Examining the Colonization and Survival of *E. coli* from Various Host Sources in Drainage Basin Sediments and Stormwater

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Abstract

Stormwater drainage has a significant impact on the health of tidal creek systems via regular inputs of runoff from the surrounding watershed. Due to this hydrologic connection, contamination of the upstream drainage basin will have a direct effect on estuaries and tidal creeks that often act as receiving waters. This study builds on the growing body of research emphasizing the importance of drainage basin sediments as they enhance the persistence and transport of the fecal indicator bacteria (FIB) *E. coli* within a watershed. Experiments presented here use microcosm environments with drainage basin sediments and stormwater to investigate *E. coli* colonization of stagnant waters and the importance of host sources to bacterial survival. The colonization of sterile sediment environments is also examined using two common host sources (human and avian). Each experiment uses sediments of varying grain size and organic content to examine the influence of physical characteristics on bacterial prevalence. Results indicate an extended persistence of *E. coli* in sediments influenced significantly by grain size and host source of bacteria.

Introduction

Objectives:

1. Investigate the ability of sediment-borne FIB to colonize overlying waters in the absence of flow/agitation
2. Examine the effects of physical sediment characteristics on FIB colonization and persistence
3. Examine the effects of host organism on the survival and persistence of FIB in sediment and stormwater matrices

Figure 1. Sites of sediment sample collection in the Withers Swash drainage basin.

Hypotheses

Experiment 1

1. *E. coli* from ambient sediments will enter the water column without agitation or flow
2. Microcosms with smaller grain size will sustain higher concentrations of FIB which persist longer

Experiment 2

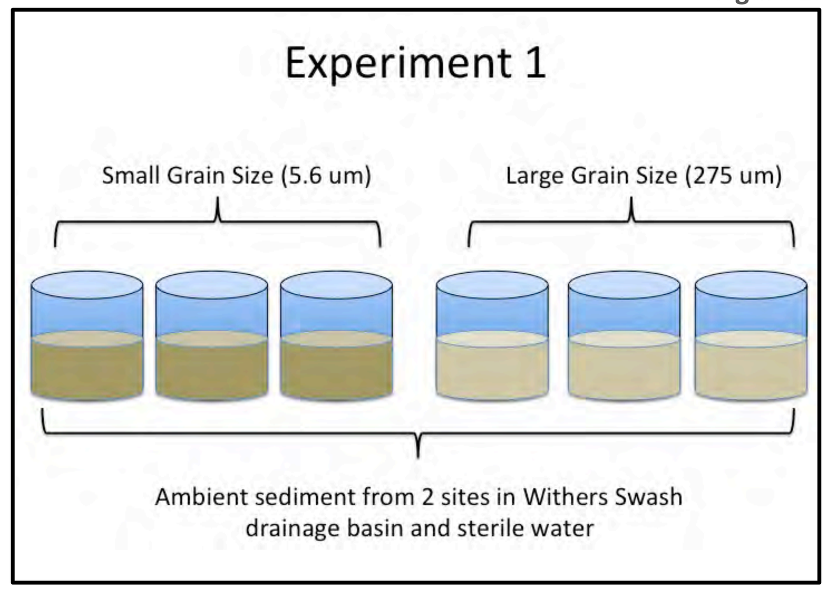
1. *E. coli* from the water column will colonize sterile sediments
2. Host source of FIB will significantly influence FIB concentration and survival

Experimental Design

Microcosms were established to mimic drainage basin conditions. Local watershed sediments and stormwater were used to incorporate the effects of microbial predation and competition on FIB. The influence of host source was investigated using spikes of human (mixed liquor from wastewater treatment facility) and avian (seagull feces) origin.

