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ABSTRACT BOOK

ORAL PRESENTATIONS

The abstracts on the following pages are listed by session number. The presenter's name has been underlined.

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Mechanistic modelling of chlorine decay in reclaimed water distribution systems – case study applications

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Session 8B: Urban reuse, Meeting Room 1.4.1 - 1.4.4, March 19, 2025, 10:00 - 11:00

The Lisbon Water Smart Living Lab was established in the scope of the B-WaterSmart project (2020-2024) with a strong focus on urban water reuse for unrestricted irrigation and other non-potable uses and will continue beyond 2024 as a water-oriented living lab (WOLL) of the Water4All "Atlas of EU WOLLs". In urban reuse, risk management during distribution is often critical, particularly in big cities subject to climate-change, as droughts and heat waves, where urban reuse is emerging to mitigate water scarcity and increase water resilience.

Safe reclaimed water (RW) use often requires disinfection and a sound management of chlorine residuals throughout the RW distribution systems (RWDSs) from the production site to the point(s) of use. However, accurate prediction of chlorine decay in RW lacks robust models and precise estimation of model parameters, more than in drinking water. The higher concentrations of organic matter (OM) and (potentially) ammonia in RW may induce microbiological regrowth and disinfection by-products (DBPs) formation (public health and ecosystems hazards) in RWDSs, stressing the chlorine dosage control relevance. Chlorine can react with ammonia to produce monochloramine, dichloramine, and trichloramine, depending on the chlorine and ammonia nitrogen ratio, pH, and temperature (breakpoint reaction). Monochloramine is a weaker disinfectant than free chlorine, but is more stable, particularly in the absence of nitrifying conditions, and produces smaller amounts of chlorinated-DBPs.

Based on Duirk's et al. (2005) studies of monochloramine decay in drinking water under the effects of monochloramine and OM, we have recently modelled, validated, and calibrated chlorine decay in RW by integrating monochloramine auto-decomposition reaction scheme (14 reactions) with a semi-mechanistic chlorine decay in OM presence (Costa et al. 2021). Despite the overall model complexity, it was successfully implemented in the hydraulic modelling open-source tool EPANET-MSX (Costa et al. 2023) and in the licensed Baseform software.

The presentation will focus on the implementation and calibration of this model in a real RWDS, incorporating both chlorine bulk and wall decays. Field experiments were conducted to calibrate the complete model with two (tank and pipes) wall decays. This model was used to diagnose the RWDS status condition and cleaning needs, and to manage its operation. The model allowed predicting adequate chlorine dosing in summer and winter scenarios, which matches the network properties and flows, the water reuse quality standards, and, eventually, the RW characteristics. Simulations were performed showing the major impact of ammonia concentration on the optimization of the disinfection process and that water quality models (advanced, mechanistic) must play a central role in the planning, design, and operational control of distribution systems for managing water reuse risks.

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References
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Duirk S.E. et al. 2005. Water Res. 39, 3418–3431.