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Release of *Escherichia coli* from the bottom sediment in a first-order creek: Experiment and reach-specific modeling

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SUMMARY

Escherichia coli release from streambed sediments may substantially affect microbial water quality. Models of *E. coli* release and transport commonly use a single set of parameters for the whole stream or reservoir, yet little is known about the magnitude and sources of the variability of parameters of the streambed bacteria release. The objectives of this work were: (a) to obtain and compare parameters of streambed *E. coli* resuspension in three stream reaches with distinctly different bottom sediment textures, and (b) to see whether the modeling of streambed *E. coli* resuspension with reach-specific parameters could provide substantially better accuracy than modeling with a single set of parameters. Sediment particle size distributions and the streambed *E. coli* concentrations were measured along a first-order creek in the USDA-ARS OPE3 experimental watershed in Maryland. Afterwards, 80 m^3 of water were released into the creek at a rate of 60 L per second in four equal allotments separated by 1–3 min intervals. Flow rates and *E. coli* concentrations were monitored with automated samplers at the ends of the three reaches with a total length of 630 m. A high concentration of streambed *E. coli* ("hotspot") resuspended within the first reach caused a pulse of high *E. coli* concentrations that propagated along the creek without substantial attenuation; inputs of sediment-borne *E. coli* from the next two reaches were relatively small. The *E. coli* transport model included one-dimensional Saint–Venant and advective–dispersive equations. The calibrated roughness coefficient values were comparable for the three reaches, whereas the critical stress and the entrainment rate differed among reaches by a half order and an order of magnitude, respectively. Overall, better accuracy was observed when the model contained reach-specific parameters. Additional research is needed to understand which and how sediment properties affect parameters of streambed *E. coli* release into the water column.

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1. Introduction

Microbiological impairment of drinking, irrigation, or recreational waters is commonly monitored using concentrations of fecal indicator bacteria (FIB). The 2000 US National Water Quality Inventory (NWQI) reported that approximately 93,000 rivers and streams in this country contain elevated levels of FIB (USEPA, 2002). Mandatory water quality improvement programs, such as the USEPA Total Maximum Daily Load (TMDL), have been established in an attempt to decrease the fecal contamination of surface waters. Similarly, mandatory FIB concentration levels have been established for European coastal waters (Council of the European Communities, 1976, 2002). *Escherichia coli* is the FIB commonly used to evaluate microbiological water quality. Studies of fate and transport of *E. coli* in water bodies have shown that concentration levels of *E. coli* are significantly influenced by various nonpoint sources such as surface runoff, bank soils, recreational activity, and animal excreta (Geldreich, 1996; Ferguson et al., 2003; Kim et al., 2007; Servais et al., 2007; Wilkinson et al., 2006).

Bottom sediments have been recognized as a major reservoir of *E. coli* in freshwater environments (Geldreich, 1970). Many studies indicate that sediments can harbor much higher populations of both fecal coliforms and *E. coli* than the overlying water column (Goyal et al., 1977; Doyle et al., 1992; Buckley et al., 1998, Crabill et al., 1999; Smith et al., 2008; Rehmann and Soupir, 2009). Sediments appear to serve as a hospitable environment for bacterial survival due to the availability of soluble organic matter and nutrients (Jamieson et al., 2005), protection from predators such as protozoa (Decamp and Warren, 2000), and shielding from exposure to UV sunlight (Koirala et al., 2008).

The importance of the sediment-borne *E. coli* on microbiological water quality during and after high-flow events has been shown both in specially designed experiments and in modeling studies.

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