tributary of the Ondava river. From a hydrological point of view, the territory of the Trebišov district belongs to the sub-basin of the Bodrog river. The whole Bodrog basin can be assessed as water-rich, rainfall-rich and with a relatively high runoff coefficient.The Trebišov district is mainly an agricultural region. The dominant features are fertile lands, orchards, green gardens, floodplain forests with nature reserves and picturesque hills with the scenery of the Slanské Hills,

which provide opportunities for recreation and relaxation. The Tokaj wine region is a part of this locality, which has excellent wines of the highest quality and great recreational potential (Junakova et al. 2020; 2021).
Revitalization and design of water retention measures is carried out in the area of a secondary school in the town of Trebišov (Fig. 1). The original state of the existing objects and the solved area is shown in Fig. 2.

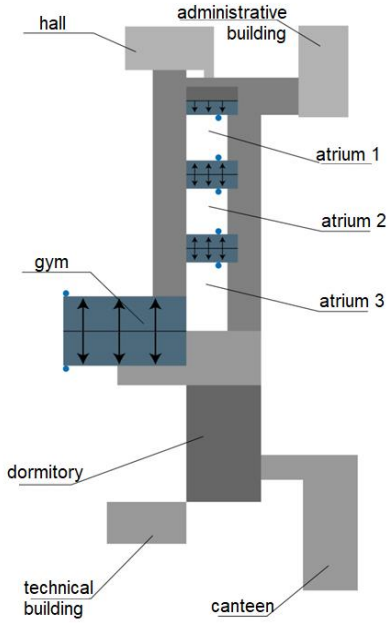

Fig. 1: Design of rainwater harvesting system from the roofs of the school (Note: The arrows show the slope of the roof)

The proposed measures are intended to retain and drain rainwater to the collecting underground tank, rain garden, and infiltration trenches from the roof and paved areas in the area of the school atrium and thus reducing the total amount of water flowing into the area during torrential rains. At the same time, the goal is to improve the fauna and flora in the solved area during the drought.

Results and discussion

Technical description of the proposed water retention measures

The proposed water retention measures consist of the following objects: rain garden, underground rainwater tank, vegetation blocks, infiltration trench and vertical vegetation wall.
The bio-retention rain garden is used to collect rainwater from the school roof and rain gutters in Atrium 1, as well as from other paved areas. The planned area of the garden is 19.0 m^2 with the shape of an ellipse with dimensions of 4x6 m. The realization of the bio-retention garden is preceded by the construction of a grassy area of the school Atrium 1 by the reconstruction of a paved concrete area. This object consists of individual branches of collecting pipes, which are connected to an underground rainwater tank, where rainwater flows gravitationally through the existing rain gutters of the school roof.
The underground rainwater collection tank with a capacity of 1500 L (determined according to the amount of rainwater and usable roof area) is an object partially engaged below ground level, which is used to collect and regulate rainwater during torrential rains from the school roof collection areas in Atrium 1, 2, and 3. Object consists of individual branches of collecting pipes, which are connected to existing rain gutters. Parts of this object are directly interconnected and at the same time the tank is connected to the rain garden, and/or infiltration trench. The water retained in the reservoir can serve as irrigation during the dry season. The tank is designed with a safety overflow.

a)

b)

c)

d)

Fig. 2: Original state of the existing objects in area of school: a) Atrium 1; b) Atrium 2; c) Atrium 3; d) Area in the western part of the school

Another proposed water retention measure in the area is the use of vegetation blocks, which serve to strengthen and protect grasslands burdened by walking and lightweight means of transport (bicycles). Their surface makes up more than 90% of the space for rainwater infiltration, while ensuring free circulation of water and air. Grass blocks make it possible to change paved areas to a green zone and their great advantage is the possibility of use immediately after installation.

Rainwater from the underground collection tank that retain rainwater from the collecting roof areas of the buildings and from the grassed areas will be taken by the infiltration trench. The proposed trench infiltration area in Atrium 2 will be a trapezoidal cross-section with dimensions of 9.0 m^2 (1.5x6.0 m). In Atrium 3, the area of the infiltration trench will have a triangular cross-section with an area of 10.0 m^2 and dimensions of 1.0x10.0 m.

The vertical vegetation wall in the Atrium 3 will consist of a panel construction with vegetation plantings of climbing plants with drip irrigation, the length of which will be 7.5 m. The wall will serve as a visual barrier and will use part of the retained rainwater. Various and well-proven plant species can be used for planting, such as *Hedera helix*, *Celastrus scandens* or *Parthenocissus quinquefolia*. The advantages of the system are the color diversity of the surface, increased biodiversity, increased utility value of the building, non-flammability, and the possibility of use as a double-sided green partition wall, screen or double-sided green hedge.

Conclusion

The main goal of adaptation to climate change is to reduce the vulnerability of the settlement environment to the adverse effects of climate change and to increase the ability of settlements to

adapt to new, often extreme conditions. Rainwater management in urban areas can be based on the principle of retaining rainwater in the environment where it falls. The current practice is focused on the fastest possible drainage of rainwater from the urban area. Innovative solutions based on the artificial retention of rainwater in the city's structures in the rain-free period allow this water to be used to improve the city's microclimate, irrigation of parks, atriums or through recycling to other urban needs. There are several technological solutions available to improve the environment, which are often used in developed countries. Several systems can have alternative solutions and by connecting them it is possible to achieve a quality and pleasant environment, which is the aim of this study.

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Souhrn

Cílem adaptace na změnu klimatu je především snížení zranitelnosti sídelního prostředí vůči nepříznivým důsledkům změny klimatu a zvýšení schopnosti sídel přizpůsobit se novým, často extrémním podmínkám. Manažment dešťových vod v intravilánech měst lze založit na principu zadržení dešťové vody v prostředí, kde padne. Dosavadní praxe je orientována na co nejrychlejší odvedení dešťové vody z území intravilánů. Inovativní řešení založená na umělém zadržení dešťové vody ve strukturách města v období bez dešťů umožňují tuto vodu využívat ke zlepšování mikroklimatu města, závlahy parků, atrií resp. prostřednictvím recyklace na jiné potřeby míst. Pro zkvalitnění prostředí je k dispozici několik technologických řešení, která jsou ve vyspělých zemích často využívána. Několik systémů mohou mít alternativní řešení a jejich propojením lze dosáhnout kvalitního a příjemného prostředí, což je cílem i této studie.

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