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Urban Drainage Modelling for the Design of Treatment Technologies †

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Abstract: A recent evaluation of the UWWTD confirmed that overflows from combined systems and surface water runoff are a significant pressure of the aquatic environment in terms of pollution. Increasing urbanization, climate change, and the evolution of pollutants suggest that CSOs may worsen in the future, impacting on the ecological status of rivers. In the Italian case study, an urban drainage model of the Bologna sewer network is applied to quantify the pollution load discharged from CSOs, which represents the main parameter for the design of treatment technology.

Keywords: urban pollution; urban drainage models; CSOs

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1. Introduction

Management of non-point and point source pollution from urban areas is essential for reducing the stress on urban water bodies, providing the appropriate ecosystem services. A recent evaluation of the Urban Wastewater Treatment Directive (UWWTD) imposed the increased monitoring and control of pollution from both combined sewer system overflows and surface water runoff [1]. In line with this is the Horizon Europe project StopUP (https://stopup.eu/, accessed on 30 August 2024), which, with its seven case studies and 11 partners over all Europe, aims to minimize pollution from urban runoff by better understanding pollutant sources and pathways and providing innovative monitoring, treatment technologies, and tools to enable end-users to apply existing and new SUDS practices. In detail, the work package 2 addresses the pollution modeling in urban drainage networks; over the past few decades, sewer networks have been subject to significant changes due to several factors, including population growth, climate change, variation in pollutant discharge patterns, human activities, as well as the emergence of new technology and changing regulations [2]. Urban drainage models are very effective in the management of these issues, and they are applied for several purposes, such as the assessment of pollution, prediction, operational management, real-time control, and the design of new treatment technologies. In the following Italian case study, an urban drainage model is applied to quantify the pollution load discharged from CSOs, i.e., the main parameter for the design of treatment technologies.

2. Materials and Methods

The Italian case study domain includes the main combined sewer overflow (CSO) of Bologna in terms of the largest amount of mass and volumes discharged on a yearly basis [3]. Bologna, located in the northern part of Italy, has an urbanized area of more 4700 ha, and it is drained by a combined sewer system of a total length of 800 km (Figure 1). The sewer system and wastewater treatment plant of the city (650,000 E.I), located in the northern part, are managed by the major stakeholder of the Emilia–Romagna region Hera S.p.a. Overflows, which occur in wet weather periods, are received by three main watercourses

(Reno river, Savena river, and Navile channel) through 123 spills. In particular, during rainfall events, the Navile channel receives the overflow before the inlet to the WWTP.

