

## **“Pathogen exposure modeling: from recreational waters to your plumbing”**

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Abstract: Fecal indicator bacteria have reached their limit in aiding pathogen exposure assessments of waters. This is in part due to their ubiquitous occurrence in animal excreta, which is poorly correlated with zoonotic pathogen occurrence, and that various fecal indicators naturally colonize aquatic/sediment/soil habitats. On the other hand, direct pathogen quantification at points of exposure to waters (via swimming, drinking water or inhaling aerosols) has largely been unsuccessful – and methods would generally have to improve by some orders of magnitude to detect what our quantitative microbial risk assessment (QMRA) models indicate are problem levels (e.g. one virus per million liters of drinking water). Hence, exposure modeling for pathogens often uses a hybrid approach; describing probability density distributions for reference pathogens (viral, bacterial and protozoan) in source materials (wastewater, excreta, pipe biofilms), and combines that with fate and transport models in which surrogates for each group of pathogens are assayed (e.g. bacteriophages, *E. coli* and spores). As waterborne pathogens have acute effects, it is also important to include a range of scenarios in these models, reflecting various hazardous events for the location under investigation. Then, for each reference pathogen, sensitivity analysis is used to identify the most important pathways to manage, which often also identifies key research gaps. Exposure assessment examples for fecal pathogens in recreational water and environmental pathogens via pipe biofilm aerosols will be described.