Storm-water tree as (new) way to manage urban runoff

Martin Seidl, Hayath Zime, E. Berthier, Didier Techer

FUTURE
INVENTER LES VILLES DE DEMAIN

Storm-water tree as (new) way to manage urban runoff

Martin SEIDL[1], Hayath ZIME[1], Emmanuel BERTHIER[2], Didier TECHER[3]
[1]*LEESU ENPC Université Paris-Est,* [2]*CEREMA TEAM,* [3]*CREMA/DTerEst-3ERTD*

Summary

Climate change is disrupting our ecosystems, affecting weather phenomena and modifying the hydrological cycle. In urban areas, these impacts are reinforced by imperviousness. Urban trees offer multiple ecosystem services and are therefore an optimal solution to mitigate such effects, particularly through the hydrological cycle and the local climate. In order to optimize these advantages, a pilot system was set up at the end of 2019 in the Sense City test area, to better quantify and qualify the role of trees in urban space from hydrological and climatic point of view. The contribution of Future Days will present the results of the first follow up of tree boxes, launched in the spring 2020.

I. Introduction

Urbanization is a major phenomenon, which designates a continuous process of population growth and urban expansion. Although it is a source of economic development, it alters and destroys many natural areas. The continuous development of urban areas affects the natural hydrological cycle principally through soil imperviousness, decreasing lag time between precipitation and runoff and increasing peak flow and volume of total runoff (Flores et al. 2015; Berthier et Joannis 2010). Facing the problem, various ways of compensation have been implemented such as green roofs, permeable pavements, rain gardens or storm trees. In this presentation we focus on the last approach, as it's often presented as modular solution, best suited for existing urbanisation due to its small dimensions and the multiple ecosystem services the tree can provide.

The city tree represents a well-known urban object, experiencing different approaches starting with ecology, passing by aesthetics to finish with sociology (Gourrierec 2012). The tree ecosystem functions are diverse. We can cite, among others, the cooling effect due to shading and evapotranspiration or the improvement of the living environment through green biotope (Vergriete et Labrecque 2007; Vinet 2010; Musy et al. 2014; Seidl et Saifane 2020).

Trees can constitute an alternative way for storage and treatment of runoff close to the point of its production. Studies (EPA 2012; CRWA 2008) in Anglo-Saxon countries show that one lined-up tree can treat more than twenty square meters of surface area. Thus, a city like Paris could manage up to 5% of its roadway runoff just by transforming the existing line trees.

[1] Auteur correspondant Tél: +33 1 64 15 39 75; *Adresse mail*: martin.seidl@enpc.fr

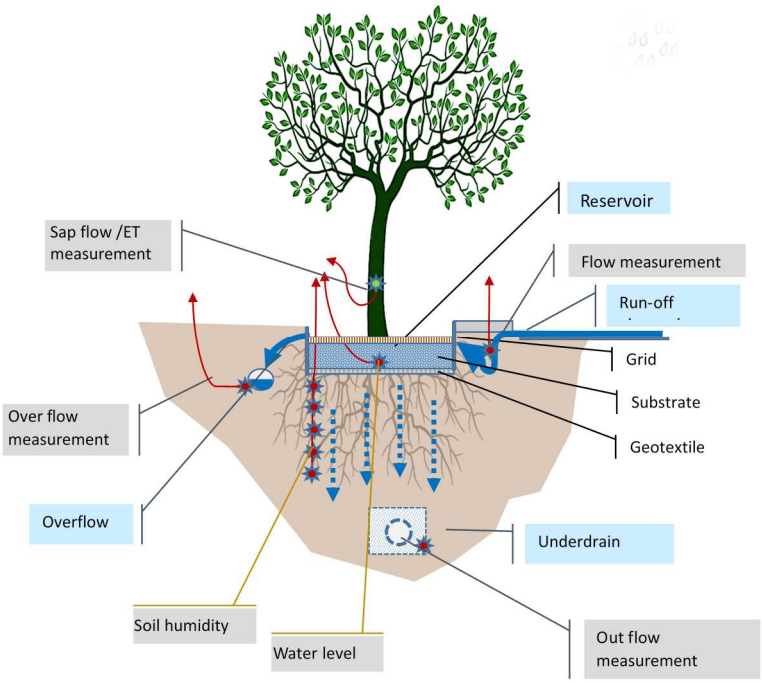
Université Gustave Eiffel
École des Ponts ParisTech
UNIVERSITÉ PARIS-EST

FUTURE bénéficie d'une aide de l'État gérée par l'Agence Nationale de la Recherche (ANR) au titre du programme d'investissements d'Avenir (référence ANR-16-IDEX-0003) en complément des apports des établissements et partenaires impliqués.

To better understand the hydrological and climatic functioning of storm water trees, a pilot device has been studied in the Sense City since early 2020. The presentation therefore proposes to present the device instrumentation and the first results of the current measurement campaign.

