Sustainable Urban Stormwater Management Using Green Infrastructure

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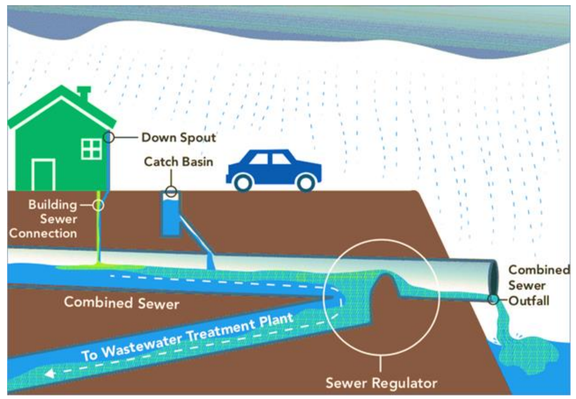
PROBLEM STATEMENT

Urban stormwater runoff is one of the great challenges of modern water pollution control as it is a principal contributor to water quality impairment of waterbodies worldwide. In most older cities, including the District of Columbia (DC), a combined sewer system of pipes and tunnels are designed to simultaneously collect surface runoff and sewage water in a shared system. This combined system can surpass the capacity of the pipes and result in Combined Sewer Overflows (CSOs) during periods of heavy or extended precipitation. Almost for every inch of rain, there is CSO in DC, and consequently all main water bodies in DC are impaired. According to sustainable DC Plan, the city wants to make its all waterways 100% fishable and swimmable by 2032 by implementing both gray and green infrastructure solutions. Green Infrastructure (GI) systems like green roofs can reduce CSOs by retaining and filtering stormwater runoff, but implementing effective green roof systems that address both storm water quality and quantity related problems is challenging.

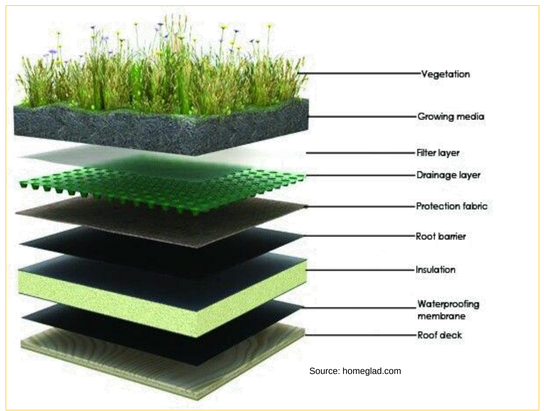


OBJECTIVE

The objective of this study is to assess the stormwater retention storage ability of green roofs and policy initiatives that have been implemented and effective in incentivizing and/or enforcing green roof installations in urban areas.

METHODOLOGY

Green roofs are an engineered system which consists principally of a plant cover layer, growing media, drainage layer, and an impermeable layer on the bottoms which protects the roof deck itself. Typical design of green roofs looks as follows:



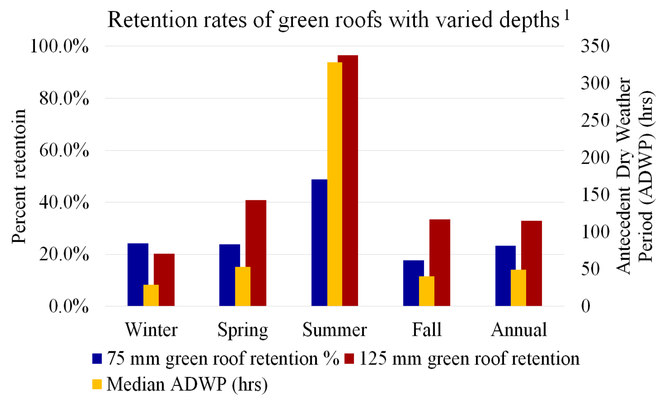
A literature review was conducted analyzing various green roof designs and their measured efficiency in retention volume and retention time. Additionally, incentive programs and policy measures which encourage or require green roof installations were reviewed.

Comparison of three different designs of standard green roof is presented as follows[9]:

Maintenance	Extensive Green Roof	Semi Intensive Green Roof	Intensive Green Roof
Irrigation	No	Periodically	Regularly
Plant Communities	Moss-Sedum-Herbs and Grass	Moss-Herbs and Shrubs	Lawn or Perennials, Shrubs and Trees
System build-up height	60-200 mm	120-250 mm	150-400 mm on underground garages >1000 mm
Weight	60-150 kg/m²	120-200 kg/m²	180-500 kg/m²
Costs	Low	Middle	High
Use	Ecological protection layer	Designed Green Roof	Park like garden

RESULTS AND DISCUSSION

Extensive literature study showed that longer periods between precipitation events and soil moisture flux from soil media are the best indicators for increased retention on green roofs and not solely soil media depth.[1] Large antecedent dry weather periods (ADWP) allow for greater retention in green roofs with deeper soil media.[2] In highly urbanized or impervious areas, stormwater runoff can be retained and slowly released after a storm event, especially during warm summer months with long AWDP. In all seasons except for winter, the deeper soil media green roofs retained more water than shallow soil medias (see below). It could be surmised that deeper soil media green roofs will have larger retention volumes over the course of a year, depending on precipitation patterns. This increased potential retention space can alleviate stormwater systems even more than shallower green roofs.



Although green roof systems can have high up-front costs compared to traditional rooftops, they often end up saving building owners money in the long run: longer roof lifespans, increased building value, added amenity value, and improved heating and cooling efficiency.[3,4] High initial costs can be abated through incentive programs such as the District Department of Energy and Environment's (DOEE) RiverSmart Rooftops program.[5] Policy measures to enforce conditional or mandatory green roof installations on certain buildings that may qualify depending on their location and criteria have been shown to be effective stormwater management tools in many cities and communities.[6,7,8]

TAKE HOME STATEMENT

- When intensive green roofs are expensive and retain highest runoff volume, incentive policy is still treating all green roof designs the same.
- Dry weather periods between storm events increase retention ability, especially with increased soil media depth, but even with extensive, shallow green roofs.
- Policy measures taken in municipalities around the world have shown that functional regulation and useful incentivization programs can facilitate increased green roof installations and lower burdens on stormwater systems.

FURTHER STUDY

Further study should be conducted on how to effectively leverage policy tools to incentivize the installation of green infrastructure. Additionally, analysis of the effect of green roof implementation on retention volume, site suitability, and demand should be performed to look for areas where a green roof buildout would be fitting.

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