Selecting locations for the implementation of NBS from a sewer's perspective

Choix des emplacements pour la mise en œuvre de solutions fondées sur la nature du point de vue des réseaux d'assainissement

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RÉSUMÉ

L'utilisation accrue des solutions basées sur la nature (NBS) afin de soulager le réseau des usées et de parvenir à un drainage urbain plus durable dans les lotissements a conduit au développement d'une variété de systèmes d'aide à la décision. L'un des aspects pris en compte dans les systèmes d'aide à la décision est l'effet de la NBS sur le réseau d'eaux usées. Une analyse de sensibilité d'un point spécifique du réseau d'eaux usées vers les bassins versants, fournit un outil utile pour évaluer les emplacements potentiels de NBS dans le réseau d'eaux usées. Dans l'étude de cas présenté, une analyse de sensibilité est effectuée et deux critères d'évaluation sont définis correspondant à des objectifs différents. L'un des objectifs est de réduire au minimum le volume de rejet des CSO et l'autre de maximiser la réduction potentielle par mètre carré de surface découplée. La comparaison des emplacements préférentiels pour les NBS obtenus par les deux critères d'évaluation montre que différents emplacements sont prioritaires pour le découplage en fonction de l'objectif spécifié

ABSTRACT

The increased application of nature-based solutions (NBS) in order to relieve the sewer system and achieve more sustainable urban drainage in settlements has led to the development of a variety of decision support systems. One aspect considered in decision support systems is the effect of NBS on the sewer system's performance. A sensitivity analysis of a specific point in the sewer system towards the connected catchments provides a useful tool to evaluate potential NBS locations from a sewer's perspective. In the presented case study, a sensitivity analysis is performed and two evaluation criteria are defined corresponding to different aims. One aim is to minimize the CSO discharge volume and the other is to maximize the potential reduction per square meter of decoupled area. The comparison of the preferential locations for NBS obtained by the two evaluation criteria shows that different locations are prioritized for decoupling depending on the specified aim.

KEYWORDS

(decision support, GIS, hydrodynamic modelling, sensitivity analysis, sewer adaptation)

1 INTRODUCTION

Increased urbanisation and changes in precipitation patterns put pressure on the existing drainage system (Skougaard Kaspersen et al., 2017) leading to the need of adaptations of existing systems. In addition, considering more aspects than flood protection has become more important in the recent years when planning adaptation measures (Fletcher et al., 2015). Nature-based solutions (NBS) offer multiple benefits while relieving the sewer system by decoupling sealed areas (European Commission and Directorate-General for Research and Innovation, 2015). However, as catchment wide implementations of NBS are usually unfeasible a variety of decision support systems for selecting NBS has been developed (Voskamp and Van de Ven, 2015; Wang et al., 2017). The decision support systems build on various constraints and benefits associated with NBS. For each parameter considered in the decision support system individual tools for evaluation are needed (Morales-Torres et al., 2016). One aspect considered is the impact of NBS on the sewer system's performance. Zischg et al. (2018) show how a sensitivity analysis can be used to evaluate the location of NBS from a sewer's perspective.

The aim of this paper is to apply the sensitivity analysis in a case study as a tool to support the decision process for stormwater management adaptations from a sewer perspective and to discuss the influence of different performance criteria on the location prioritization.

2 MATERIAL AND METHODS

For the analysis of the impact of the individual catchments on the CSO a sensitivity analysis based on the One-factor-at-a-time (OAT) approach by Mair et al. (2012) and Zischg et al. (2018) was performed. In a first step, a hydrodynamic sewer model is created comprising of all catchments with their current drainage area, which is used as the base scenario. In a second step, the drainage catchment of one individual catchment at a time is set to zero. From the individual simulation runs, differences of selected parameters such as CSO overflow volume in comparison to the base scenario are calculated. A graphical representation of the steps performed is given in Figure 1.

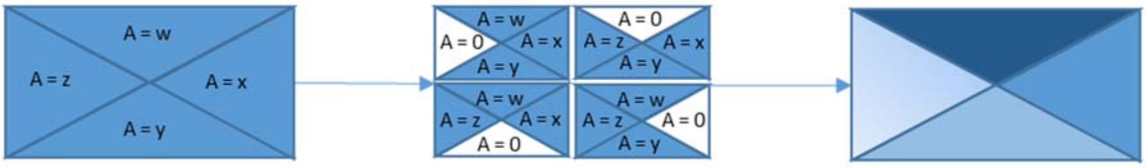

Figure 1 Schematic representation of the method

The case study, in which the analysis was performed, is Wagram, a district of the city St. Pölten located in Lower Austria. The model of the case study was set up in MIKE Urban (DHI, 2017). It consists of 463 catchments with a total drainage area of approximately 39.5 ha and more than 800 conduits. An Euler II design storm event (De Toffol, 2006) with a return period of 1 year was used for the simulations with a total of 13.4 mm. The variation of the drainage area and the simulations were automated using a python script.

