WP6.5 - Improved energy-efficiency in wastewater treatment processes by modelling techniques validation

Nearshore coastal water quality could impose risk to public health through recreational activities and affecting human food chain. Furthermore, impaired water quality could have large financial consequences by affecting tourism and aquaculture activities. Faecal indicator organisms (FIOs) are amongst the most important pollutants in coastal waters.

A World Health Organisation (WHO) report estimated that diarrheagenic *E. coli* causes more than 300 million illnesses and nearly 200,000 deaths globally in year 2010. It is also estimated that sea-swimmers are 77% more likely to develop earaches and 29% more likely to develop gastrointestinal illnesses compared to non-sea swimmers. Treated and untreated discharges from wastewater treatment works (WWTWs) are one of the main sources of pollutants, and particularly FIOs, in coastal waters.

To ensure public health is protected, the European Union (EU) revised bathing water directive (rBWD) sets acceptable standards for FIO concentrations, such as *E Coli* and *Enterococci*. The rBWD also requires beach water quality to be monitored at least monthly. While most of the beaches in UK and EU are of good water quality standard according to rBWD in year 2021, the water quality of a beach is known to vary within a month or even a day by 10 or 100 times. A sampling study in Swansea Bay, UK showed that the beach was classified “Good” or “Sufficient” in afternoons but was classified “Poor” in mornings and evenings in year 2011.

The EERES4WATER project aims to develop coastal water quality prediction models, which enable:

1. Real-time data-driven Artificial-Intelligence (AI) bathing water quality prediction in order to inform the public and regulatory authorities.
2. Increasing efficiency of wastewater treatment works by optimising their operations based on their estimated impacts on receptors by hydro-environmental models.

Public water quality warning systems provide real-time warning of impending poor water quality, hence reduce the public health impact related to poor water quality. Hydro-environmental models enable optimisation of WWTW operations that increases efficiency of the system and reduce energy and resources consumption.

These models can predict pollutant concentrations at sensitive receivers, such as beaches, under different WWTW discharge pollutant levels and different environmental conditions such as temperature and sunlight. WWTWs may then treat wastewater only up to a level that does not cause unacceptable pollutant concentrations at sensitive receivers based on the environmental conditions.

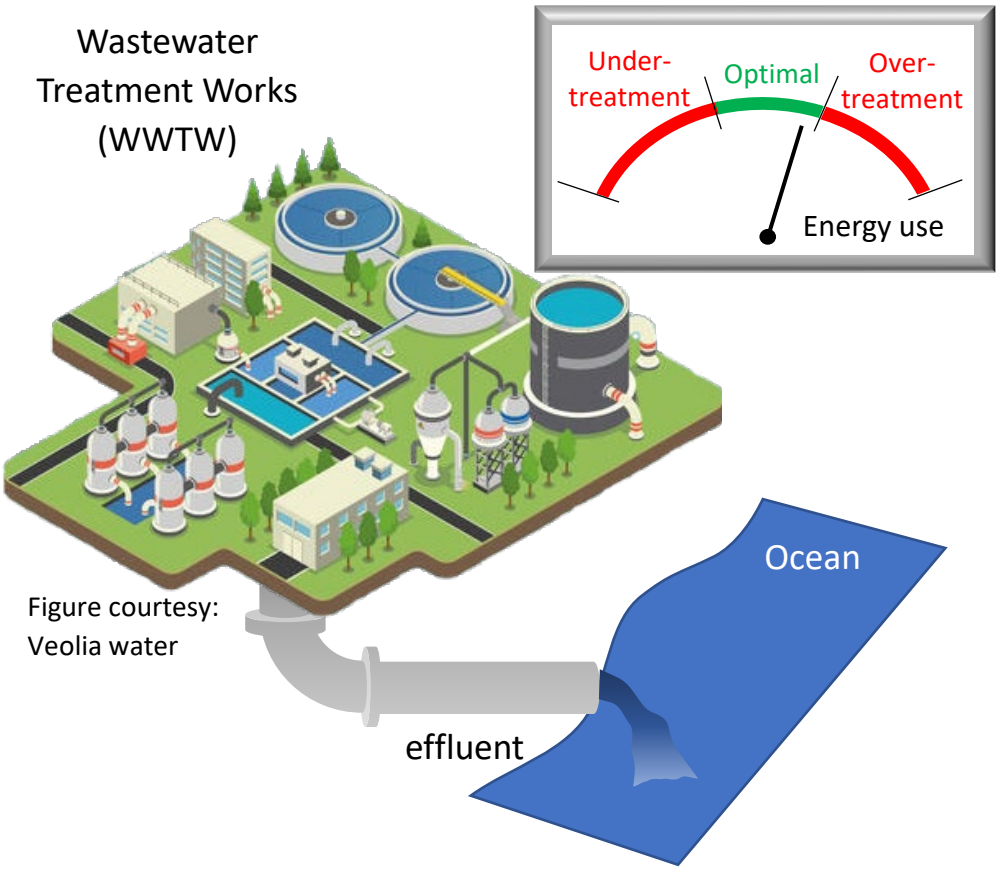

Figure 1. A wastewater treatment work under optimal operation, achieving water quality standard yet saving energy.

