FLOOD PROTECTION OF THE NIŽNÝ HRUŠOV VILLAGE USING WATER RETENTION MEASURES

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Abstract
Green-blue infrastructure elements provide a wide range of ecosystem services, such as water purification, air quality, space for recreation, and climate change mitigation and adaptation. Their integration makes our urban spaces more resilient, pleasant, and healthy places to live, work and play.
The contribution is focused on the proposal of suitable water retention measures in the village of Nižný Hrušov (Slovakia) with the aim of ensuring the safe drainage of rainwater and the protection of the inner village against flood flows in the stream during increased surface rainwater flows. The result of this study is the design of several separate objects, such as an infiltration pipe - a trench, inspection and cleaning shafts, a detention tank, and a rain garden, whose technical and social functions are interconnected.

Keywords: green-blue infrastructure, rain garden, infiltration system, detention tank, floods

Introduction

The consequences of climate change have different frequency and intensity in different regions, and we observe their manifestations in Slovakia more and more frequently in the form of floods (Zeleňáková et al. 2017), landslides, long-lasting periods of drought, etc. It is climate change that results in frequent and intense rainfall that leads to floods (IPCC 2023). These floods can have devastating consequences on people's lives, infrastructure and the economy and therefore require an active solution.
The selected adaptation measures can be implemented as a set of measures aimed at improving the country's hydroclimatic conditions, primarily by influencing its water retention function (ME SR 2018). The implementation of water retention measures for adaptation to climate change in settlements and the landscape and preparation for floods are key for reducing the risk of floods and their impacts. Their goal is to retain water and thus slow down its outflow into rivers, which reduces the risk of floods. Already in 2006, the Association of Cities and Towns of Slovakia proposed a new approach to flood prevention, which consists in restoring the water-holding capacity of a sub-basin and reducing erosion processes (e.g. Junakova & Balintova 2012) in the territory of the municipality (ZMOS 2007). The implementation of such measures will make it possible to prevent the occurrence of floods in the territory of the municipality to a minimum.
An important element that complements the function of water retention measures not only in reducing the risk of floods is green infrastructure (Jarosińska & Gołda 2020). It creates a pleasant environment for rest and recreation, offers various possibilities for active and passive relaxation, thereby contributing to the improvement of the quality of life in cities and towns.
The aim of this contribution is the proposal of suitable water retention measures in the village of Nižný Hrušov (Slovakia).

Material and methods

Study area

The cadastral territory of the village of Nižný Hrušov extends on the Ondava ridge of the East Slovak Plain on the terraces of the Ondava river, which pass into the Pozdišovská upland. Based on the administrative division, the village of Nižný Hrušov is located in the Prešov region and the Vranov nad Topľou district. The center of the village is at an altitude of approx. 130 m a.s.l. The assessed cadastral territory falls into the warm climatic region, moderately humid sub-region, with cold winter. The average annual temperature is 7.8 °C, the average temperature in January ranges from -2.5 to -5 °C, the temperature in July is from 17 to 18.6 °C. The average amount of precipitation is 700 to 720 mm per year. The richest months for precipitation are July

and August, the poorest are February and March. The number of days with snow cover reaches 80 days. From a hydrological point of view, the territory of the village of Nižný Hrušov belongs to the Bodrog watershed. The Ondava watercourse and its tributary Kyjov watercourse, Hrušovský stream and other small watercourses flow through the village of Nižný Hrušov. The village is part of the water management important area called “River alluvium of the Ondava”.

Design of a rainwater management optimization system and its technical description

To improve the system for optimizing rainwater management in the village, several separate objects should be designed as part of water retention measures in the village such as an infiltration pipe - a trench, inspection and cleaning shafts, a detention tank, a rain garden and semi-vegetation panels. The main goal of this system is the collection of rainwater and its reuse in the studied location.

The system of collecting infiltration perforated pipes - trench offers an effective and sustainable solution for managing stormwater runoff and promoting groundwater recharge in urban and suburban areas. Their purpose is to improve the collection of rainwater from the surface, its retention and slowing the infiltration.

