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Contributions to the design of rainwater harvesting systems in buildings with green roofs in a Mediterranean climate

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ABSTRACT

Green roofs (GRs) are becoming a trend in urban areas, favouring thermal performance of buildings, promoting removal of atmospheric pollutants, and acting as possible water collection spots. Rainwater harvesting systems in buildings can also contribute to the management of stormwater runoff reducing flood peaks. These technologies should be enhanced in Mediterranean countries where water scarcity is increasing and the occurrence of extreme events is becoming very significant, as a result of climate change. An extensive pilot GR with three aromatic plant species, *Satureja montana*, *Thymus caespititius* and *Thymus pseudolanuginosus*, designed to study several parameters affecting rainwater runoff, has been in operation for 12 months. Physico-chemical analyses of roof water runoff (turbidity, pH, conductivity, NH_4^+, NO_3^-, PO_4^{3-}, chemical oxygen demand) have shown that water was of sufficient quality for non-potable uses in buildings, such as toilet flushing. An innovative approach allowed for the development of an expression to predict a 'monthly runoff coefficient' of the GR system. This parameter is essential when planning and designing GRs combined with rainwater harvesting systems in a Mediterranean climate. This study is a contribution to improving the basis for the design of rainwater harvesting systems in buildings with extensive GRs under a Mediterranean climate.

Key words | runoff coefficient, *Satureja montana*, stormwater management, *Thymus caespititius*, *Thymus pseudolanuginosus*, water runoff

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INTRODUCTION

Increasing attention is being paid to the negative impacts of expanding urban infrastructures and replacement of vegetated landscapes by impervious surfaces in city centres. The impacts of climate change on urban environments are starting to be felt and the intensity and frequency of heavy rainfall events are expected to increase in the next decades (Chalmers 2014). The design of buildings and public spaces that are capable of dealing with the effects of climate change is crucial. The use of green roofs (GRs) on top of buildings may counteract some of these effects since it reduces the flow of stormwater and increases the number of green infrastructures contributing to the mitigation of climate change.

The implementation of GRs can have many environmental and economic benefits, such as mitigation of the urban heat island effect, improving air quality in urban areas, adding aesthetic value to urban architecture, enhancing biodiversity and increasing the life span of the building materials (Berndtsson 2010; MacIvor *et al.* 2013). On the other hand, the construction of GRs combined with rainwater harvesting systems appears as a fundamental measure to reduce peak flows in the drainage of stormwater (Kasmin *et al.* 2010; Stovin 2010). Improving stormwater management systems for rainwater harvesting in buildings is particularly appropriate to address the many impacts of climate change because, besides reducing the flood peaks in urban areas, it promotes additional water storage in buildings (Silva-Afonso & Pimentel-Rodrigues 2011).

The combination of a GR with a rainwater harvesting system is a particularly promising tool in the Mediterranean

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