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## Rain gardens as integral parts of urban sewage systems-A case study in Thessaloniki, Greece

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### Abstract

The use of rain gardens and other ecological rainwater management methods in urban areas aims, among others, at: 1) reduction of total rainwater runoff and of its peak and 2) reduction of property damage and activity disruption, which is due to insufficient sewer network capacity. While rain gardens cannot substitute sewer networks, they can be used as integral parts of sewer systems in a cost-efficient way.

In this paper, integration of rain gardens in sewer systems is investigated, by means of a case study, in Thessaloniki, Greece. The effect of location and size of rain gardens is examined, together with the quality of local sewer network. Our calculations have shown that existing infrastructure is insufficient and that construction of rain gardens could substantially mitigate the nuisance caused by inundation of streets and sidewalks during rain events.

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## 1. Introduction

Sewer networks for rainwater and domestic sewage are integral parts of urban infrastructure. Regarding rainwater, their aim is to transfer it quickly and safely to sewage treatment facilities or, in cases of heavy rain, mainly to surface water bodies directly. Even in developed countries, though, these networks may fail to protect fully all parts of urban areas during heavy rain events. In such cases, water accumulating on street surfaces and sidewalks renders their use by pedestrians a challenging task and car driving unsafe. In the worst cases, shops and houses, in particular house basements, are inundated and even human lives are exposed to danger.

Solutions to handle such problems could be sought in the framework of integrated rainwater management, which combines sewer networks with low impact techniques, such as rain gardens and green roofs. These solutions, which are advantageous from the environmental point of view, might also prove more cost efficient than sewer network upgrading.

In this paper, application of rain gardens in a neighbourhood of Thessaloniki, the second largest city in Greece, is discussed.

## 2. Brief description of rain gardens

Rain gardens are the most important method of ecological rainwater management for urban and suburban areas. Their main assets are low construction and maintenance cost, easy adaptation to urban space and high aesthetic value. A typical rain garden includes: a) a ponding area and b) inflow and outflow structures (e.g. [1], [2], [3]).

The ponding area is a natural or artificial ground depression, constructed by soil excavation, which, in sloping ground, can be combined with building an earth berm at the downslope side, using the excavation material. Surfaces with large slope are not that suitable for rain garden construction. The bottom of the ponding area is usually covered by a mulch layer, before adding the top soil. If water infiltration rate in the underlying strata is small, a gravel layer is constructed or a perforated underdrain pipe is installed.

Inflow structures are used to convey rainwater from downspouts or adjacent impermeable areas (streets, sidewalks) to the ponding area.

Finally, overflow structures allow water to exit a rain garden, when its ponding area is full. This structure is necessary in order to reduce erosion risk and to direct outflowing water towards the desired place (usually the sewer network).

Plants (usually native ones) that can tolerate periodic inundation are an integral part of rain gardens, since they contribute to: a) Upgrading the local urban landscape and b) retention of certain pollutants and of water quantities. Actually, improvement of rain runoff quality is an important additional asset of rain gardens (e.g. [4], [5]).

## 3. The area of interest

The area studied in this paper, is shown in Figure 1 (based on Google maps). It is part of Saranta Ekklisies, a neighborhood close to the centre of Thessaloniki, the second largest city in Greece. There are more green spaces in Saranta Ekklisies, compared to the rest of the city centre, but the ground surface in its largest part is sloping. This results in quick concentration of rainwater at lower points with small slope, such as Agiou Dimitriou Street, which separates Saranta Ekklisies from the campus of Aristotle University of Thessaloniki (AUTH) and a major hospital. Moreover, inlets to the sewer system are inadequate and rain runoff takes place mainly on the impermeable street and sidewalk surfaces, even during rain events of medium intensity. For these reasons, construction of rain gardens could be very beneficial, as indicated in [6] and [7].

Available sewer network in the study area is shown in the map of Figure 2, provided by Thessaloniki Water Supply & Sewerage Co. S.A (EYATH S.A.). It consists both of separate rainwater collection and of mixed flow sewer pipes (depicted with blue and green color, respectively). The worst problem of rainwater ponding appears along Agiou Dimitriou Street. The problem there is aggravated by heavy car traffic and high pedestrian flow. The photo of Figure 3, which is taken during a short, but rather intense, rain event, is quite indicative. Our aim, though, is to mitigate nuisance due to rain events in all of the study area, by means of rain gardens.

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