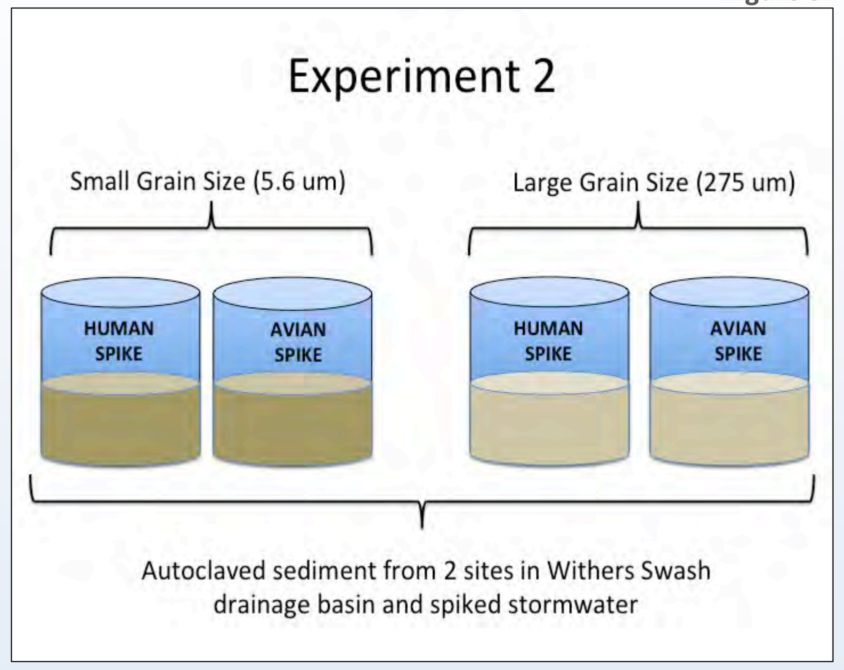
Experiment 1 tested the ability of *E. coli* in sediments to enter the water column in the absence of flow. Grain size effects on *E. coli* concentration were examined using two particle size treatments (Figure 2).

Figure 2.



Experiment 2 examined the ability of *E. coli* from the water column to colonize sterile sediments. Concentration and persistence were examined based on host source of FIB and grain size treatments (Figure 3).

Figure 3.



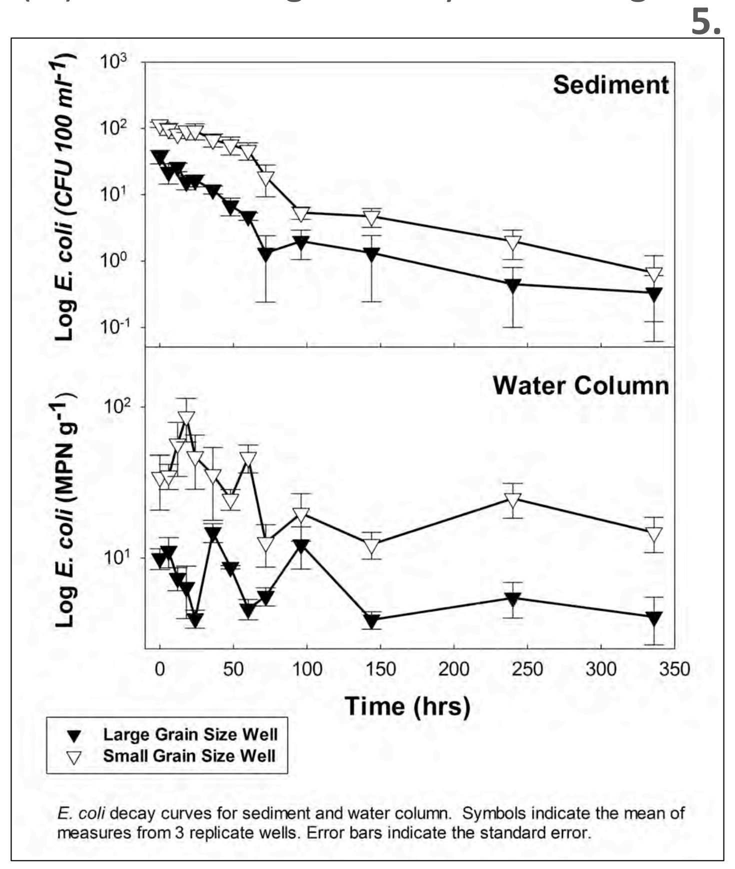
Throughout each experiment microcosm water and sediment were sampled successively. Each were analyzed for bacterial concentration using Colilert (IDEXX).

