Strategic planning of blue-green infrastructure to reduce surface water pollution from combined sewer overflows

F. Knoche[1,], F. Schumacher[2], M. Zamzow[1], J. Sohrt[3], M. Rehfeld-Klein[3], A. Matzinger[1], U. Johne[4], I. Meier[4], P. Rouault[1], E. Pawlowsky-Reusing[4], P. Schütz[1]*

[1]*Kompetenzzentrum Wasser Berlin gGmbH, Cicerostraße 24, 10709, Berlin, Germany+*

[2]*Ingenieurbüro für Wasser und Umwelt, Südwestkorso 70, 12161 Berlin, Germany*

[3]*Senatsverwaltung für Mobilität, Verkehr, Klimaschutz und Umwelt, Brückenstraße 6, 10179 Berlin, Germany*

[4]*Berliner Wasserbetriebe, Neue Jüdenstraße 1, 10179 Berlin, Germany*

**Corresponding author email: franziska.knoche@kompetenz-wasser.de*

Introduction

Berlin's combined sewer system, which is subject to overflows after heavy rainfall, has a negative impact on surface waters, resulting in low oxygen levels and fish mortality (Riechel et al., 2016). A modernisation program aims to limit the annual volume of combined sewer overflows (CSOs) to 25 % of stormwater runoff by 2024. However, achieving the ecological objectives of the Water Framework Directive (EU 2000) for the affected surface waters remains a challenge. To address this, the MiSa project is assessing the impact of impervious area reduction, sewer network adaptation and river management on CSOs and oxygen conditions to support city-wide surface water quality improvement strategies.

Methodology

The MiSa project consists of four steps: deficit analysis, model setup and validation, establishing realistic management strategies with authorities and modelling of these management strategies.

Deficit Analysis:

To evaluate dissolved oxygen (DO) conditions for fish, three indicators were defined: the time below critical DO concentration, the number of critical DO events, and the negative deviation from a reference state. Critical DO conditions for fish were defined as a concentration below 1.5 mg/L.

Model Setup and Validation:

A model chain including sewer network model (InfoWorks ICM) and surface water quality model (GERRIS/HYDRAX/QSim) (Matzinger et al., 2013) was extended to the entire Berlin combined sewer system. The individual and combined calibrations for 2017 used high-resolution monitoring data for the affected river sections in Berlin, data from rain gauges and flow data from the main pumping stations.

Establishing Realistic Management Strategies:

Workshops with stakeholders, including the Senate Department for Urban Mobility, Transport, Climate Protection and the Environment (SenMVKU), the Berliner Wasserbetriebe (BWB), the Berliner Regenwasseragentur and two Berlin district authorities, led to the development of feasible management strategies. These strategies integrate impervious area reduction, sewer network measures, aligned with climate adaptation, flood protection, and biodiversity goals. Specific measures have been defined for three time horizons (10, 30 and >30 years).

Modelling of Management Scenarios:
To ensure realistic conclusions, the effectiveness of measures was assessed using 14 selected rainfall events from 2011 to 2019, simulating scenarios with the model chain. These scenarios, assessed using the MiSa indicators, were compared with the base scenario representing the current state.

Results and Discussion

Deficit Analysis:
Pollution is most significant in the city center. While the mean of critical events between 2000 and 2019 is only 0.06/a in the river sections at the beginning of the city center and the combined sewer system, it increases to 2.63 in the central main channel of the River Spree and up to 7.67 in some side canals in the city center.

Model Chain Validation:
The DO concentrations were successfully simulated throughout the time period, during dry weather and after combined sewer overflows.

Management Scenarios:
Eight scenarios combining impervious area decoupling and sewer adaptation were developed. Reductions range from 1.5 % to 47.5 % over the timeframes, demonstrating major improvements in water quality for longer-term scenarios.

Conclusions and Future Work:
The MiSa indicators assess combined sewer system renovation based on immissions. The model chain, combining sewer network and surface water quality models, accurately represents combined sewer overflow impact on Berlin's watercourses. Integrated urban drainage management scenarios, considering efficiency, feasibility, and climate adaptation, are planned through collaborative workshops. Simulations indicate a substantial need for catchment and stormwater management adaptation, highlighting potential for effective combined sewer overflow mitigation. Further workshops with relevant districts and refined river management strategies are underway, demonstrating authorities' motivation for implementation.

References

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