The Cardiff University team has developed an Artificial Intelligence (AI) faecal indicator organism (FIO) prediction model and is enhancing their hydro-environment model to predict fate and transport of FIOs (Figure 2). The models were applied to Swansea Bay, located on the north of the Bristol Channel, UK, where large amount of data was collected through previous projects.

The newly developed AI model better captures poor water quality events. The model predicts FIO concentrations from the environmental data obtained by sensors or analysis of water samples, e.g. temperature and salinity, with minimal computational time. The capability of capturing poor water quality events and giving timely prediction make this model suitable for real-time bathing water quality warning systems.

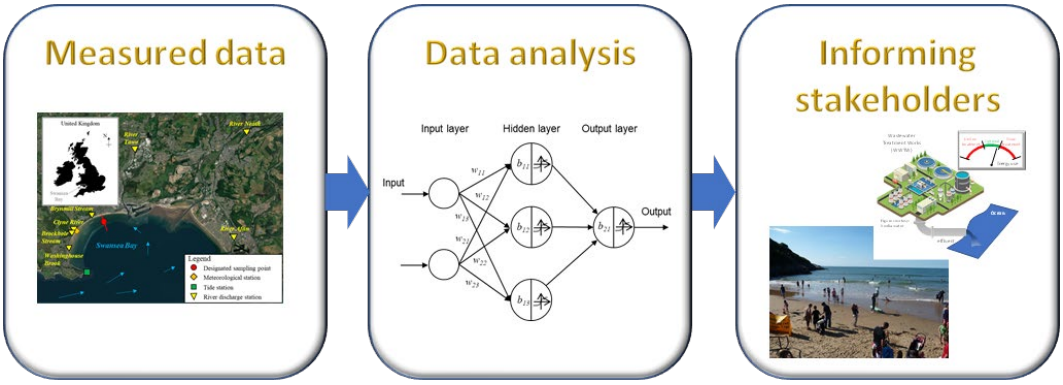

Figure 2. Schematic diagram of the data-driven AI model.

The hydro-environmental model simulates the fate and transport of FIOs by solving the governing equations for water flow and considering processes affecting FIOs, e.g. dynamic decay. The model was applied to identify the sources of the FIOs at sensitive receivers (i.e. source-receptor connectivity) under different environmental conditions (Figure 3).

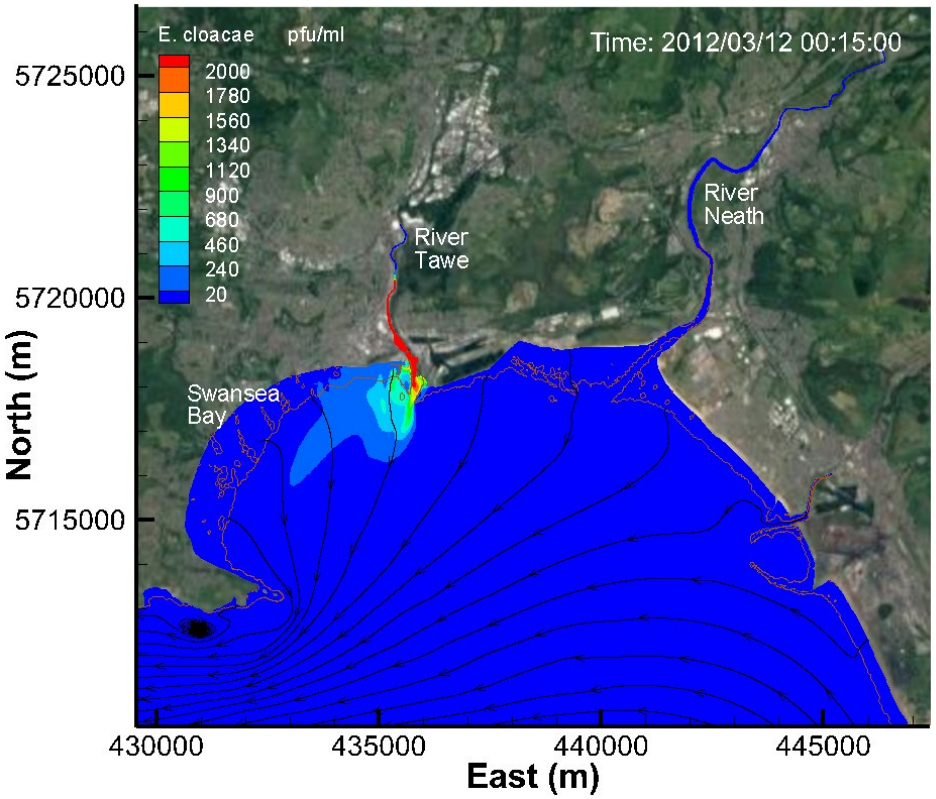

Figure 3. A hydro-environmental model for bacteria in Swansea Bay, UK. The brown line indicates land-sea interface, and the black arrows indicate flow direction.

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