In a water retention system that uses infiltration trenches with perforated pipes, the use of **inspection and cleaning shafts** are crucial components (Fig. 1). They enable monitoring, maintenance, and ensure the system functions effectively and durably in managing stormwater runoff and promoting groundwater recharge.

Artificial structures - **detention tanks** - can be designed to temporarily retain stormwater runoff, where stormwater runoff enters through storm drains (Fig. 2). Surface runoff is collected in these structures until the maximum inflow volumes have fallen. From there, the retained rainwater is released at a controlled rate into nearby water bodies, or it can then be used for various purposes. This method of rainwater management helps reduce flooding in our municipalities. They can be installed either above ground or below ground. Underground detention systems are suitable because they allow the space above them to be used for parking lots, grass areas, etc.

Fig. 1: Example of inspection shaft

Fig. 2: Example of underground detention system

Rain garden is a practical tool for water retention strategies. It isn't a unit of measurement itself, but its design and function significantly impact how much rainwater is captured, stored, and infiltrated back into the ground. It can help reduce the risk of flooding in municipalities. During the design phase, it is necessary to estimate its potential water retention capacity based on its size, depth, and soil properties (Zeleňáková & Junáková 2023). This helps determine if the rain garden can manage the targeted amount of stormwater runoff for the specific area.
Other components of a water retention strategy that can indirectly influence water retention are **semi-vegetation panels.** They can be a contributing factor in a water retention strategy when used alongside other methods and with careful plant selection.

Results and discussion
Figure 3 shows the situation of wider relations of the designed water retention measures in the village of Nižný Hrušov.

Infiltration pipe - a trench (SO.01) with a clear width of 350 mm will be implemented in the places of the original sewer channel formed by concrete slabs in the shape of a trapezoid, where the width conditions of the road and the relevant plots do not allow the installation of an open channel. Sewerage will be implemented in a section of approximately 194 m in length in the green belt next to the road, where three cleaning shafts will be installed. Above the route and along the route of the infiltration pipe - trenches, trees must not be planted so that the roots do not enter the pipe and break it.
Three **inspection shafts** (SO.02) are designed on the inlet infiltration perforated pipe in front of the detention tank and along the length of the pipe.
A **sludge tank with cleaning shaft** (SO.03) is designed to collect coarse dirt. The design is based on the value of the 5-year rain ($q = 141\ l.s^{-1}.ha^{-1}$). Considering the terrain and the surrounding road, the design considers a surface factor of 0.8. $Q = (1{,}950\ m^2 \times 0.8 \times 141 / 10{,}000) = 21.99\ l.s^{-1}$. The proposal considers the nominal size of the trap NS 40 with a total volume of $4m^3$. A self-supporting sludge tank made of fiberglass is designed, without the need for concreting. The tank has a total height of 2,050 mm and a diameter of 2,340 mm. An inspection shaft with a non-return valve will be installed on the supply sewage pipe in front of the detention tank. The flap will also be used as an inspection – service (cleaning shaft).
The collection of rainwater flows into a collection **detention tank** (SO.04), which will be installed in a green area at the end of the collection system and another near the cemetery. The retained water will be used for watering the greenery. The detention tank will be designed from system infiltration boxes with a permissible load of SLW30 (passenger transport). The proposed retention system will have a total system volume of $2 \times 12.0\ m^3$. The tank consists of basic elements (800 x 800 x 660 mm), which are assembled into a connected block system.

The **rain garden** (SO.05, Fig. 4) is designed in the place of the safety overflow of the concrete threshold of the water flow in front of the municipal office, with a total area of approx. 120.0 m^2 with an irregular floor plan shape. Its task is the retention and slow the natural absorption of surface water from the banks of the water course in the studied area place. The rain garden is technically designed as a drainage depression at a depth of 500 mm below ground level. The planting and species composition of the plant formations respects the climatic conditions of the environment, and is designed to achieve a year-round effect with a minimum of necessary maintenance. The planting itself is handled in two zones - according to the state of wetting. At the edge of the garden - in zone 1, plants suitable for normal and partially wet environments are planted such as *Ajuga reptans, Anemone hybrida, or Liatris spicata*. Plantings with occasional flooding are intended for the 2nd zone (e.g. *Iris sibirica, Pachysandra, Physostegia*).

