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Early stage planning tools for stormwater quantity and quality management in Denmark and China

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Abstract: In order to accommodate the increasing need for early phase planning and design tools that allows for a holistic approach to stormwater quantity and stormwater quality management, a new planning tool is suggested by adding a quality module onto an existing WSUD tool.

Keywords: Stormwater management; Stormwater quality; Planning tools; WSUD tool

1. INTRODUCTION

The increased frequency of extreme rain events in both China (Zhou et al., 2017) and Denmark (Gregersen et al., 2014) combined with growing urbanisation (United Nations - Department of Economic and Social Affairs, 2014) has resulted in increasingly frequent occurrences of urban flooding. This has initiated infrastructural investments in stormwater management systems, which are coordinated through the Chinese Sponge City construction plans, (MOHURD, 2014), and the Danish Climate Change Adaptation and Cloudburst Management plans (City of Copenhagen, 2011; 2012).

The applied solutions have been decentralised stormwater control measures (SCMs), where water is stored for infiltration and evaporation or delayed in order to reduce peak flows. Emphasis has been on above-ground, nature based solutions, often referred to in literature as Water Sensitive Urban Design (WSUD), Low Impact Development (LID), Best Management Practices (BMPs) and Sustainable Urban Drainage Systems (SUDS) (Fletcher et al., 2015). These solutions help restoring the hydrological balance disturbed by the sealing of surfaces that comes with urbanisation (Henrichs et al., 2016) and hold great potential for retaining micro-pollutants (MP) and increasing liveability (Liu & Jensen, 2017).

Compared with traditional underground drainage systems, planning of near surface, nature based SCMs to comply with goals concerning both stormwater quantity management and stormwater quality management, require collaboration across a broader spectrum of professions. Bridging the gap between different water officials sets requirements for planning and design tools to be intuitive in their application and easily understandable in their presentation of results. Additionally, they should consider stormwater quantity and quality holistically and be quick to use for the purpose of screening many possible solutions.

We have previously shown the benefits of using a simple, early phase planning tool for hydraulic and hydrological contexts. The WSUD tool presented by Lerer et al., 2015 emphasizes reducing complexity in order to help drainage engineers communicate their priorities to stakeholders. However, it is targeted at Danish planning context only and does not include water quality assessment. The objective of this study is to explore the possibility of developing a similar tool that also includes stormwater quality assessment to be used for screening in early planning and design phases.

2. MATERIALS AND METHODS

2.1 The Three Points Approach

The Three Point Approach (3PA) suggested by Fratini et al. (2012) has proven useful to facilitate transdisciplinary collaboration on multipurpose stormwater control projects across different decision domains (Lerer et al., 2017). The 3PA addresses solutions on scales ranging from (A) everyday rainfall and rainwater resource utilization, over (B) design rain and urban drainage service levels, to (C) extreme rainfall and pluvial flood mitigation.

2.2 WSUD planning tool

The WSUD tool described by Lerer et al. (2016) is a simplified planning tool for assessment of the hydrological performance of different WSUD elements based on few input parameter and uses look-up tables on simulations of detailed hydrodynamic models. The tool is based on Danish weather statistics, and it can currently be used to assess the performance of permeable paving, bio-retention units or local detention ponds. The results are presented in the context of the 3PA, as demonstrated in **Figure 1**. In addition, an annual water balance is provided to illustrate the potential for restoring a more natural hydrological cycle.

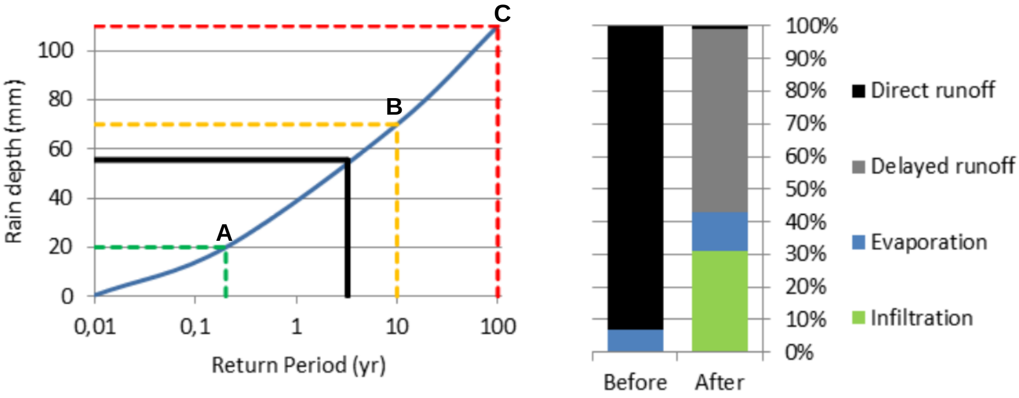

Figure 1: The WSUD tool presents (left) the maximum rainfall event depth that can be controlled by the SCM and the associated return period, and (right) the water balance before and after implementation. This example is edited from (Lerer et al., 2016).

