Implementing different decentralized stormwater techniques to reduce pressure on the urban drainage system and mitigate the urban heat island effect

Mise en œuvre de différentes techniques décentralisées de gestion des eaux pluviales pour réduire la pression sur le système d'assainissement et les îlots de chaleur urbains

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Résumé
Dans la mesure où les effets du changement climatique entraînent des précipitations plus fréquentes et plus intenses, les systèmes d'assainissement urbain doivent supporter une plus grande quantité d'eau pendant une période plus courte, ce qui augmente le risque de graves inondations urbaines. Pour réduire la pression sur le réseau urbain, il est nécessaire de s'adapter en mettant en œuvre différentes techniques décentralisées de gestion des eaux pluviales, ce qui présente, en outre, de multiples avantages. En raison de la présence d'infrastructures bleues/vertes dans les zones urbaines, l'infiltration et l'évaporation sur site favorisent une circulation de l'eau plus proche du cycle naturel de l'eau. De plus, cela aura un effet positif sur le microclimat urbain, en atténuant les îlots de chaleur urbains. En comparant différentes techniques décentralisées de gestion des eaux pluviales, selon la structure de l'aménagement, dans des zones abritant un îlot de chaleur urbain, lesquelles sont étudiées grâce à une plateforme de conception simulant l'aménagement urbain et la performance dans le temps des interventions en gestion des eaux, il sera possible de mettre en lumière des adaptations propices et de valoriser les multiples avantages.

Abstract
As the effects of climate change are causing more frequent and extreme precipitation events, urban drainage systems are consequently facing higher amounts of water during a shorter amount of time. This increases the risk of severe urban flooding. To reduce the pressure on the urban network, adaptation through the implementation of different decentralized stormwater techniques is required and additionally contains multiple benefits. Due to the presence of blue/green infrastructure in urban areas, on site infiltration and evaporation are enhancing a water circulation closer to the natural water cycle. In addition, this will have a positive effect on the urban microclimate, mitigating the urban heat island effect. A comparison of different decentralized stormwater techniques, generated through a settlement structure type approach, for areas containing an urban heat island, studied with a Design Platform simulating urban development and the performance of water management interventions dynamically over time, will point out suitable adaptations emphasizing the profit from multi-benefits.

Keywords
Climate Change, Decentralized Stormwater Treatment, Green/Blue Infrastructure, Urban Heat Islands, Urban Microclimate
1 INTRODUCTION

As cities evolved, more and more people moved from rural settlements enhancing the growth of urban areas. As a consequence to this transition, landscapes changed and vegetated areas were transformed into concrete, steel and tarmac. As a part of these changes, climatic conditions in the cities differ as e.g. air temperature, wind speed, cloud cover, precipitation and solar irradiation from the surrounding natural areas (Kleerekoper et al., 2011). Obviously the city influences its climate. But this specific relationship is reciprocal, as the climate influences the ways in which the city space is being used (Kleerekoper et al., 2011). The geometry, spacing and orientation of buildings and outdoor spaces are key factors for the appearance of microclimates and especially urban heat islands (UHI). These effects have a negative influence on human well-being and their health and are strongly influencing the natural water cycle and water flow behaviour. Due to the effects of climate change, precipitation events and dry periods occur more frequent and extreme (IPCC, 2014). Adding all the mentioned factors up, this could lead to severe urban flooding in extreme events. To enhance a water circulation closer to the natural water cycle, reduce the pressure on the urban drainage system and mitigate the urban heat island effect, an implementation of decentralized stormwater techniques is required. Tackling the rising pressure by implementing blue/green infrastructure means that factors which enhance UHI can be reduced with the same measures at the same time. By doing so, cities and their inhabitants can profit from multiple benefits. This paper approaches this challenge by overlaying the outcome of a settlement structure type approach to place decentralized stormwater treatment techniques and the Design Platform simulating the presence of UHI, to generate an overview of adaptation measures in certain urban areas and to enhance the implementation of such multi-benefit infrastructures.

