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Water and health seminar and special issue highlight ideas that will change the field

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The 11th international "Water & Health" seminar took place from June 24–26, 2019 in Cannes, France. The seminar is sponsored annually by Suez, a 150-year-old multinational water and waste management company, to support research into water quality and health carried out by advanced doctoral students. It promotes ongoing communication among students, established scientists, and industry practitioners from all over the world. The seminar aims to: enhance dialogue between junior scientists and senior mentors, spotlight early-breaking research concepts and results, cross disciplinary boundaries to contribute to the advancement of water safety, and identify new critical research needs.

This special issue contains a number of articles on challenges such as emerging pollutants and antimicrobial resistance, as well as both high-tech and nature-based solutions. Some key topics from the seminar and this special issue include advancing data modeling to consider heterogeneity of populations, recognizing synergies among environmental health interventions, optimizing health by building resiliency through measured risk exposure, and understanding the role of contextual factors in tailoring intervention strategies to a given population or setting.

The winning seminar presentation came from Tanguy Pouzol, who modeled the release of 15 pharmaceuticals in effluents from a semi-urban area of 16,000 inhabitants and a 450-bed hospital. Pharmaceuticals have been detected in all types of water bodies worldwide and have been the subject of numerous risk assessments since the 1970s, as described in several recent comprehensive reviews (Ebele et al., 2017; Kümmerer, 2016; Li, 2014; Palli et al., 2019; Yang et al., 2017). Gosset et al. (2020) report a comparison of ecotoxicological risk

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assessment approaches for a “cocktail” of chemical pollutants, including pharmaceutical residues, discharged by urban wastewater treatment plants near Lyon, France. Their findings demonstrate the importance of jointly considering all the components of a pollutant mixture for accurate assessment of environmental risks. However, measuring concentrations of pharmaceutical residues in water remains a complex task. Analytical techniques under development that may improve environmental detection of pharmaceuticals include DNA nanobiosensors, which are reviewed by Soukarié et al. (2020) in this special issue. DNA nanobiosensors present a promising approach for an array of water quality monitoring applications, including the detection of microorganisms, as described by one of the review co-authors, Diana Soukarié, in a seminar presentation on her ongoing research. The ongoing challenge of environmental measurement also highlights the need for complementary approaches to characterize pharmaceutical concentrations in environmental waters, such as simulation modeling. The model proposed by Dr. Pouzol (Pouzol et al., 2020) was based on the monthly sales recorded in 6 pharmacies and the daily consumption of the hospital, over 2.5 years, with hypotheses on the frequency of consumption, metabolism and release in wastewaters. For most molecules, the modeled concentrations matched well with the concentrations observed during several monitoring campaigns. The model allowed prediction of wastewater flows and changes in concentrations of pharmaceuticals in the effluents, on an hourly time scale, and thus prediction of important concentration peaks that cannot be observed by random or integrated sampling. Compared to classical approaches, such a model improved the average performance by one-third while giving additional information. Future improvements and perspectives should focus on improving knowledge on pharmaceutical loads, especially their variability at both daily and hourly scales, including in-sewer processes and improving the usability of the model by simplifying it while keeping its stochastic nature.

The recent Sustainable Development Goal (SDG) Synthesis Report on Water and Sanitation emphasized that the world is not on track to achieve global SDG 6 targets by 2030 and highlighted the need for improved understanding of the baseline status and trends of global indicators to support renewed progress (UN Water, 2018). The seminar and special issue addressed the challenges and interactions among development goals that must be considered to achieve sustainable water and sanitation for all. A microbial source tracking (MST) study conducted by Dr. David Holcomb in Mozambican households found widespread human fecal contamination, highlighting the obstacles to improving sanitary conditions through simple interventions directed at households (Holcomb et al., 2020). A study characterizing human fecal pollution of Thai surface waters using host-associated bacteriophages identified opportunities to reduce diarrheal disease risks at a broader scale through improved coastal water quality management (Chyerochana et al., 2020). These and other recent evaluation studies reflect a growing awareness of the synergies among water and health risks and other development interventions.

For instance, efforts to mitigate environmental transmission of fecal pathogens must address sustainable management of fecal wastes throughout the sanitation chain. The decentralized sanitation infrastructure common in rapidly growing urban areas in particular requires effective solutions for fecal sludge removal and treatment. An intervention impact study in Maputo, Mozambique demonstrated how subsidized pour-flush sanitation systems can increase hygienic emptying of fecal sludge, but also highlighted that the use of such services was unaffordable for many users (Capone et al., 2020).

Dr. Paul Hunter presented a discussion on how our ongoing knowledge of threats posed by waterborne noroviruses is shifting to account for population variability and the factors that influence susceptibility. Along the same lines, Sital Uprety demonstrated geographic variation in diarrheal disease risk in rural Nepal through a quantitative microbial risk assessment (QMRA) informed by a cross-sectional evaluation of household drinking water quality in the aftermath of the 2015 earthquake disaster (Uprety et al., 2020). While Uprety et al. used the fecal indicator bacterium (FIB) *Escherichia coli* to characterize risk under a reference pathogen approach, the seminar featured a discussion of the limitations of QMRA for predicting pathogen-specific risks. Specifically, QMRA has been found to overestimate disease burdens for pathogens such as norovirus, for which there remains substantial uncertainty around both the dose-response relationships and the implications of population immunity (Van Abel et al., 2017).

The growing issue of antimicrobial resistant (AMR) organisms compounds the risks posed by enteric infections. In addition to selection pressure driving an increase in AMR organisms in clinical settings, the presentation and article by Voigt et al. (2020) presented evidence for the introduction of antibiotic residues, antibiotic resistant bacteria (ARB), and antibiotic resistance genes (ARG) to environmental waters downstream of wastewater treatment facilities. Such risks are not confined to surface water, as demonstrated in an article by Salazar et al. (Salazar et al., 2020), which found aerosolized ARB in proximity of a river passing through La Paz, Bolivia, where urban population densities imply an elevated risk of exposure.

A seminar presentation by Dr. Karen Setty discussed intervention design, specifically the evidence base to address contextual variability in Water Safety Plan implementation and scale-up (Setty et al., 2019; Setty, 2019). Water safety plans represent a risk management approach developed by the World Health Organization to support safe drinking water provision (Bartram et al., 2009). These plans can be adapted to different resource settings from a community to industrial scale, and have the potential to enhance equitable outcomes (Ross et al., 2019). Dr. Setty borrowed concepts from the emerging field of implementation science to understand and better explain why results of complex interventions often vary among locations. Recognizing these site-specific contextual constraints or “barriers” and matching them to active, proven strategies can help to extend water, sanitation, and hygiene services to all under SDG 6 (United Nations, 2015). Articles in this issue recognize the outstanding needs of underserved populations such as the Roma in Europe (Anthonj et al., 2020), sustainable pit latrine emptying practices in low-income settings such as Mozambique (Capone et al., 2020), and affordable drinking water treatment using local materials such as curry leaf (Mukherjee et al., 2020). Contextual clues also offer a bridge to potential “quality improvement” solutions through rapid experimental cycling of pilots, data collection, and adjusted approaches (Setty et al., 2019; Setty, 2019).

Finally, a short communication by Dr. Mark LeChevallier bridges the ideas and challenges raised in the 2019 seminar with other global phenomena underlying access to safe water (namely, climate change). Dr. LeChevallier illustrates how climate shifts are already impacting water and health by heightening risks and requiring innovative adaptation of existing systems (LeChevallier, 2020). Climate adaptation will draw increased attention as the central theme of a future Water and Health seminar.

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