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Desempenho de infraestrutura de WSUD: a influência da variabilidade de projeções de precipitação de alta resolução

WSUD infrastructure performance: the influence of variability in high-resolution rainfall projections

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1. INTRODUCTION

Water Sensitive Urban Design (WSUD) is a tool that aims to build city resilience. This is to be accomplished not only through stormwater management but also in fields such as microclimate improvement and water security, while striving to achieve a high level of liveability in urban spaces. The design of WSUD systems is critical for the optimal management of stormwater, since their performance is generally directly linked to their construction characteristics. Furthermore, since rainfall has also been identified as a major factor influencing this performance (Wettenhall and Wong, 2006), it is essential to understand the effects of its variability.

The current WSUD preliminary design procedures adopted in Australia involve performance curves, which are plots of the modelled effectiveness of different systems for defined criteria against their surface area (as a percentage of the catchment's effective imperviousness) (Engineers Australia, 2006). Similarly to conventional stormwater drainage systems, these guidelines do not account for uncertainty in rainfall projections. In this context, the study aimed to establish a process for estimating the influence of such variability in the simulated performance of WSUD features, in order to allow the generation of updated performance curves for these systems.

2. METHODS

Three WSUD features had their performances modelled in the study: constructed wetlands, biofilters and infiltration systems. The input parameters were coefficients related to the generation of runoff and pollutants according to the land use and design parameters for the treatment nodes. The different settings were tested with the aid of the programming software (MATLAB). The surface area of each WSUD element (as a proportion of the catchment's effective imperviousness) was the main parameter of interest, against which the performances in different aspects were to be estimated. The performance criteria to be considered for each system were selected according to the primary aims of each structure, and are summarised in Table 1:

Table 1. Summary of selected systems and respective output parameters.

Output parameters (performance criteria)	Systems		
	Wetlands	**Biofilters**	**Infiltration systems**
Hydrologic effectiveness	✓	-	✓
Total Suspended Solids removal	✓	✓	✗
Total Nitrogen removal	✓	✓	✗
Total Phosphorus removal	✓	✓	✗

Key:
✓ Parameter considered
- Parameter considered (secondary relevance)
✗ Parameter not considered

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) (Ewater Crc, 2013) was selected as the model through which the treatment performances were to be estimated. This choice was based chiefly on the fact that the currently adopted performance curves were generated through the same software, but also on its ability simulate all the specific required conditions (in terms of climate data input, modelling timestep, spatial scale and treatment features) and the fact that it is widely used by the stormwater industry in Australia.

Three locations were chosen in order to estimate the sensibility of the results to spatial variability for different rainfall patterns across the greater Melbourne area, Australia. The rainfall data comprised one radar time series and three simulations that were generated by the project Urban Rainfall in a Changing Climate (P2) from the Cities as Water Supply Catchments research program, headed by Monash University (Australia). The latter consisted of three different rainfall patterns for the same time period (2008-2009) generated through dynamical downscaling, yielding data with a spatial resolution of 1 km at a 6-minute timestep.

3. RESULTS AND DISCUSSION

A total of 10.320 performance estimates for different design specifications, locations and time series according to the defined performance criteria were generated for wetlands, biofilters and infiltration systems, respectively. This allowed for several performance comparisons within each category, as exemplified in Figure 1.

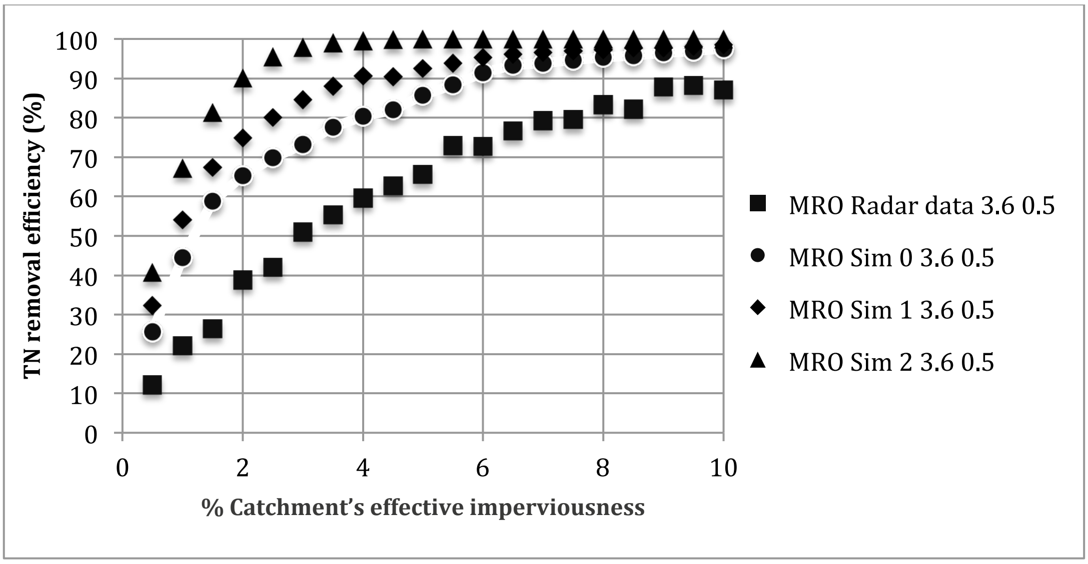

Figure 1. TN removal efficiency estimates according to radar rainfall and three modelled rainfall timeseries for wetlands in the Melbourne Regional Office location with an exfiltration rate of 3.6 mm/h and an extended detention depth of 0.5 m.

It is perceivable that, for a given performance requirement, location and design setup, the estimates of area requirements may vary considerably between each other depending on the assumed rainfall distribution. As a general pattern, treatment performances have sharp increases for small increments in surface areas when this variable corresponds to small fractions of the catchment's imperviousness.

However, it is relevant to remark that performance data generated by this method, in the same way as the current curves, consists of basic initial design guidelines, since other factors may also substantially affect the pollutant removal and flow attenuation capacity of each system.

4. CONCLUSIONS

The current study presented a methodology for assessing the influence that uncertainty in rainfall projections may have in the performance prediction of WSUD features. Where the required parameters are available for input in MUSIC, the described method may be adopted in several major cities for the generation of performance curves for WSUD elements which account for rainfall uncertainty. It is advisable that several high-resolution rainfall projections covering a wider time frame be available in order to improve the accuracy in the estimation of performance uncertainty.

The scope of this study was restricted to modelling wetlands, biofilters and infiltration systems. However, the adopted methodology can also be applied to other systems such as ponds and grassed swales, provided appropriate parameters and respective value ranges are selected. Common treatment train combinations and the interactions between elements (e.g.: sedimentation basin + wetland) may also be modelled, as well as different design specifications for systems that allow for a wide range of combinations such as biofilters.

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