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The power of Open Data – Using free data for a preliminary screening of impact from urban wet-weather discharges on Danish streams

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Highlights

- Simple screening models can foster the implementation of effective pollution management plans
- Results from river and urban drainage models, made publicly available by Danish authorities, were combined in a simplified model to assess impacts from wet-weather discharges
- The simple model was applied to the whole Denmark, providing an initial screening of the areas potentially impacted by urban discharges and requiring major attention by stakeholders

Introduction

Integrated management of urban water have been promoted for decades at the European level, promoted by legislation such as the Water Framework Directive (2000/60/EC). Given the challenges to monitor the impact of urban wet-weather discharges (SSSO -Separate Storm Sewer Outlets and CSO - Combined Sewer Overflows) by using current protocols and techniques, complex integrated models have been proposed as effective tools for planning and implementing integrated solutions and for achieving the desired quality status (e.g. Gill et al., 2019). The implementation of these complex models, however, requires large resources for data collection, model implementation and validation. Thus, these tools are not suited for preliminary screening activities, where urban water managers need to identify critical areas for prioritizing their investments.

This study exploits data that are freely available in the Danish context (modelled flows in natural streams, and wet-weather discharges, measured concentrations) to perform screening of the potential threat posed by micropollutants to the chemical status of Danish natural streams. A simple river model, based on dilution and advection, allowed to identify stream stretches were Environmental Quality Standards (EQS) could potentially be exceeded as consequence of wet-weather discharges.

Although benefitting from a “rich data” context, the proposed approach can be adapted to the measured/modelled data in other countries to provide a first indication of the areas negatively affected by wet-weather discharges. This will allow a prioritization of available resources, enabling the implementation of integrated modelling and management approaches in the most critical areas.

Methodology

Available data

As part of the digitalization strategy promoted by the Danish Government, several environmental data are publicly available. These include:

- Modelled flow data for all Danish streams, obtained by the *Hydrological Information and Prediction* system (HIP model - hip.dataforsyningen.dk). These are calculated by using the *National Water Resource Model*, a tridimensional representation of the integrated water cycle (including rainfallrunoff, groundwater and surface water, urban water contributions) with a 100 m grid resolution. Model results are available with monthly resolution for over a 30 years period for almost 47,00 nodes across 2787 streams (with 787 receiving wet-weather discharges).

- Modelled wet-weather discharges. These results are generated from the 98 Danish municipalities by using detailed hydrodynamic models, providing the yearly discharged volume for each of the 4,500 CSO and 14,500 SSSO (Vezzaro et al., 2019). All this information is available on the *Danish Environmental Portal* (arealinformation.miljoeportal.dk)
- Measured concentrations of micropollutants from monitoring campaigns performed by the Danish Environmental Protection Agency. Given the limited number of monitored sites and events, these measurements were integrated with those reviewed by Mutzner et al. (2021).

Simple river model

A simple advection model was created, starting from the stream discretization of the HIP model. For each known discharge point, the concentration in the *i-th* river section was calculated by using a simple dilution-advection model (Figure 1):

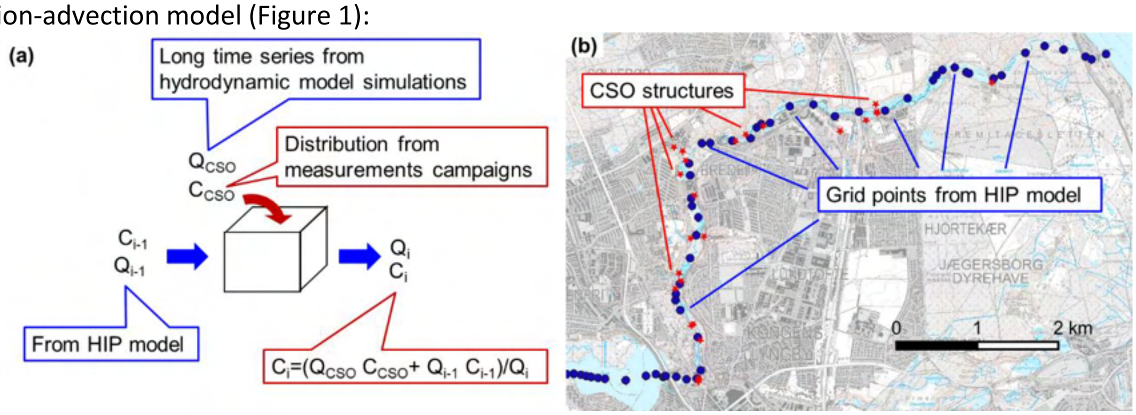

Figure 1. (a) Schematic representation of the simple river model for a i-th grid node, (b) example of discretization for a 10 km stretch of the Mølle Å river with HIP grid nodes (blue dots) and CSO structures (red stars).