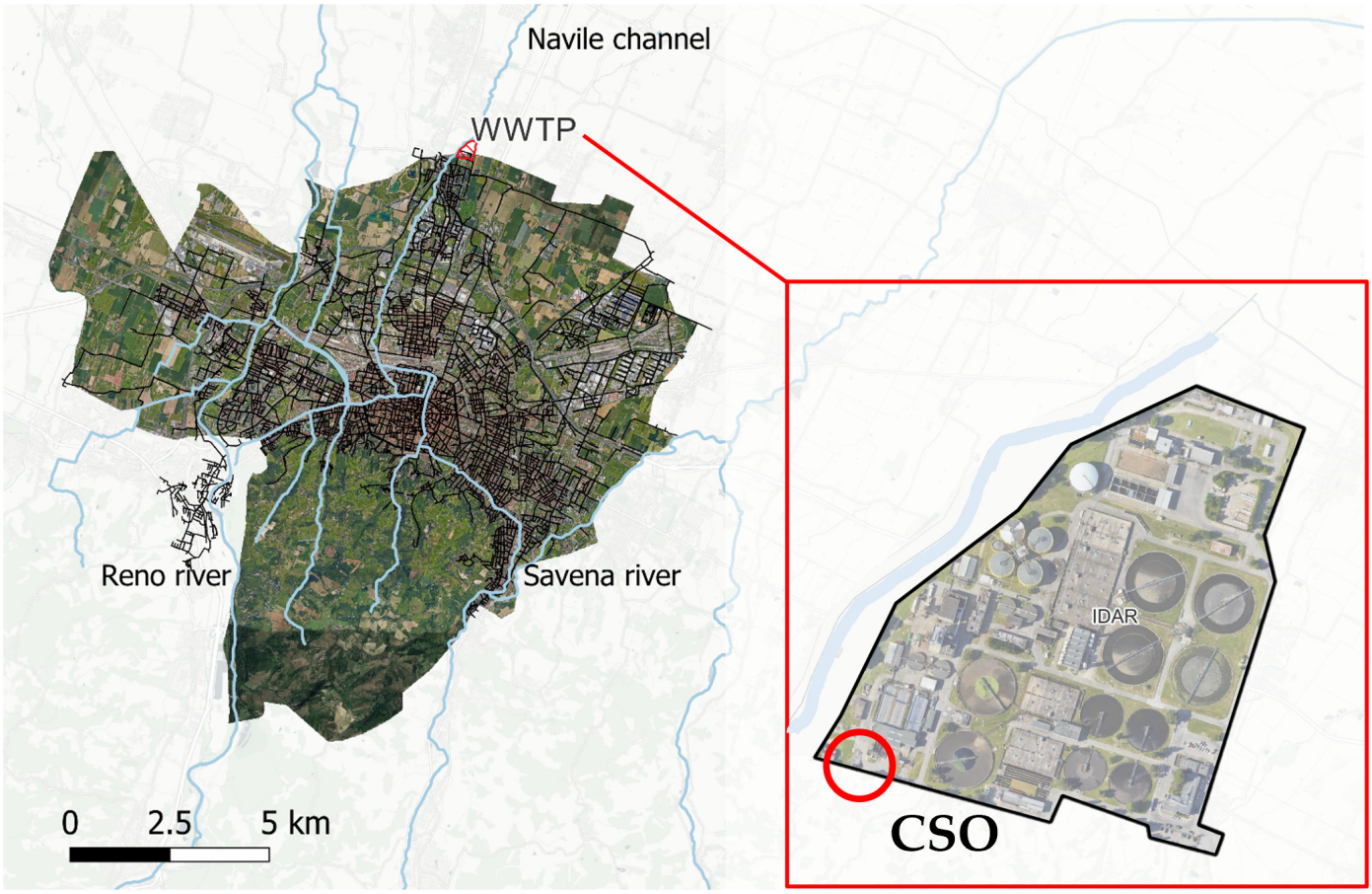

Figure 1. Bologna case study: watercourses, sewer network, and wastewater treatment plant.

2.1. Experimental Set-Up

The measurement point is set up in the pipe before the inlet to the WWTP that drains sewage and stormwater. Unfortunately, it was not possible to install sensors in the CSO since the same collector transports both the spills during rainfall events and the treated water by the WWTP. However, the continuous measure of the water level in the pipe provides information on the verified spills and the relative volume. Sensors continuously measure electrical conductivity, turbidity, and water level.

2.2. Hydraulic Model

The first hydraulic model was developed in Infoworks CS, and several long-term simulations were performed by [3] for the 1994–1998 period to evaluate the combined sewer overflow impact of the Bologna sewer system. However, recent data and the advanced calibration techniques now available allow for the implementation of a novel calibration of the hydraulic and water quality model. Water level data from 10 network points, rainfall data, and inline quality measurement acquired in the period of January–July 2023 will be exploited to perform the calibration of the simplified drainage network model; the model simplification was carried out by adopting pruning and merging techniques in order to reduce the operation running time.

3. Results and Discussion

Preliminary data acquired by the sensors are shown in Figure 2. For the configuration of the set-up, the dashed line represents the water level threshold above which the spill

is activated. The first peak of turbidity registered during May 2023 is associated with transport of high loads of suspended solids due to the extreme rainfall events occurred in Emilia–Romagna region.