For the tool to include assessment of both water quantity and water quality impacts of SCM installations, an additional module will have to be added, as illustrated in **Figure 2**.

2.3 Quality modelling

In order to create the quality module, we will be simplifying the wash-off and removal modelling procedure described by (Vezzaro et al., 2015). Based on existing literature and database systems (e.g. Lützhøft et al., 2012 or Revitt et al., 2013), values of MP release from different land uses can be applied to an accumulation-washoff-model to estimate 'before' loads, while the WSUD removal will be modelled by applying the Stormwater Treatment Unit model for MicroPollutants (STUMP) (Vezzaro et al., 2010).

As illustrated in **Figure 2** the quality module should be able to display the amount of MP that is degraded in the WSUD as well as the accumulation within the important receiving compartments of the urban water system.

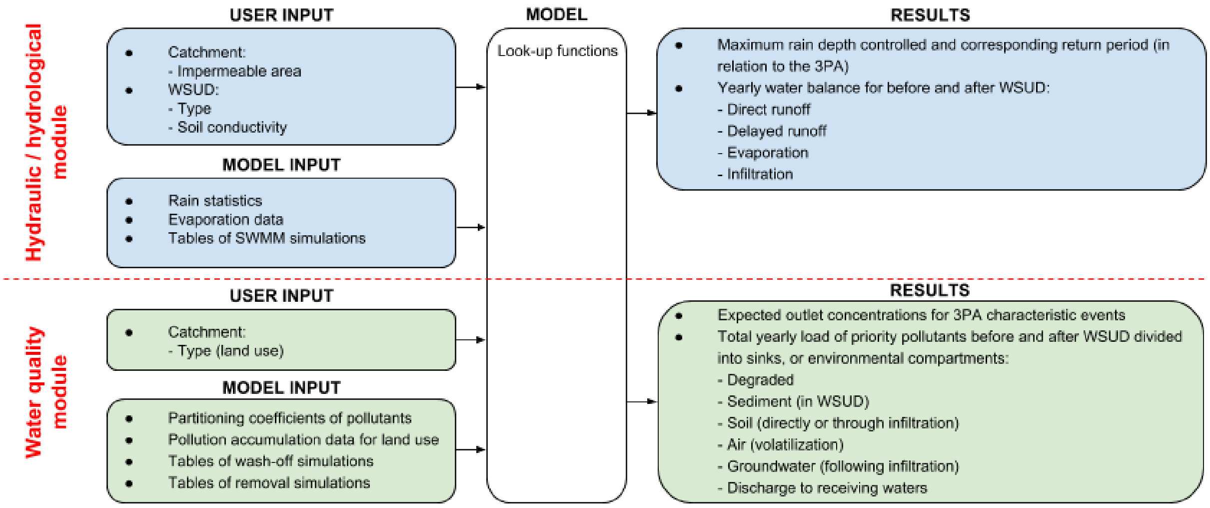

Figure 2: Conceptualisation of the existing WSUD tool with outline of additional inputs and model functions to create a water quality module.

2.4 Case studies

The development of the water quality module will be supported by data collected in a series of case studies, where the results from the simplified model can be compared to monitoring data and detailed modelling results. In 2018 two field studies will be established for this purpose: the Danish FUPARU project, where a HydroSeparator® SCM has been installed in Kærby to mitigate pollution loads into the natural water system, and the sponge city project in Shenzhen (southern China). Here the monitoring campaign is already in progress, collecting data before, during and after the construction of sponge city elements. Here the WSUD tool will have to be adjusted to local rain statistics before implementation.

3. RESULTS AND DISCUSSION

We argue that a simple tool that assesses both stormwater quantity and quality is needed, and that such a tool can be created by expanding the WSUD tool concept of Lerer et al. (2016). As the WSUD tool illustrates results by showing the percentage of the water balance that is managed, this will be very well suited for addressing the Chinese sponge city goals of controlling a certain fraction of the total yearly runoff. Also, the division into three event regimes using the 3PA will serve as a good communication tool in China, where distinction is already made between small, medium and large scale rain events.

The tool simplicity can benefit a planning situation without compromising early design decisions. The tool will be a steady state tool, and therefore increased pollutant emissions (as discussed by Ma et al., 2018) during construction phase are not considered in the presentation of results. Mitigation of this and many other considerations should be handled in a detailed design phase following the initial planning phase.

4. CONCLUSIONS

The results from this study are intended to be used for holistic evaluation of both water quantity and quality in early stage planning processes of stormwater management in Denmark and China.

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