Figure 4. Sediment extraction

Results

Experiment 1 Microcosms with smaller grain size sediments had significantly higher *E. coli* concentrations and lower decay rates (5.). Multivariate analysis of variance (MANOVA) found a significant grain size effect on bacterial concentration for sediment ($p<0.001$) and overlying waters ($p<0.001$)(6.). Decay rates (7.) were also significantly affected grain size in sediment ($p=0.016$) and overlying waters ($p=0.005$).

5.



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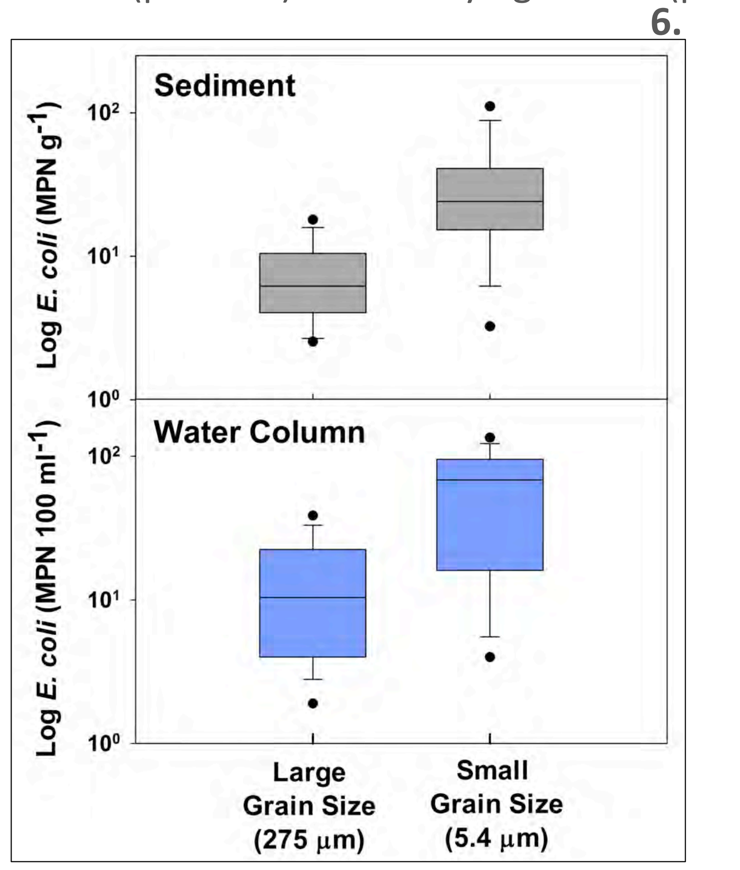