In order to mitigate the negative consequences of excessive rainfall, the paved areas will be designed as **semi-vegetated concrete grass panels**. The total proposed area of semi-vegetated areas will be 180.0 m^2.

Fig. 3: Location of individual proposed objects of water retention measures in the village of Nižný Hrušov (SO.01 Infiltration pipe - a trench, SO.02 – Inspection shaft, SO.03 – Sludge tank with cleaning shaft, SO.04 – Detention tank, SO.05 – Rain Garden)

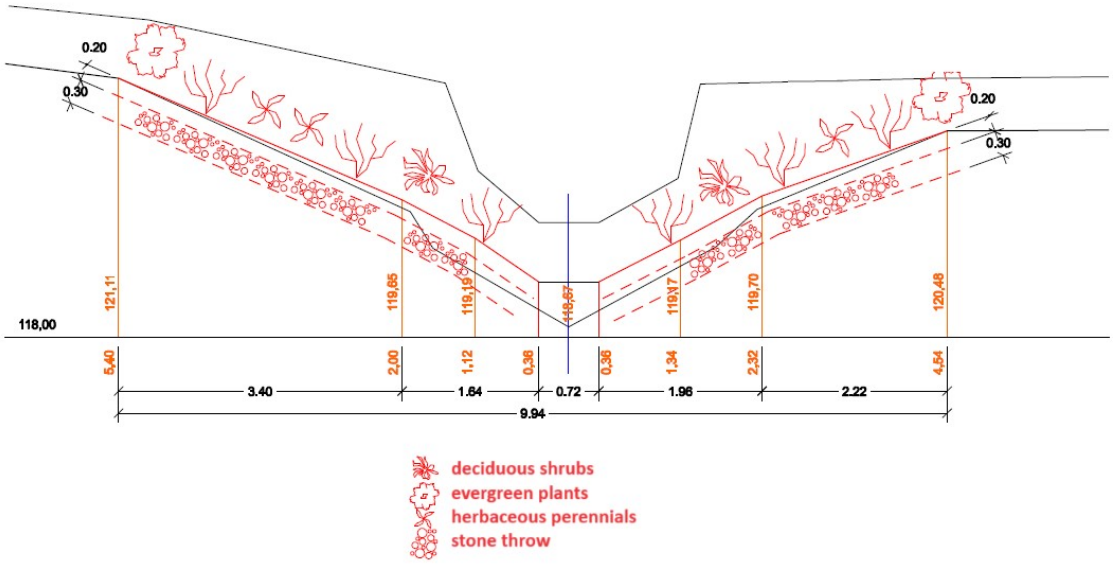

Fig. 4: Cross-section of a rain garden

Conclusion

The implementation of water retention measures and green infrastructure with recreational potential is an effective way to increase the quality of life in cities and towns, and at the same time to reduce the risk of floods and improve the quality of the environment.

In order to ensure the safe drainage of rainwater, to protect the urban area of the village of Nižný Hrušov (Slovakia) from flood flows, and to increase the quality of people's life, the paper proposes a combination of suitable water retention measures (an infiltration pipe - a trench, an inspection and cleaning shaft, a detention tank and a rain garden), which technical and social functions are interconnected.

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Souhrn
Zavádění opatření na ochranu vody a zelené infrastruktury s rekreačním potenciálem je účinným způsobem, jak zlepšit kvalitu života ve městech a obcích a zároveň snížit riziko povodní a zlepšit kvalitu životního prostředí.
Za účelem zajištění bezpečného odtoku srážkových vod, ochrany intravilánu obce Nižný Hrušov (Slovensko) před povodňovými průtoky v toku a zlepšení kvality života obyvatel je v příspěvku navržena kombinace vhodných vodohospodářských opatření - vsakovacího potrubí (příkopu), revizní a čisticí šachty, retenční sběrné nádrže a dešťové zahrady, jejichž technické a sociální funkce jsou vzájemně propojeny.

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