2 CASE STUDIES

The settlement structure type approach and the Design Platform will be based on the urban structures of three cities on different scale levels. Table 1 gives a brief statistical overview of the case studies Telfs, Innsbruck (both Austria) and Melbourne (Australia). The presented data was provided by “Statistik Austria” and “Australian Bureau of statistics”.

<table>
<thead>
<tr>
<th>City</th>
<th>Country</th>
<th>State</th>
<th>Inhabitants</th>
<th>Altitude</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telfs</td>
<td>Austria</td>
<td>Tirol</td>
<td>15,747</td>
<td>634</td>
<td>45,47</td>
</tr>
<tr>
<td>Innsbruck</td>
<td>Austria</td>
<td>Tirol</td>
<td>132,498</td>
<td>574</td>
<td>104,9</td>
</tr>
<tr>
<td>Melbourne</td>
<td>Australia</td>
<td>Victoria</td>
<td>4,670,461</td>
<td>14</td>
<td>8.830</td>
</tr>
</tbody>
</table>

These cities were chosen, due to the availability of high resolution data and to have a closer inside look into implementing decentralized stormwater techniques on different scale levels. Because of their geographically different locations, regional climatic conditions need to be taken into account. Nevertheless, the fact that more frequent and extreme precipitation events and dry periods occur due to the effects of climate change, are valid for all three locations.

3 METHODOLOGY

As already mentioned, a settlement structure type approach and the Design Platform will be used to compare the implementation of different decentralized stormwater techniques within areas containing UHI, on different scale levels. The following point 3.1 describes shortly the approach and functionality of the used models. The second point 3.2 sets the focus on expected results.

3.1 Models

In order to identify potential locations to implement decentralized stormwater techniques, analysis of the built structure, land use and zoning is necessary. The settlement structure type approach categorizes urban structures based on official available data, to identify potentials and constraints for stormwater management (Simperler et al., 2018). Ten different categories have been predefined to recommend different rainwater treatment concepts depending on the urban structure. The rainwater treatments are listed within the expected result chapter. Five categories (road network, water streams, high vegetation, arable land and green areas) have been additionally chosen to generate a completely covered map. Figure 1 demonstrates first results for Telfs and Innsbruck, generated with a GIS - geographical information system (ArcMap 10.6.1). To ensure a better overview, the cities are not at their exact
geographical locations to each other, as indicated by the black line.
The Design Platform is a planning-support tool that enables users to simulate urban development and the performance of water management interventions dynamically over time. In this specific case, an extreme heat assessment module is used to simulate the presence of UHI and to compare the UHI effects to different development strategies. The Design Platform is accessible via web browser and uses geographical information systems (GIS) to provide its modelling with the necessary information. Figure 2 shows a microclimate model based on a land surface temperature model set up for Innsbruck.

3.2 Expected Results

The outcome of this paper contributes to the project CONQUAD – Consequences and adaptation: Assessing multi-benefits and challenges in the transfer to more resilient and sustainable urban water systems. As a first step, a suggestion (recommended, allowed, not recommended or individual assessment required) of certain rainwater treatments for specific urban structure types can be made, in order to reduce pressure on the urban drainage system. The following list displays the recommended rainwater treatments depending on the structure types (Simperler et al., 2018):

- Retention and Drainage
- Retention and Evapotranspiration
- Retention and Utilization
- Infiltration with mineral filter
- Infiltration with lawn
- Infiltration with ground filter
- Infiltration with technical filter
- Drainage above ground
- Drainage underground

As a second step, the results from step one can be overlaid by the generated data from the Design Platform. It is then possible to compare the urban structure types and the suggested rainwater treatments with appearing UHI effects. Gathering this information, location and type of the rainwater treatments implemented for specific urban structure types can be optimised to cope with the rising pressure on the urban drainage system and simultaneously mitigate the UHI effect in particular areas of the case studies. The results from the different case studies should then be compared, to analyse the implementation of decentralized stormwater techniques on different scale.

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LIST OF REFERENCES


