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INVESTIGATION OF SOIL PERMEABILITY AND SUITABLE VEGETATION FOR RAIN GARDENS IN KECSKEMET

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Abstract
Nowadays, the implementation of integrated stormwater management is an important element of urban climate adaptation. Rain gardens are part of this system, which effectively handles large amounts of sudden precipitation. In this way, they are suitable for preventing the increasing frequency of flash floods. For rain gardens, it is important to collect information about the soil and the vegetation.
We examined the permeability of the typical soil types in Kecskemét – humus sandy soil, solonetz meadow soil – and Bácsvíz compost, in order to decide what proportion of soils and compost can be considered ideal for rain gardens. In addition, experiments were performed with three broad-tolerant plants (Inula Britannica, Aster tripolium subsp. pannonicus and Limonium gmelinii) planted in the studied soil types and compost, as well as in a mixture of these.
Based on our results, it can be concluded that the solonetz meadow soil practically means a waterproof layer, while a mixture of half of this soil type and compost already has adequate water permeability and water storage properties, which provide the necessary living conditions for plants.

1 Introduction

One of the most useful tools for urban climate adaptation can be rain gardens. Rain gardens can make a significant contribution to the management of excess rainfall, urban flash floods and the reduction of problems caused.

Heavy rains and the resulting flash floods will be more and more common in our climate in the future. Handling the flash floods is the responsibility of urban storm water management. One element of this is the construction of rain gardens. These are artificially formed, deeper surfaces in the soil, with the function of collecting, temporary storing and filtering rainwater, and desiccation.

Urbanization has several adverse hydrological effects, among which rainwater management is a complex problem. In order to reduce adverse effects, both Best Management Practice and Low Impact Development should be kept in mind [5]. There are a number of possible solutions, most of which require the combined use of different solutions to deal effectively with the problem. The traditional solution is to build storm water drainage channels. But building the network is extremely expensive, which imposes a significant financial burden on the water utility company, the municipality and the dwellers too.

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The issue has long been known internationally. The topic has been addressed in the past mainly in countries where the natural feature of the climate is extremely high rainfall, e.g. some areas of the USA, or the oceanic regions of Western Europe. For this reason, the development of possible solutions is also linked to these countries [1]; [2].

In cities, the root of the problem is the excessive extent of paved surfaces. Paved surfaces prevent precipitation leakage into the soil, which is why there is a need for drainage of the entire amount of water. However, this solution – in addition to being unfeasible – will cause further difficulties in the future. Water will be missing during periods of low rainfall, especially for vegetation. Therefore, the goal is to facilitate the leakage of precipitation into the soil. Because of this, it is necessary to reduce the amount of paved surfaces, to use water-permeable paving, and to create areas that can temporarily store water. For temporary storage rain gardens can provide a solution. Their construction requires a partnership in which both municipalities and the dwellers are committed to success. Without this, rain garden projects are doomed to failure [3].

Till nowadays, few studies have quantified how the hydrological performance of rain gardens is affected by vegetation type. However, even in the absence of measurement results, it is recommended that in rain gardens have be taxonomically and structurally diverse species [4].

In our study we examined the permeability of the typical soil types in Kecskemét – humus sandy soil, solonetz meadow soil and a kind of compost – which was made by Bácsvíz Zrt. – in order to decide what proportion of soils and compost can be considered ideal for rain gardens. In addition, experiments were performed with three broad-tolerant plants (*Inula britannica, Aster tripolium subsp. pannonicus* and *Limonium gmelinii*) planted in the studied soil types and compost, as well as in a mixture of these.

2 Methods

To investigate the permeability of soil types and compost, 0.5 kg of the samples was weighed into plastic containers to which 0.5 liter of water was poured. The samples were air dry. Infiltration was recorded using a stopwatch, was followed visually and the results were represented on Excel charts.

To study the viability of selected broad-tolerant plant species *(Inula britannica, Aster tripolium subsp. pannonicus* and *Limonium gmelinii*), we planted the plants into different soil types (humus sandy soil, solonetz meadow soil, flower soil), compost and 50-50% mixture of soils and compost. The solonetz meadow soil comes from sewage treatment plant of Bácsvíz Zrt., the humus sandy soil from Csabagyöngye street in Kecskemét. Peaty flower soil is a common type and available in florists, while Bácsvíz compost is a sewage sludge compost mixed with wood chips. The use of the soil sample on the territory of Bácsvíz Zrt. and the compost produced by them was justified by the fact that the company plans to establish an experimental rain garden in the area of their sewage treatment plant.