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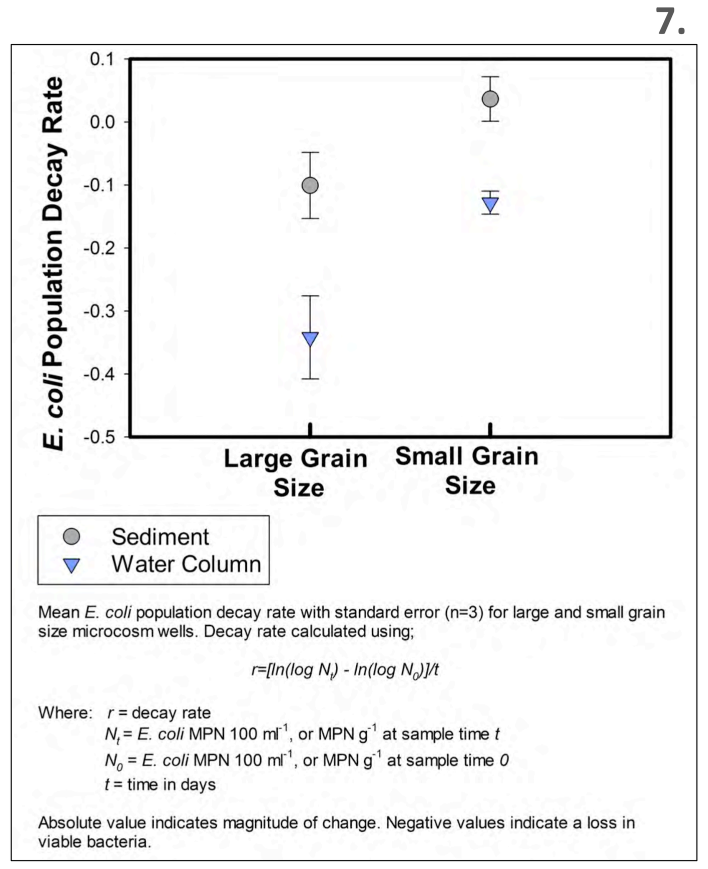
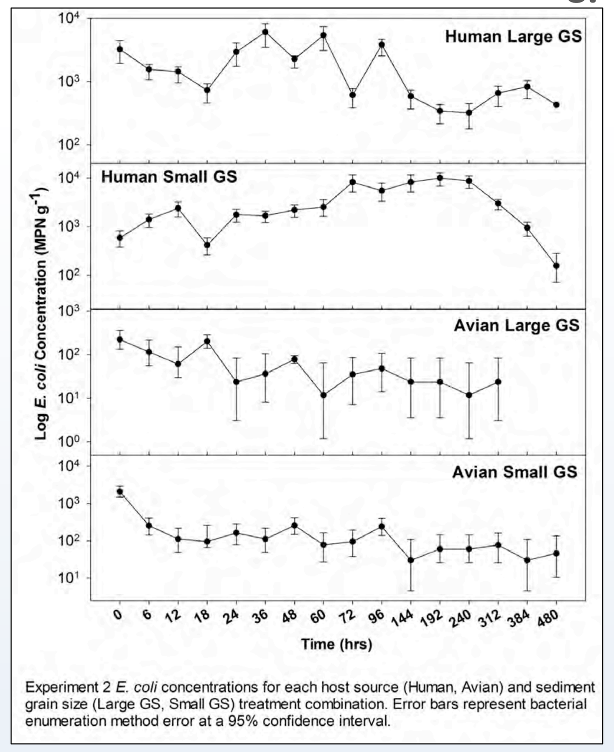


Experiment 2 *E. coli* from human source spikes exhibited higher concentrations and lower decay rates (8., 9.). MANOVA results (10.) indicated a significant host effect on bacterial concentration for sediment ($p<0.001$) but not overlying waters ($p=0.138$). Host source significantly influenced *E. coli* persistence in both the sediment ($p=0.01$) and overlying water ($p=0.001$) matrices (11.).

8.



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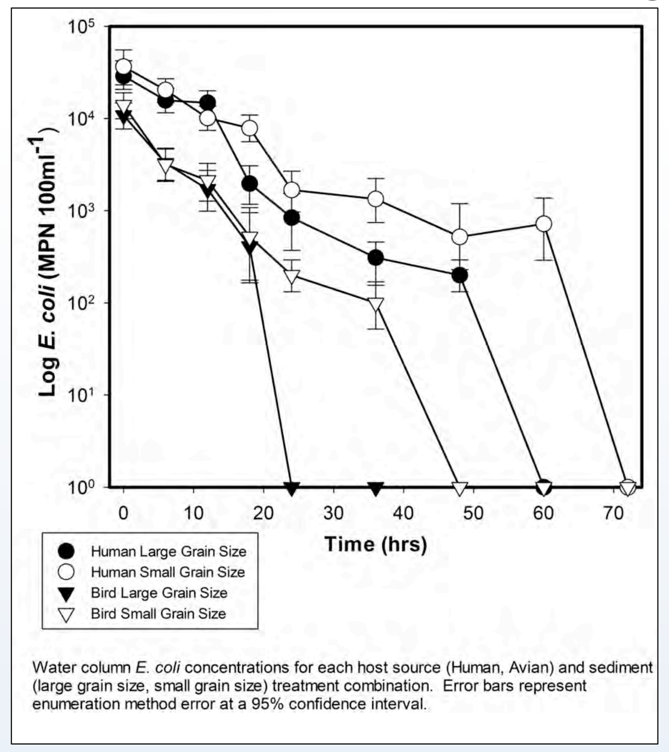

