BACTERIA IN CONSTRUCTION SITE SEDIMENT BASINS

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REFERENCE: Proceedings of the 2010 South Carolina Water Resources Conference, held on October 13-14, 2010 at the Columbia Metropolitan Convention Center

Abstract - Each year thousands of acres of land undergo construction-related land disturbance in the rapidly developing Piedmont region of the southeastern United States. