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Modeling tools for the assessment of microbiological risks during floods: a review

Philip Collender (1), Wen Yang (1), Marc Stieglitz (2), Justin Remais (1,2)

(1) Emory University, Atlanta, GA, United States (philip.andrew.collender@emory.edu, wen.yang@emory.edu, justin.remais@emory.edu), (2) Georgia Institute of Technology, Atlanta, GA, United States (marc.stieglitz@ce.gatech.edu, justin.remais@emory.edu)

Floods are a major, recurring source of harm to global economies and public health. Projected increases in the frequency and intensity of heavy precipitation events under future climate change, coupled with continued urbanization in areas with high risk of floods, may exacerbate future impacts of flooding. Improved flood risk management is essential to support global development, poverty reduction and public health, and is likely to be a crucial aspect of climate change adaptation. Importantly, floods can facilitate the transmission of waterborne pathogens by changing social conditions (overcrowding among displaced populations, interruption of public health services), imposing physical challenges to infrastructure (sewerage overflow, reduced capacity to treat drinking water), and altering fate and transport of pathogens (transport into waterways from overland flow, resuspension of settled contaminants) during and after flood conditions. Hydrological and hydrodynamic models are capable of generating quantitative characterizations of microbiological risks associated with flooding, while accounting for these diverse and at times competing physical and biological processes. Despite a few applications of such models to the quantification of microbiological risks associated with floods, there exists limited guidance as to the relative capabilities, and limitations, of existing modeling platforms when used for this purpose. Here, we review 17 commonly used flood and water quality modeling tools that have demonstrated or implicit capabilities of mechanistically representing and quantifying microbial risk during flood conditions. We compare models with respect to their capabilities of generating outputs that describe physical and microbial conditions during floods, such as concentration or load of non-cohesive sediments or pathogens, and the dynamics of high flow conditions. Recommendations are presented for the application of specific modeling tools for assessing particular flood-related microbial risks, and model improvements are suggested that may better characterize key microbial risks during flood events. The state of current tools are assessed in the context of a changing climate where the frequency, intensity and duration of flooding are shifting in some areas.