HYDROINFORMATICS OF SMART CITIES: REAL-TIME WATER QUALITY MONITORING AND PREDICTION

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ABSTRACT
This project focuses on the condition of surface water in urban areas, an important aspect of smart cities. Water quality monitoring has an important role in health and environmental management. This study aims at creating a prediction model for water quality based on real-time data which will help policy and decision makers.

Keywords: Artificial Intelligence, Hydroinformatics, Numerical Modelling, Smart Cities, Water Quality.

1 INTRODUCTION

Water is one of the most important resources for human society. The world is currently undergoing a wave of urban growth, and pollution problems are of a great impact. Monitoring water quality is a key task for the future of the environment and human species.

In recent times, researchers, using Smart Cities technologies are trying to mitigate the problems generated by the population growth in urban areas. The availability of huge amounts of data collected by a pervasive urban IoT can increase the transparency of decision making. Several services have already been implemented in Smart Cities, but more and more services will be involved in the future. Water quality monitoring can successfully be implemented in the urban IoT. The combination of water quality sensors, cloud computing, smart city infrastructure, and IoT technology can lead to a bright future for the environment monitoring.

In the past decades, lots of effort have been put on monitoring and predicting water quality using traditional approaches based on manual collection and laboratory-based analysis, which are slow and laborious. The present study proposes a methodology for implementing a water quality prediction model using artificial intelligence techniques and comparing the results obtained with different algorithms. Furthermore, a numerical model will be created, and simulation results will be used as a training dataset for the Artificial Intelligence algorithm. This study derives the methodology and demonstrate its implementation based on information and data collected at the floating harbour in the city of Bristol (UK).

2 STUDY AREA

The area of interest for this project is the Floating Harbour located in Bristol, UK (Figure 1).

The Floating Harbour is a large hand-made standing fresh water body with occasional saline intrusion. It was built for commercial purposes in 1809. Merchants in Bristol at that time wanted to make the fluvial harbour of river Avon non-tidal in order to facilitate the commercial exchanges. The tidal range of the rivers in the Bristol Channel is the second greatest in the world (the biggest is the Bay of Fundy, Nova Scotia, Canada). At the mouth of river Avon, the tide can rise and fall as much as 14 metres twice a day and even in Bristol the water level can change as much as 12 metres. By damming river Avon and creating a tidal bypass, from then on, the ships that were in harbour would be able to stay afloat hence the name ‘Floating Harbour’.

Today the harbour’s role has changed, it is mainly a tourist attraction with museums, galleries, exhibitions, bars. The harbourside is largely used for leisure boats. Former workshops and warehouses have now largely been converted or replaced by cultural venues.(Malpass and King, 2009)

The Floating Harbour has two main inlets. The feeder canal (Figure 1 [B]) is the major source of fresh water for the harbour. At that entrance, the flow is controlled by gates at Netham Lock (Figure 1 [A]). The water level in the harbour is continuously monitored and it’s kept constant at 9 meters local datum by the sluice gates at Underfall Yard (Figure 1 [C]). The sluice gates at Underfall Yards represent the main outflow together with the Ship Lock (Figure 1 [D]).

The Floating Harbour is a complex system, there are different sources of contamination that can access the harbour at different places and different times, and they can have different origins. Most of the source of pollution depends on heavy rainfall. Investigative work is ongoing to gather information to better understand the dynamic system.

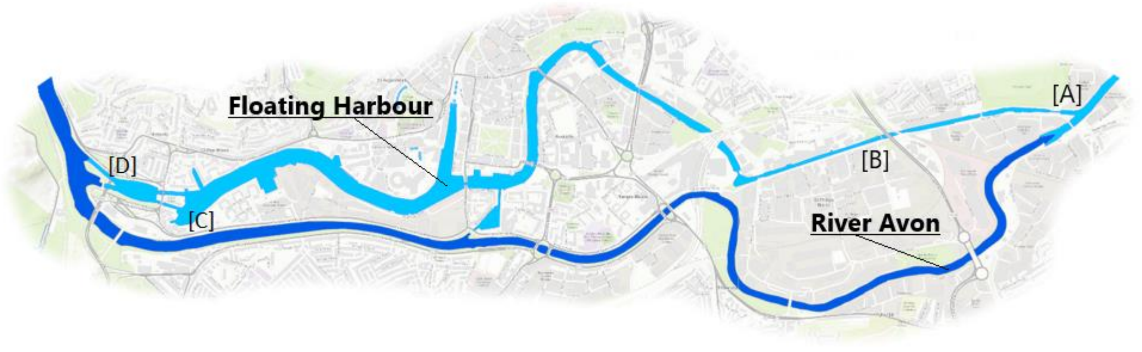

Figure 1. Map of the Bristol Floating Harbour.

3 DATA COLLECTION

In this study different datasets will be used depending on the water quality parameter that will be predicted.

One of the main concerns for the studied area is the level of pathogens contained in the water.

Bristol City Council monitor the content of Escherichia Coli (E.Coli) at 4 sites in the harbour taking weekly measurements and at 5 sites taking monthly measurements (Figure 2). This database is uploaded online on an open platform.

Figure 2. Monitoring sites for E.Coli.