The plantation of *Inula britannica* and *Aster tripolium subsp. pannonicus* was on April 15, 2021, while the *Limonium gmelinii* was planted on September 3, 2021. In order to model the unpredictability of precipitation, samples were watered without regularity, weekly, every ten days, and between May 3-7. on a daily basis. The experiment extended to one month after planting for *Inula britannica* and *Aster tripolium subsp. Pannonicus*, because the plants had dried out after one month.

The irrigation experiment to examine the viability of *Limonium gmelinii* lasted for two months, as the plant species proved to be more tolerant compared to the other two species, and the plants survived.

3 Results

Based on the results of the infiltration measurement (Fig. 1.), it can be seen that the water permeability and water holding capacity of different samples vary within very wide limits.

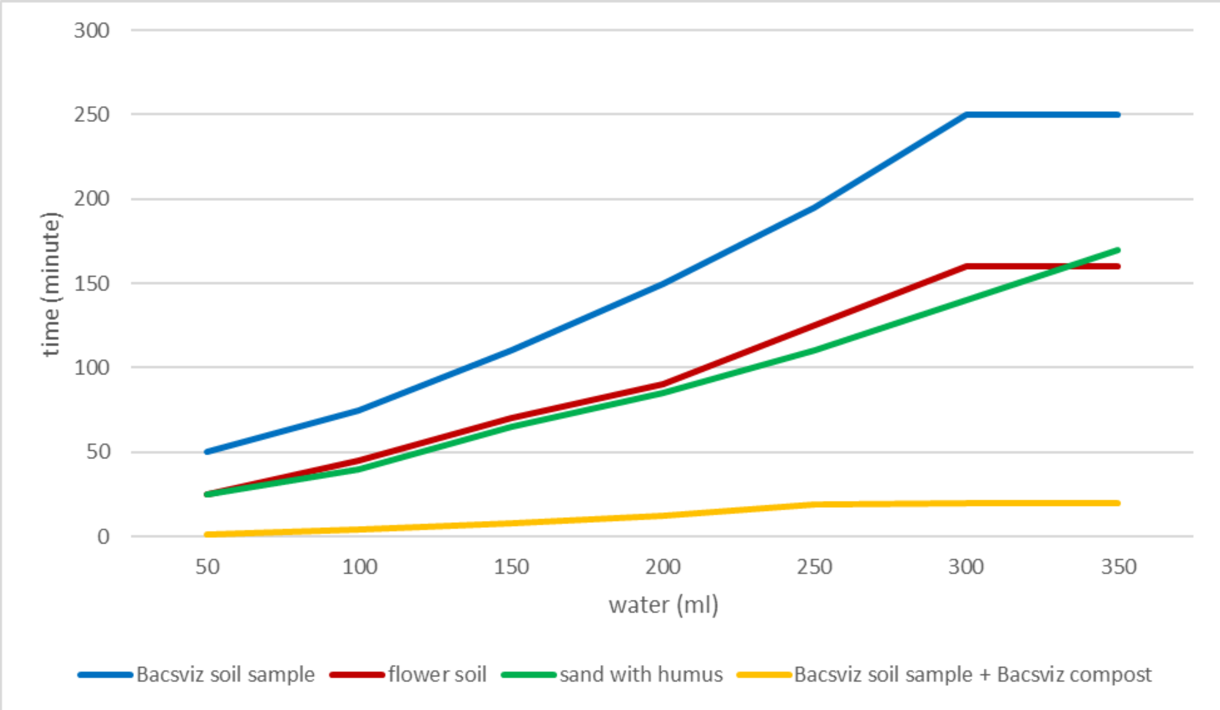

Figure 1.: Permeability of studied samples

The solonetz meadow soil from the Bácsvíz sample area passed 300 ml of water in four hours. The rest of the water remained on the surface of the sample, so the soil functioned practically as a waterproof layer. The common flower soil and the humus sandy soil permeated and retained water in a similar manner. 300 ml passed through for about two and a half hours and then the remaining water was taken up by the samples. With the addition of excess water, the water began to leak again, in contrast to the solonetz meadow soil sample. Solonetz meadow soil (Bácsvíz sample area) mixed with Bácsvíz compost in 50-50%, passed 250 ml of water very quickly – in about half an hour – and then absorbed the remaining amount of water. After adding more water, the leakage started again, so like the flower soil and humus sandy soil, it stores moisture and then releases it gradually.