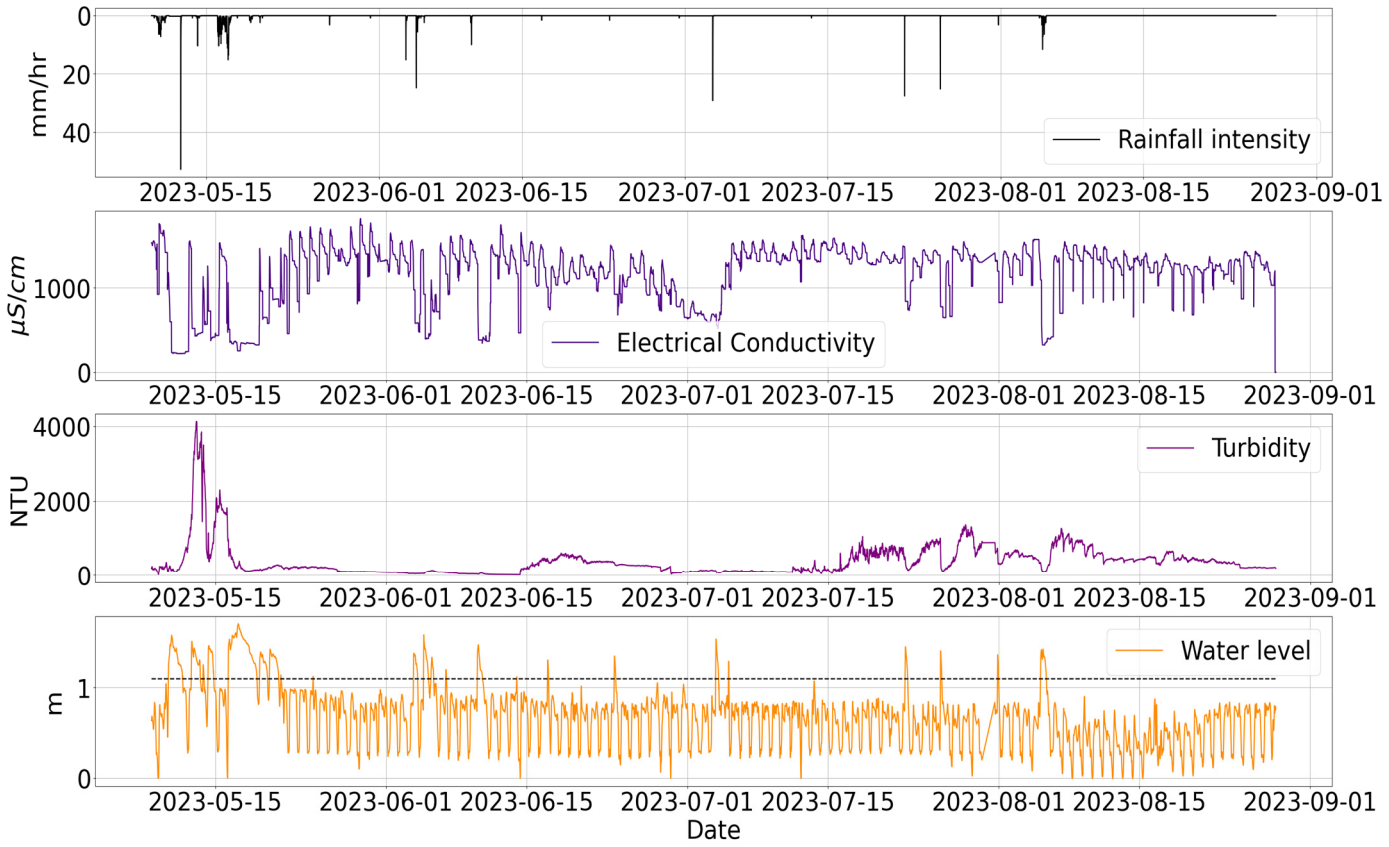

Figure 2. First data collected at the inlet to the WWTP. From above rainfall intensity, electrical conductivity, turbidity, and water level.

Good results were obtained for the preliminary hydraulic single-event simulations that occurred in 2023. As an example, the simulated flow trend for the event on 19 March 2023 is reported in Figure 3, together with the observed flow values at one point of the network.

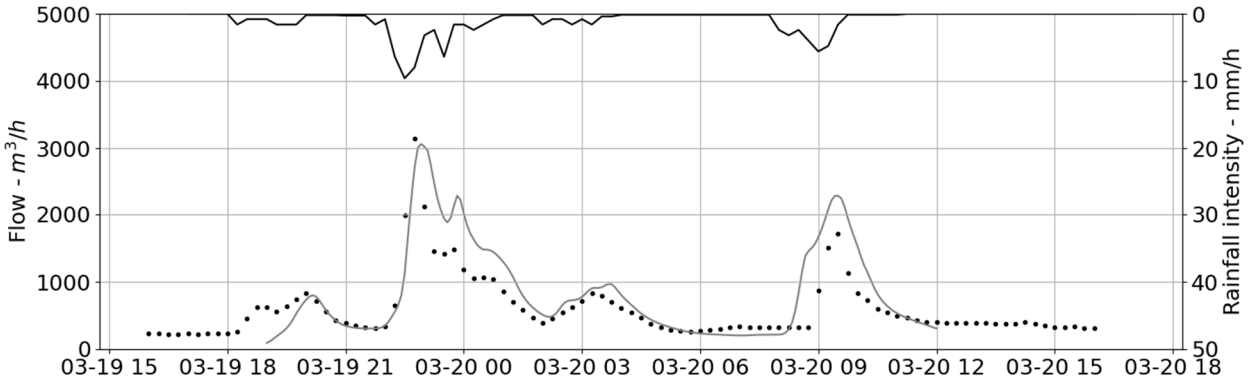

Figure 3. Flow trend simulation and observed values for a single-event simulation at one measurement point in the network.

4. Conclusions

The project StopUP is currently underway, along with ongoing monitoring. Over the next few months, additional data will be acquired; they will allow us to calibrate the model

and perform long-term simulations in order to quantify the pollution load discharged from CSOs. The calibrated model will enable us to effectively assess the efficacy of treatments and identify any potential impacts of climate and urban changes.

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Conflicts of Interest: The authors declare no conflicts of interest.

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