Fostering the digitalization in urban water systems with low-cost monitoring of combined sewer overflows.

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Highlights

- A new device for low-cost monitoring of combined sewer overflows is being deployed in large sewer networks.
- Data obtained will support the digitalisation of urban water systems and improve the knowledge of utilities regarding the performance of sewer networks during rainfall events.
- This device is only one out-of-15 innovative technologies tested within the H2020 digital-water.city innovation project.

Keywords: digitalization, urban wastewater systems, combined sewer overflows

Introduction

Digital solutions open up a variety of opportunities for the water sector. Digital water is now seen not as an ‘option’ but as an ‘imperative’ (Sarni et al., 2019) for a more sustainable and secure water management. Many solutions leverage the latest innovations developed across industries and business activities including advanced sensors, data analytics and artificial intelligence. The EU H2020 innovation project *Digital-water.city* (DWC) aims at demonstrating the capability of data and digital technologies to boost the integrated management of waters systems in five major European cities – Berlin, Copenhagen, Milan, Paris and Sofia. The goal is to quantify the benefits of a panel of 15 innovative digital solutions and achieve their long-term uptake and successful integration into the existing digital systems and governance processes.

One of these promising technologies consists of the use of innovative low-cost temperature sensors to estimate combined sewer overflow (CSO) discharges from sewer systems. In a CSO event, a mix of sewerage and stormwater runoff is discharged directly into the environment. Heavy rainfall and the limited drainage capacity of combined sewer systems are the triggers for CSO events. Thus, CSOs are a source of contaminants for the receiving media (such as solids, organic matter, nutrients, metals, organic compounds and pathogenic microorganisms) and can have acute negative impacts on aquatic organisms, e.g. in the form of critical oxygen concentrations (Harremoes 1982, Riechel et al. 2016).

Traditionally there has been a lack of reliable data-information about the occurrence and duration of CSOs. Two of the main limitations with regards to CSO monitoring to date were: i) the high number of CSO structures-points per municipality-catchment and ii) the high cost of the flow-monitoring equipment available in the market to measure CSOs. These limitations have become particularly relevant since recent regulations promote the appropriate monitoring of all CSO structures in order to control and avoid the detrimental effects described above to achieve and maintain a good ecological status of the receiving media (Geiger 1998, EC-WFD 2000)

The main objective of this work is to integrate the use of low-cost sensors for CSO detection in large sewer systems in order to foster the digitalization of urban water systems. Data is used to improve the knowledge of the sewer network behaviour during rainfall events and the calibration of hydrodynamic sewer models.

Methodology

The CSO detection method consists in installing a low-cost temperature sensor at the overflow crest of a combined sewer. In the case of dry weather, the sensor measures the air phase, whereas in the case of CSO the discharged storm and wastewater is measured. The start and end of a CSO event can be determined via a drastic shift in measured temperature (Montserrat et al, 2013). The sensitivity and precision of the method depend on the difference between air and water temperature as well as their diurnal variations. The measurement concept is visualised in Figure 1.

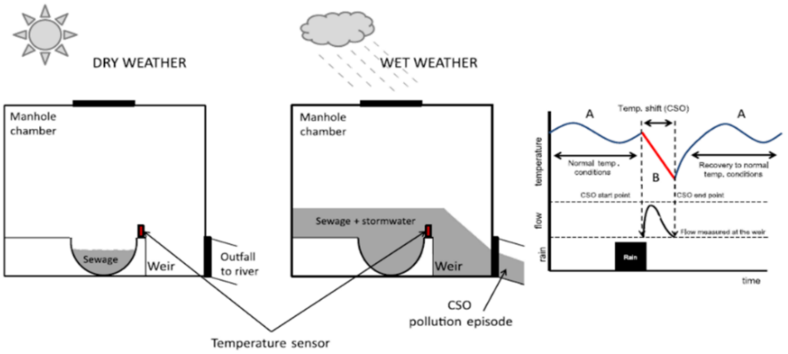

Figure 1. Diagram of the concept of using Temperature sensors as a measurement of CSO events. A temperature drop-change can be identified when a CSO event is occurring.

The described method was brought to a large scale, by deploying a total of 50 sensors in the cities of Sofia (Bulgaria) and Berlin (Germany). Sensors are coupled to wireless communication and cloud data transmission through state-of-the-art data-shared platforms to allow online visualization and data processing. Artificial intelligence and predictive analytics techniques were developed to extract accurate real-time knowledge from the raw temperature measurements and define a user-friendly set of rules for optimal CSO prevention.

Results and discussion

In the large-scale demonstration within the DWC project, sensors were tested in Sofia and Berlin, two metropolitan sewer systems with different operational and climatic conditions. The method was assessed by performance indicators consisting of accuracy metrics such as CSO occurrence and duration, CAPEX and OPEX, to quantify their added value for water utilities.

With regards to the accuracy metrics, the results obtained were very satisfactory in terms of the higher number of CSO structures being monitored, thus increasing the knowledge of how their respective sewer systems react to rain and storm events. For a given fixed budget, the low cost of the sensors allowed to monitor a higher number of points compared to other more costly options, thus expanding the geographical extent of the monitoring.

Figure 2. Comparison of the CSO occurrence in Belin sewer system. A). CSO's detected using the low-cost temperature sensors. Coloured dots are different overflow points in the network, B). Rainfall events, and C) Water level measurement in a nearby location.

Detection of CSO occurrence and CSO duration was compared to results obtained with previously installed sewage level sensors in the Berlin sewer network. Level sensors are commonly used as CSO detectors as they measure the height of the wastewater surface within the sewer. This information, linked to the height of the CSO crest, can be used to estimate CSO metrics. Figure 3 presents the results of the detection of CSO using temperature sensors (Fig 2.A), rain events (Fig 2.B) and levels sensors (Fig 2.C) in April 2021. It can be seen that, for the rain events, some of the overflow structures spilled sewage and that was simultaneously recorded with the two methods, Temperature sensors and level sensors. The different coloured points in Fig 2.A correspond to different CSO structures' locations in the sewer system and represent de behaviour of the overflows. The blue line in Fig 2.C. shows the increase and decrease of the water level at one location, being the higher peak periods of heavy rain. Overall, there was a reasonable correlation between the two methods, thus suggesting the performance of the Temperature-based solution was providing reliable information.

The sensors will help ensure compliance with environmental regulations and, in addition, to increase hydraulic modelling capabilities through improved calibration. Thanks to the CSOs data, more accurate simulations can be performed as we have representative data from a higher number of points, thus enhancing the calibration and the accuracy of the simulations. Results of the advanced calibration will be presented at the conference together with the approach to data wireless communication and cloud data transmission, all with the goal to integrate this promising technology into the digitalisation of urban water systems.

Figure 4. From left to right: example of a CSO event with sewage being discharged in a river stream, CSO structure in the sewer network of Berlin and CSO structure of the sewer network of Sofia.

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