PhD subject (Paris, France)

Environmental footprint of decentralised urban water management and reuse

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Location:

École nationale des ponts et chaussées – Institut Polytechnique de Paris
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Context and issues

Faced with the limitations of the historical centralised sanitation system and the growing pressure on water resources caused by climate change, new concepts of decentralised urban water management are being widely promoted. They aim to achieve integrated management of runoff and grey water, by encouraging the local use of this water and/or its return to the soil. The aim is to restore an urban water balance that is closer to the natural balance, to limit the amount of water drawn from resources, and to encourage the water recharge of soil and subsoil while supporting the development of vegetation and evapotranspiration.

Integrated urban water management is based on the deployment of decentralised systems - from the plot to the neighbourhood level - using more or less extensive systems to ensure the functions of collection, purification, storage and evacuation or local use of water. These systems can be nature based or, on the contrary, highly technical (see smart and connected), with greater or lesser reliance on non-renewable resources for their construction, and varying maintenance and energy requirements for their operation. Often, even when ecosystem functions are involved, the structure requires the use of synthetic materials, or materials derived from limited resources, for their construction.

The few studies available on the life cycle analysis of stormwater management systems at source (Moore and Hunt 2013; O'Sullivan et al., 2015; Byrne 2022; Tang et al., 2023) show, for example, that the impacts can vary greatly depending on the choice of structure. The materials used for construction (presence or absence of concrete, technical substrate, geotextile, etc.) have a major impact, as does transport for structures requiring frequent maintenance (Öhrn Sagrelius et al., 2022). The end of a structure's life, which is often not taken into account in studies, can also contribute significantly to impacts, due to the treatment or management of by-products and the deconstruction phase (Lerey and Neaud, 2020).

Over and above the performance of these systems in terms of controlling the urban water balance and the services provided in terms of protecting the urban environment and the receiving environment, the *in-situ* and *ex-situ* environmental impact of decentralised systems therefore needs to be assessed more holistically, covering the construction, implementation and end-of-life phases.

Objectives of the PhD thesis

The PhD aims at developing a framework for a systemic evaluation of integrated urban water management systems on the scale of a neighbourhood or development zone, enabling the services provided to be compared with the overall environmental footprint.

The main objectives of the analysis will be to

- identify the stages in the life cycle that have the greatest impact for different integrated water management scenarios, and determine the construction, maintenance and by-product management strategies with the best performance;

- determine the level of decentralisation, but also the level of intensiveness (hydraulic load factor of structures) that should be targeted in order to optimise the overall environmental balance of water management systems.

Methodology

The project is based on the construction and analysis of a panel of decentralised water management scenarios, covering both rainwater and grey water, on the scale of an urban district. Three levels of decentralisation will be considered: water management at neighbourhood level, at housing block level and at plot level. In addition, for each scenario, more or less intensive/extensive management solutions will be considered, as well as more or less rustic or technological solutions.

The panel of scenarios constructed will be based on international benchmarking of practices and the study of a number of exemplary districts. Feedback will be provided on a selection of pilot sites in order to gain a better understanding of construction practices, maintenance requirements and energy needs, as well as how these solutions are perceived by users and taken on board by management departments.

Assessment of the performance and environmental footprint of these scenarios will combine an analysis of the district's water balance and discharges (water and associated pollutants) with a life-cycle analysis of the management system put in place.

The LCA life cycle analysis method (Saadé and Jolliet 2024) will be applied. 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, on the basis of their function. The method makes it possible to assess direct impacts, caused for example by pollutant emissions into the natural environment during the life of the structure, as well as indirect impacts, linked to the supply chains that make materials and services available (transport, etc.). Initially developed for industrial products, this approach is now being applied to more complex systems with a strong regional dimension.

Contacts et application :

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