PhD subject (Paris, France)

Designing resilient and low environmental impact micro-NBS to support urban renaturation

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Location:

École nationale des ponts et chaussées – Institut Polytechnique de Paris
6 et 8 av Blaise Pascal, Cité Descartes, 77455 Marne la Vallée cedex, France

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Keywords : Life Cycle Analysis, urban runoff, sustainable urban drainage, vegetation, monitoring, hydrological modelling, innovation

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Context and issues

Urban greening is increasingly recognized for its role in enhancing liveability and supporting biodiversity in cities. However, in dense urban environments, opportunities for implementing nature-based solutions (NBS) can be severely limited due to space constraints and the only feasible interventions often consist of very small-scale NBS, here referred to as µNBS. The deployment of µNBS solutions, in a context of climate change resulting in increased droughts and a decrease in water resources, raises the question of water needs to support vegetation growth. Passive watering with runoff from adjacent urban surfaces offers a promising prospect for sustainable greening. The challenge targeted in this PhD is to develop water storage methods within µNBS, with limited use of synthetic materials or ex-situ resources, and to ensure sufficient access to water for plants without risking their asphyxiation from excess water.

Objectives of the PhD thesis

This PhD targets the design of robust, low maintenance and low environmental impact µNBS, relying mainly on passive watering with urban runoff, improved storage capacity and optimization of the plant palette to satisfy the water demand of the vegetation.

Methodology

The work will be divided into three parts:

1. Based on an extended literature review and international benchmark, as well as cocreation workshops within the Seed2Green project, mesocosms representative of a selection of µNBS designs will be built and equipped for hydrologic monitoring. The monitoring will extend over at least two years and be complemented by laboratory tests on substrate properties. Results will be analysed in terms of hydrologic water balance and hydric conditions of vegetation, with a special focus on hydric stress periods (drought or waterlogging).

2. A life-cycle analysis will be conducted for a range of designs, including those of the mesocosms, to clarify the environmental footprint of such systems. This multi-criteria, multi-stage method, enables the environmental assessment of socio-technical systems, considering their entire life cycle, from the extraction of materials to their end-of-life, including their maintenance requirements. It will assess which part of the life cycle, or which component of the system involves the highest environmental impact.

3. In this part, main results from mesocosm observations and from LCA analysis will be taken into account to select the more relevant designs. A hydrological modelling framework will be implemented to further

analyse the hydric conditions within µNBS and optimized it for a range of alternative design options, different stormwater feeding ratios and different PET conditions, based on numerical modelling of hydrologic processes (presumably with HYDRUS software).

Associated project and pluridisciplinarity

This PhD is part of the French national research project Seed2Green, funded under the 2025 PEPR SoluBiod call for project on NBS. Seed2Green is a project focused on robust, water efficient and socially embedded micro-NBS for renaturing dense town centres, which involves researchers from a variety of disciplines: horticulture, soil sciences, ecology, hydrology, LCA, ecodesign. Interaction with experts from these different fields within meetings and co-creation workshops are planned to foster the sustainable and innovative design of µNBS as part of the PhD thesis. The PhD subject is thus highly pluridisciplinary.

PhD supervision

The PhD student will be co-supervised by Pr. Marie Christine GROMAIRE and Pr. Adélaïde FERAILLE, tenured researchers at École nationale des ponts et chaussées (marie-christine.gromaire@enpc.fr; adelaide.feraille@enpc.fr) as well as by Dr Jérémie SAGE (jeremie.sage@cerema.fr), senior researcher at Cerema. Marie-Christine Gromaire and Jérémie Sage are experts in urban hydrology and hydrologic modelling, with a focus on nature-based solutions for stormwater management, while Adélaïde Feraille is a specialist in life cycle analysis. Both areas of expertise are required for the thesis.

Working environment

The PhD student will be hosted at Ecole nationale des ponts et chaussées, within Leesu laboratory, on the Cité Descartes campus in Paris metropolitan area (https://ecoledesponts.fr/en/cite-descartes).

Leesu, (www.leesu.fr) is a French research laboratory in environmental sciences, specialized in studying water and its management in urban and peri-urban environments. Facing the challenge of making the city sustainable and resilient in the context of global changes, the lab aims to gain a better understanding of water and contaminant flows in the urban environment and to develop innovative concepts for water and soil management.

For LCA, the PhD student will rely on the expertise on the LCA team of Navier laboratory, within the Ecodesign team (https://navier-lab.fr/en/research/).

Strong interaction with the Team research center of Cerema (https://www.cerema.fr/en/innovation-recherche/recherche/equipes/team-transfers-and-interactions-linked-water-built) are planned, for the construction and monitoring of the experimental mesocosms and well as for development of the hydrologic modelling work. The experimental mesocosms will be located on the campus of Cerema in Trappes (Paris conurbation). Field work is planned on this site during the PhD.

Contacts et application :

Send CV and covering letter **before April 20** (1rst wave of application) or May 20 (2nd wave of application if needed) :

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