Editorial: Modelling and integrated assessment of urban water systems

The 10th IWA Symposium on Modelling and Integrated Assessment (Watermatex 2019) was held on 1–4 September 2019 in Copenhagen, Denmark. The conference was jointly organized by the Technical University of Denmark (Denmark) and Lund University (Sweden), and attracted more than 200 delegates from almost all continents of the world. This symposium series is part of the activities of the IWA Specialist Group on Modelling and Integrated Assessment. This special issue of *Water Science and Technology* highlights some of the presentations from the conference that have been selected and peer reviewed, together with a few submissions that pertain to the same themes as the conference but were submitted separately. In total, 91 oral and 47 poster presentations were given at Watermatex 2019 as well as seven thematic workshops.

Ever since its beginning in London, UK (1987), the Watermatex symposium series has always highlighted the application of a wide range of mathematical tools for problem solving in the water sector. From being initially an area of academic research interest, modelling tools in the water sector evolved into useful practical tools for industry and academia to address the present and future challenges in a holistic manner. This is clearly visible in the conference presentations that cover a wide range of applications from water resource recovery facilities to sewer systems and drinking water distribution networks. Not only is the spatial horizon getting wider and more integrated, the systems and tools used are also evolving. A hybrid modelling approach combining mechanistic and data-driven models is also clearly developing as the state-of-the-art. The application of big data and machine learning tools is increasing exponentially, at least from an academic perspective, and is expected to soon evolve into handy tools for practitioners. Application of computational fluid dynamics (CFD) is increasingly becoming an attractive and useful method to address and improve the design and operation of water infrastructure. The developments in process modelling have taken new directions with more focus on understanding the physical processes such as in grit chambers and sedimentation basins. Finally, process modelling and control have always been studied in

tandem and the same was visible in the conference presentations. With the advent of machine learning approaches and the focus on digitalization, researchers in the areas of monitoring, fault detection and automatic control have all attempted to combine the traditional modelling approaches with these new tools.

The special issue is broadly divided into four sections that also nicely summarize the major themes of the conference. A total of 25 papers are selected for the special issue. The key themes are:

- Systems Analysis, Big Data and Machine Learning
- Computational Fluid Dynamics (CFD)
- Process Modelling
- Instrumentation, Control and Automation (ICA)

SYSTEMS ANALYSIS, BIG DATA AND MACHINE LEARNING

One of the major aspects of the Watermatex 2019 conference is a great interest in systems analysis, big data and machine learning approaches. A combination of traditional mechanistic models and machine learning approaches is evolving as the new state-of-the-art. Such approaches are used for process optimization (Bertanza *et al.* 2020; Borzooei *et al.* 2020; Nam *et al.* 2020) and process understanding (Alejo *et al.* 2020). The importance and application of uncertainty analysis for models, especially with a large number of parameters and various forms of uncertainty is reiterated (Lindblom *et al.* 2020; Reichert 2020). Applications of system analysis in different areas of urban water systems are presented (Andersson *et al.* 2020; Hosseini *et al.* 2020; Nyirenda & Tanyimboh 2020; Wärff *et al.* 2020).

CFD

The first presentation on CFD was a plenary presentation at the conference, which addresses the importance of model validation not only to improve the CFD models but also to increase the level of trust by practitioners (Nopens *et al.* 2020). Application of CFD tools to study anaerobic digesters (Dapelo & Bridgeman 2020; Tobo *et al.* 2020) and water distribution systems (Satpathy *et al.* 2020) are presented.

PROCESS MODELLING

Process modelling is no longer confined mainly to biological processes. Plant-wide modelling approaches for biological nutrient removal are presented (Seco *et al.* 2020). A renewed interest in modelling physical processes (grit chambers, sedimentation and dissolved air floatation) is noticed (Bürger *et al.* 2020a, 2020b; Plana *et al.* 2020).

ICA

While ICA is an entire conference theme by itself, it has strong interconnections with the Watermatex conference. A growing interest in the holistic control of urban wastewater systems is evident through several studies (Ledergerber *et al.* 2020; Stentoft *et al.* 2020). Moreover, process control case studies for drinking water treatment are presented (Godo-Pla *et al.* 2020; Ndiweni *et al.* 2020). New control strategies for biofilm-based processes (Schraa *et al.* 2020), monitoring solutions for moving-bed biological reactors (Nair *et al.* 2020) and water treatment plants (Kazemi *et al.* 2020) are discussed.

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