The current EU Bathing Water standard for bacterial contamination is 2000 cfu/100ml Escherichia Coli. Bristol Floating Harbour is not a designated bathing water and therefore these water quality standards do not apply. However, Bristol City Council uses a locally derived trigger value of 5000cfu/100ml Escherichia Coli to warn users of poor water quality (Bristol City Council, 2006).

For this project this database will be used for studying the link between the trends of E.Coli and weather data (i.e. air temperature, solar radiation, rainfall…). These data will be integrated with a field measurement campaigns that will be carried on during the summer period. Daily measurements of E.Coli will be taken in order to better understand the trend and the link between these pathogen indicator and the weather.

For physical water quality parameters (pH, turbidity, conductivity, fDOM, water temperature) a 3 month database, the result of a previous study (Chen and Han, 2018) carried on in the harbour will be used. These data were collected by a real time water quality monitoring system. The network is made of 3 real- time water quality sensors (Figure 3) that were placed at different location in the harbour.

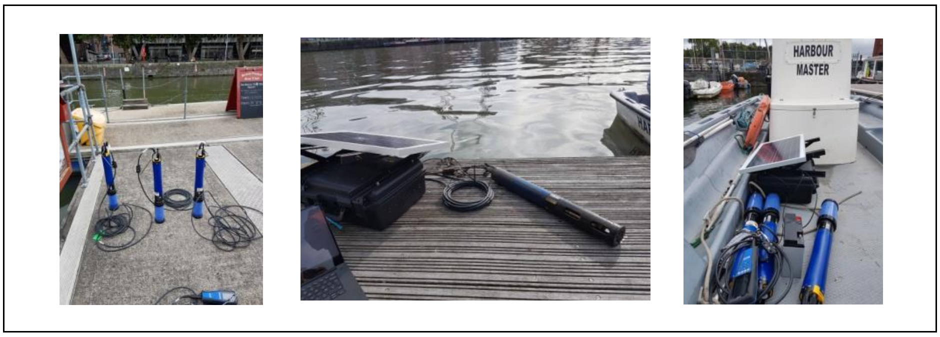

Figure 3. Real-time water quality sensors.

A real-time weather monitoring system will be installed in the harbour together with a Doppler flow meter and a water-level monitoring instrument.

4 METHODOLOGY

The main aim of this study is to implement a water quality prediction model. The prediction model will use an artificial intelligence algorithm to link real-time weather forecast to the quality of water. The project will mainly focus on predicting E.Coli concentration and physical water quality parameters.

For the prediction model four types of training datasets will be used. The first training dataset will be the E.Coli historical data collected by the City Council integrated with the field measurements that will be carried on during summer. Such data will be used as targets for the developed AI model during the training phase.

The second training dataset will be the real-time data collected by the sensors network. It will be used to build the hydrodynamic model.

The third dataset will be weather data (from the UK Met Office, and the in-situ real-time weather station) to be used as an input by the hydrodynamic model and the AI algorithm.

The fourth dataset will be created by using a numerical hydrodynamic model. It will be calibrated and validated. From the hydrodynamic simulations a water quality numerical model will be set up. Once the water quality model will be calibrated and validated it will be used to create different scenarios of weather condition and water quality. These data will be used to overcome the lack of data in the training phase of the prediction model's algorithm.

5 PRELIMINARY RESULTS

The relationship between rainfall, temperature and concentration of E.Coli is analysed at the current stage of this study.

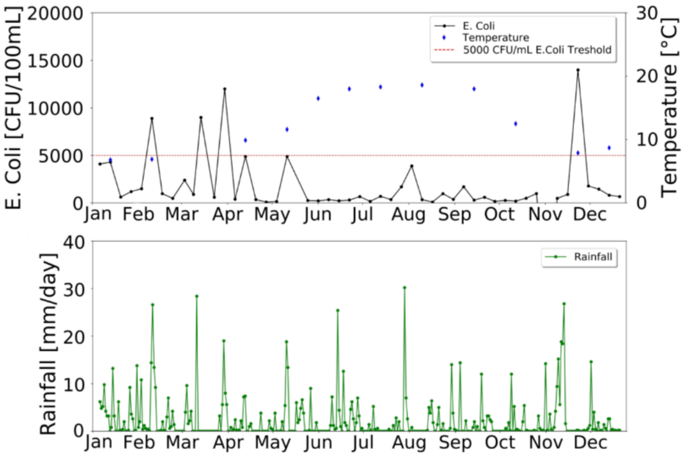

Figure 4. Effects of Rainfall and Temperature on E.Coli concentration.

As shown in Figure 4, the E.Coli concentration is more sensitive to peaks of rainfall rather than changes in temperature. It is possible to spot a peak in E.Coli concentration for almost every peak of rainfall. When there is a high rainfall there is an overflow entering the harbour. This occasional flow contains the overflow of the sewage lines that cause an increase of E.Coli concentration in the harbour. In the figure above (Figure 4), it is possible to see that in August there is a peak of Rainfall that doesn't correspond to a peak of E.Coli concentration. This might be because in that period a festival is held in the harbour. In those weeks there is a high number of vessels coming in and out of the harbour that results in a high exchange of water and so a dilution in the concentration of E.Coli.

The temperature seems to have a smaller influence on the concentration of E.Coli but this might be because of the frequency of the dataset. More data are needed to analyse these relations.

6 CONCLUSIONS

A water quality prediction model can be an important tool for environmental monitoring and it can help decision making processes.

ACKNOWLEDGEMENTS

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