II. Methodology

The Sense City experimental system of the university campus of Cité Descartes at Champs sur Marne (77) consists of a mini-city equipped with a climatic chamber. Its aim is to support urban industrial actors in the testing of their concepts and technologies (Van Eeckhout 2018). As part of the French OPUR5 research program, an artificial street section of this device was equipped with 3-meter high maple trees (*Acer platanoides 'Globosum'*) at the end of 2019. The storm water trees are equipped with a layer of 20 centimetres Rainclean® substrate, able to retain the major part of incoming runoff pollutants, an overflow and a drain 60 centimetres underneath. One side of the road serves as reference while the other side receives runoff from road section of 80 m². Three units of storm-water trees are equipped since 2020 with sensors to measure water flows in the different compartments (see figure below (Seidl 2019).



To estimate the different water balances and to model the tree box, water flow data will be continuously collected during one or two vegetative cycles under natural and controlled conditions. The depollution capacity will be monitored in parallel through chemical analyses of the incoming runoff, drain outflow and the analysis of the Rainclean® substrate.

III. Preliminary results

The research project will contribute to the reflection on sustainable water resource management in the framework of climate change. It questions the ecosystem function (s) of green spaces and in particular the link between urban runoff and the role trees could fulfil. The results will describe more accurately the water flows (Ramier, Berthier, et Andrieu 2011), the depollution mechanisms and the possible impacts or benefits for the tree in a new bio-filtering system. Finally, the research will question the management model and the position of end users vis-à-

FUTURE bénéficie d'une aide de l'État gérée par l'Agence Nationale de la Recherche (ANR) au titre du programme d'investissements d'Avenir (référence ANR-16-IDEX-0003) en complément des apports des établissements et partenaires impliqués.

vis an innovation in storm water management. The research will help the municipalities to develop the "storm water tree" as new sustainable urban drainage equipment, satisfying the hydrological, environmental and managerial conditions of the urban municipalities.

The contribution proposes to present the experimental setup and the first results of the current measurement campaign focused on the role of trees in the tree-box water balance, based on rain data, soil humidity and evapotranspiration.

IV. References

Berthier, Emmanuel, et Claude Joannis. 2010. *Hydrologie des milieux urbains pour la maîtrise de la pollution des eaux et des sols*. Laboratoire central des ponts et chaussées.

Flores, Precious Eureka D., Marla C. Maniquiz-Redillas, Jevelyn Ann S. Tobio, et Lee-Hyung Kim. 2015. « Evaluation on the hydrologic effects after applying an infiltration trench and a tree box filter as low impact development (LID) techniques ». *Journal of Korean Society on Water Environment* 31 (1): 12-18.

Gourrierec, Stéphane Le. 2012. « L'arbre en ville : le paysagiste concepteur face aux contraintes du projet urbain ». Other, SCE Nantes, Aménagement & Environnement, 5 avenue Augustin-Louis Cauchy - 44307 NANTES Cedex 03. https://dumas.ccsd.cnrs.fr/dumas-00739439/document.

Musy, Marjorie, Emmanuel Bozonnet, Xavier Briottet, Caroline Gutleben, Jean-Pierre Lagouarde, Patrick Launeau, Aude Lemonsu, Denis Maro, Fabrice Rodriguez, et Maeva Sabre. 2014. « Rapport final Projet ANR- 09-VILL-0007VegDUDProgramme Villes Durables 2009 ». Research Report. IRSTV FR CNRS 2488. https://hal.archives-ouvertes.fr/hal-01188804.

Ramier, D., E. Berthier, et H. Andrieu. 2011. « The hydrological behaviour of urban streets: Long-term observations and modelling of runoff losses and rainfall-runoff transformation ». *Hydrological Processes* 25 (14): 2161-78. https://doi.org/10.1002/hyp.7968.

Seidl, Martin. 2019. « L'arbre de pluie pour la gestion du ruissellement urbain ». In *Journée SenseCity le 26 Novembre 2019, Nov 2019, Champs sur Marne, France*. https://hal-enpc.archives-ouvertes.fr/hal-02381088.

Seidl, Martin, et Manal Saifane. 2020. « A green intensity index to better assess the multiple functions of urban vegetation ». *Environment, Development and Sustainability*, n° accepted December 2019.

Vergriete, Yann, et Michel Labrecque. 2007. « Rôles des arbres et des plantes grimpantes en milieu urbain : revue de littérature et tentative d'extrapolation au contexte montréalais ». Université de Montréal.

Vinet, Jérôme. 2010. « Contribution à la modélisation thermo-aéraulique du microclimat urbain. Caractérisation de l'impact de l'eau et de la végétation sur les conditions de confort en espaces extérieurs ». UNIVERSITE DE NANTES. https://tel.archives-ouvertes.fr/tel-00490049.

FUTURE bénéficie d'une aide de l'État gérée par l'Agence Nationale de la Recherche (ANR) au titre du programme d'investissements d'Avenir (référence ANR-16-IDEX-0003) en complément des apports des établissements et partenaires impliqués.