Continuous monitoring of oxychlorides through sensor data fusion

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Motivation

Across the globe, chlorination is critical to providing safe water. It prevents and even halts water-borne epidemics (Fig. 1), such as from cholera, typhoid and dysentery [1, 2]. However, hazardous oxychlorides may be formed during this process. These are known to affect the human thyroid gland [3]. The oxychlorides are difficult to measure and costly to remove once formed [4]. Commercial sensors are available for some of the oxychlorides but are expensive and need regular maintenance. There are no sensors for the more hazardous oxychlorides.

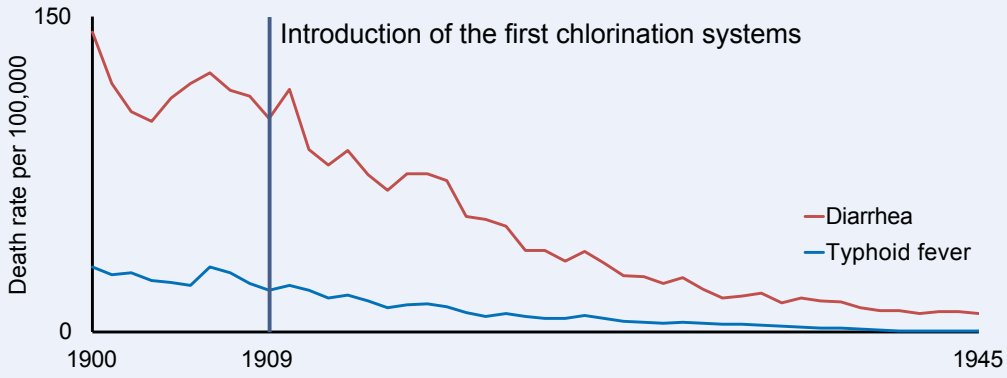

Fig 1. Death rates from water-borne diseases decreased tremendously in the U.S. as access to clean water increased [5, 6]

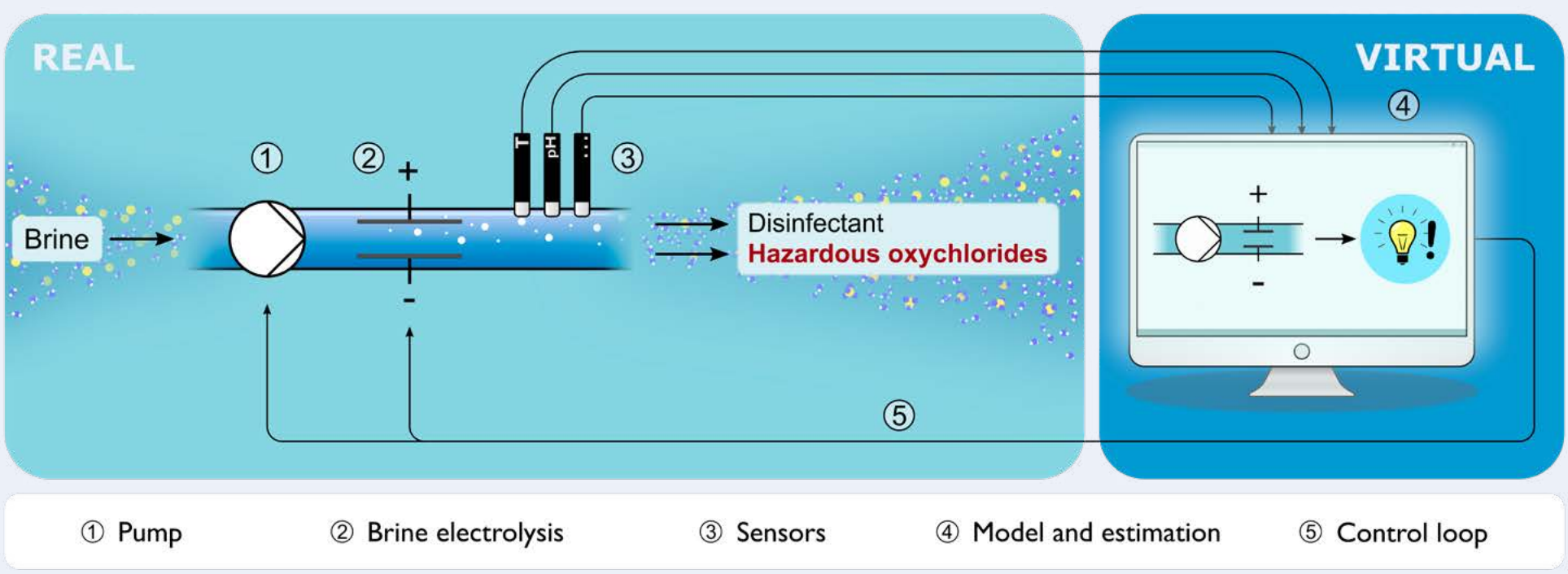

Fig 2. Experimental setup in which a physical disinfectant production process is monitored, modeled, and controlled

Technological challenge

This project aims to overcome the lack of a real-time sensor technology for such oxychloride concentrations by developing sensor technology based on sensor data fusion. In contrast to traditional sensor technology, the concentrations are not measured directly. Instead, **multiple sensors**, such as for temperature, pH and conductivity, are used to give insight into the current state of the chlorine-based disinfectant production process (Fig. 2, 3). These sensors are **widely available**, **affordable** and **robust**. The technological challenge of this project is to deduce oxychloride concentrations from these indirect sensor data, and to do so as accurately as possible.

Three data fusion methods will be investigated, based on:

- A white box model that describes the physics of the process,
- A black box model that uses machine learning for estimation,
- A combination of the two, leading to a new type of soft sensor.

[1] World Health Organization (2011). “Guidelines for Drinking-water Quality”, 4th ed.
[2] Childs, C. (1905). *Public Health* **18**, 3, 121 - 150
[3] Stanford, B. D. et al. (2011). *American Water Works Association* **103**, 6
[4] Atwood, J. et al. (2016). *Agriculture and Horticulture Development Board*
[5] United States Public Health Service (1947). “Vital Statistics of the United States, 1945, Part 1”
[6] Gleick, P.H. (2018). *PNAS* **115**, 36, 8863 - 8871
[7]

Research goals

- To develop and test a system for monitoring oxychlorides based on sensor data fusion, including sensor selection, development of algorithms and system control
- To understand the benefits and limits of machine learning for sensor fusion, and how this can supplement a traditional “white box” approach and vice versa
- To learn how uncertainties in the data and model impact the final estimates
- To generalize the sensor data fusion system design methodology to enable wider application

Fig 3. Two examples of commercial electrochlorination systems

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