In the case study the sensitivity of the CSO overflow volume towards the catchments was evaluated as an indicator for both the capacity of the sewer system as well as the ecological impact on the receiving water. The evaluation criteria calculated were total volume (Q) reduction in percentage (P) as well as the reduction per square meter drainage area (D) (2), with n representing the respective catchment with the altered drainage area and Base representing the results of the base scenario:

$$P = \frac{Q_n - Q_{Base}}{Q_{Base}} \times 100\ [\%] \qquad (1)$$

$$D = \frac{Q_n - Q_{Base}}{Area_n}\ [l/m^2] \qquad (2)$$

At the end, the results were graphically presented in sensitivity maps using a geographic information system (GIS). The maps were visually compared to evaluate differences in location prioritization.

3 RESULTS

The sensitivity analysis showed that decoupling individual catchments from the sewer network decreases the CSO discharge volume between 0 and 93 m³ for the design storm event. Looking at criterion P this corresponds to a maximum reduction of more than 5 % from the total volume discharged in the base scenario. When looking at the spatial distribution of the reduction potential, illustrated in Figure 2, it shows that the impact of individual catchments on the CSO discharge volume is spread across the district. The results show that there is a positive correlation between the catchment size and P, when looking at catchments smaller than 2000 m². However, for larger catchments the correlation is weaker and there is a higher scattering of the data.

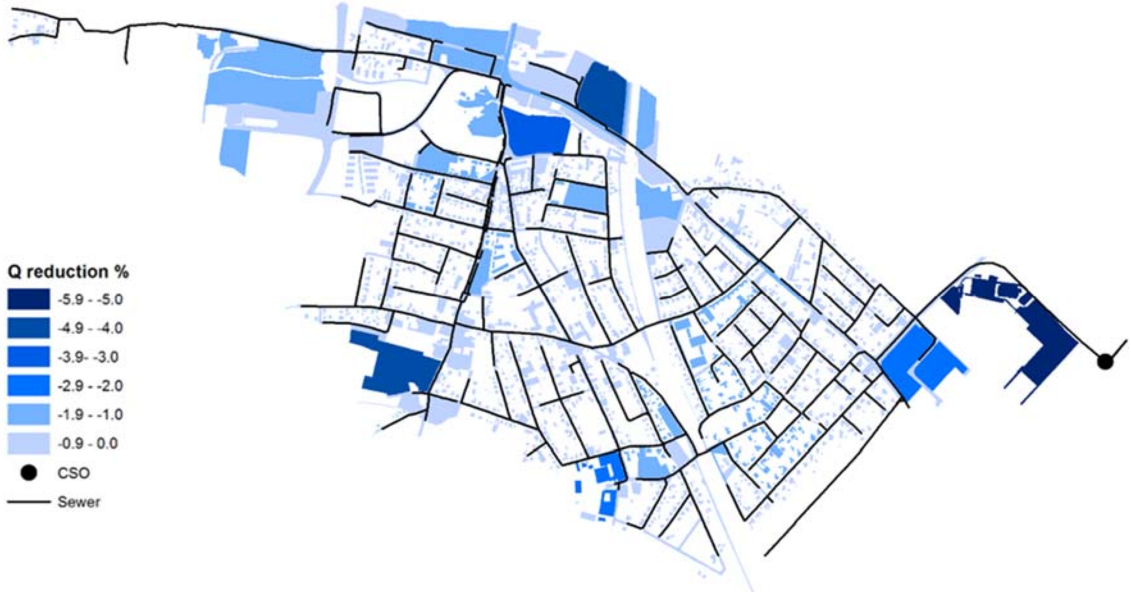

Figure 2 Reduction of CSO discharge volume in percentage

Analysing potential sites for NBS based on criterion D reveals completely different areas. The catchment with the highest performance in parameter D (-18.55 l/m²) shows only a very low reduction in parameter P (-0.2 %). For this criterion no correlation between catchment size and reduction potential D was found.

Figure 3 Reduction of CSO discharge volume in litre per square meter

A visual comparison of the sensitivity maps shows that depending on the criterion chosen for evaluation different areas are prioritized for the implementation of NBS. While criterion P evaluates the maximum CSO discharge volume reduction and focuses therefore on the impact on the receiving water, criterion D focuses on maximising the efficiency of decoupling single catchments. Although some catchments show a good performance for both criteria, the results and therefore prioritization of other catchments deviate significantly between the criteria. It shows that a careful selection of the evaluation criteria depending on the aim is necessary when applying this tool in a decision support system. The maps provide an easy way for communicating both preferential sites (Zischg et al., 2018) as well as the impact of the different evaluation criteria.

In a next step the results can be combined with other criteria representing the potential for and demand for NBS within a multi criteria decision support system. Furthermore, the effect of implementing NBS with an overflow into the sewer system could be evaluated. As this study assumed total decoupling of the catchment from the sewer system, this could of course change the prioritization of catchments.

4 CONCLUSIONS

Using a sensitivity analysis with an OAT approach to analyse potential NBS locations gives a good overview on potential catchments for decoupling from a sewer perspective. The case study has also shown that there is a significant deviation in potential locations for NBS depending on the criterion applied. Therefore, explicitly defining the desired aim for the decoupling is necessary for the selection of the evaluation criterion and a further integration of the sensitivity analysis in a decision support system.

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