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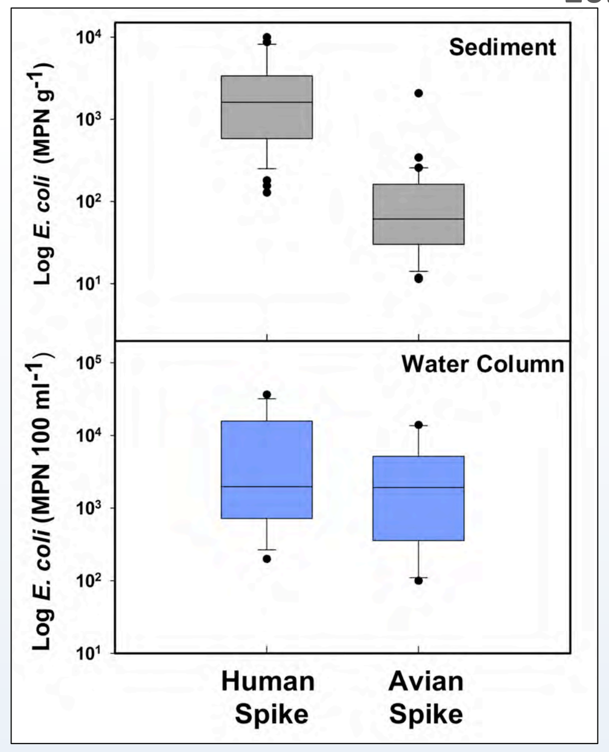
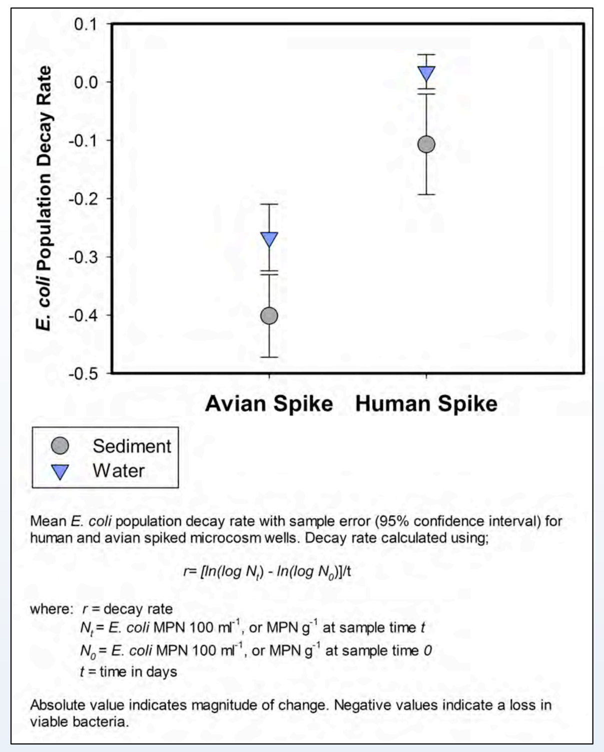


11.



Figures 5-11. *E. coli* population decay throughout each experiment are shown in figures 5.,8., and 9. MANOVA results for *E. coli* concentration (6.,10.) are shown using boxplots with boxes representing 1st and 3rd quartiles, lines indicating median, whiskers indicating 10th and 90th percentiles, and dots indicating outliers. Figures 7. and 11. show mean population decay rate with associated error.

Conclusions

The findings of this study emphasize the importance of sediments as a source/sink for FIB within a watershed.

Experiment 1

- ***E. coli* from sediment rapidly colonized overlying sterile water**
- **Sediment particle size significantly influenced *E. coli* concentration and persistence**

Experiment 2

- ***E. coli* in the water column rapidly colonized sterile sediments**
- **Host source significantly influenced *E. coli* concentrations in sediments and decay rates in the sediment and water column**

Our results suggest *E. coli* may not be an effective indicator of microbial impairment within a watershed. The efficacy of using FIB as a proxy measure for other pathogenic species is being increasingly called into question as they are known to persist in sediments and return to the water column during times of increased flow. Studies also suggest that their survival in the environment is not well correlated with the survival of pathogenic species for which they are an indicator (Lemarchand & Lebaron, 2003; Harwood et al., 2005; Noble & Fuhrman, 2001). As typical bacterial analyses cannot distinguish between recent and long-survived (or even indigenous) FIB, their use as an indicator of microbial water quality is likely problematic. Our results suggest interpretation of these measurements may be further confounded by local conditions such as physical drainage basin characteristics and host source of bacterial input.

Acknowledgements

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