The discharged CSO concentration is calculated from the distributions estimated by Mutzner et al. (2021) as 50% and 90% percentiles. The annual CSO volumes have been downscaled to single events discharging by using event durations and magnitude calculated by using 10-year simulated discharges provided by Lyngby-Taarbæk water utilities for the Mølle Å stream. Accordingly, an archetype CSO discharge event was defined to have a duration of 8 hours and a volume corresponding to the 2% of the total yearly volume. The simulated concentrations were compared to EQS defined by European and Danish legislation (plus additional EQS recommended by the Swiss Ecotox Center in case official EQS were not available). A total of 19 micropollutants were selected based on the assessment performed in Mutzner et al. (2021).

Case study

The simple river model was initially tested on Mølle Å, a 30 km peri-urban stream located north of the city of Copenhagen. The flow at the stream outlet ranges between 1.8 m^3/s (winter) and 0.3 m^3/s (summer). The river is a Natura 2000 protected area, and it crosses several urban areas, with over 25 CSOs structures located along the stream. The stream is discretised in 138 nodes in the HIP model.

Results and discussion

An example of the obtained results for Cu concentrations is shown in the Figure 2 below. This example shows how the contribution of the discharges from CSO increases the Cu concentration, leading to the exceedance of the AA-EQS (2 ug/l) in some stretches of the stream.

The results obtained for the 19 investigated substances showed that the EQS were exceeded for five substances, with different number of points exceeding the Annual Average EQS for the 50% median concentration (Benzo(a)pyrene – 83%, Copper – 18% , fluoranthene – 83%, lead – 45%, zinc – 66%). The location of these exceedance points is clearly downstream major CSO structures (as exemplified in Figure 2). This suggest that a more detailed integrated model or monitoring is needed for these river stretches in order to further investigate the impacts from wet-weather discharges and the potential mitigation strategies.

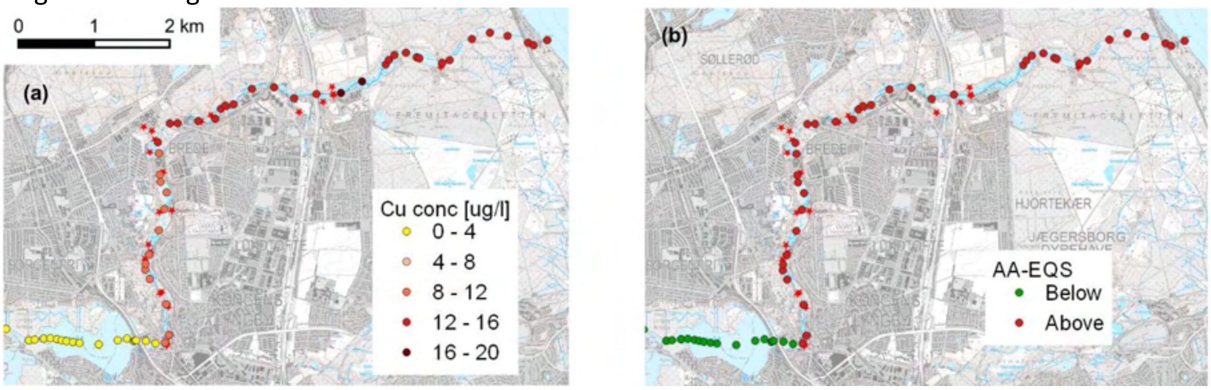

Figure 2. (a) Example of estimated of Cu concentrations and (b) exceedance of Annual Average EQS also the Mølle Å stream (average flow conditions, and 90% percentile CSO concentrations)

Conclusions and future work

The preliminary results shown here illustrate the potential of a simple modelling approach to highlight critical river stretches, where urban water managers should focus their resources to reduce wet-weather discharges and maximize the improvement in the river chemical and environmental status. The presented simplified approach has several assumptions which could be addressed to improve the robustness of its results:

- Expansion with stochastic emission models. The use of fixed CSO concentrations does not reflect the high temporal variability of wet-weather discharges. A Monte-Carlo approach can be implemented, with CSO concentrations sampled from the distributions estimated by Mutzner et al., (2021)
- Addition of simple environmental processes (e.g. first order degradation, solid/water partition) would improve the estimation of the micropollutant concentrations in the water phase
- Forward uncertainty analysis: the modelling results should be presented as risk of EQS exceedance, in order to clearly illustrate the structural uncertainties linked to the modelling approach

This work is still in progress, and the presented modelling approach will be applied to the whole Denmark (a total of 787 freshwater streams, and 1,967 CSO structures) by the time of the conference.

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