Based on this, it can be said that by improving the water permeability and water holding capacity of the solonetz meadow soil, which provides poor living conditions for the plants, more favorable conditions can be ensured for the plants as well. In case of creating a rain garden, mixing the soil with 50% compost, the water holding capacity of the area and the living conditions for the plants are also significantly improved. In this way the rain gardens can perform its function.

During the viability study of the plants, we used the same soil samples which were included in the permeability study. The worst conditions were provided by the solonetz meadow soil from the Bácsvíz sample area, in which all three plant species had difficulty coping with the soil conditions (Fig. 2.). From the three plant samples, *Inula britannica* proved to be the least resistant, it was drying out in the solonetz meadow soil within one week. The most resistant was *Limonium gmelinii*, which endured poor soil conditions even in the solonetz meadow soil.

Limonium gmelinii showed higher viability in all soil samples (solonetz meadow soil, humus sandy soil, flower soil, humus sandy soil + Bácsvíz compost, solonetz meadow soil + Bácsvíz compost) than *Inula britannica* and *Aster tripolium subsp. pannonicus* (Fig. 3).

The viability of plant samples in soil-compost mixture were better than in the sample without compost, which is a good indication that compost also significantly improves plant living conditions (Fig. 4.-5.).

Figure 2.: Aster tripolium subsp. pannonicus (flowerpot in left side) and Inula britannica (flowerpot in right side) planted to solonetz meadow soil (left) and humus sandy soil (right)

Figure 3.: Limonium gmelinii in different soil samples at the time of planting and four weeks after planting

Figure 4.: Limonium gmelinii in solonetz meadow soil at the time of planting and four weeks after planting

Figure 5.: Limonium gmelinii in mixture of solonetz meadow soil + Bácsvíz compost at the time of planting and four weeks after planting

As a result of the plant experiment, we can conclude, that the solonetz meadow soil from the Bácsvíz sample area alone provides poor conditions for the vegetation, even in the case of basically salt-tolerant species. In the case of humus sandy soil, general flower soil and compost, the soil conditions are already suitable for plant life. If we mix the solonetz meadow soil with compost in 50-50% ratio, the living conditions – nutrient supply, water management – are significantly improved, which allow the plants to survive.

4 Conclusions

Based on our experiment on soils and plants, it can be said that soil conditions significantly determine the creation of rain gardens. If the soil proves to be waterproof (e.g. clay layer, saline layer in the soil), the rain garden cannot perform its water reservoir function. In addition, suitable soil conditions must be provided for the vegetation. In our study, the solonetz meadow soil from the Bácsvíz sample area providing the worst conditions, which is not suitable for creation of a rain garden in its original state. The best conditions – in terms of water storage capacity – are provided by composts. For this reason, in case of creating rain gardens, a good solution is to mix the soils with poor water management with compost (in 50-50% ratio), which is able to improve the water-holding and water permeability of the soils to the required extent.

In addition to the water-retaining capacity of the soil, the provision of plant living conditions is an important aspect of the establishment of rain gardens. Without required conditions the survival of the rain garden is doomed to failure. From this point of view, based on our study, the solonetz meadow soil proved to be the worst. At the same time, mixing the sample with 50% compost, can already provide soil properties that are suitable for plants in a rain garden.

As final conclusion, it can be stated that before the establishment of rain gardens, soil tests – especially the examination of permeability – are essential, which helps to decide what proportion of compost mixture and what type of plants should be used in the rain garden.

With more and more experience we can hope, that rain gardens are becoming more widespread in Hungary as well, which are useful tools for urban adaptation to the negative effects of the climate change.

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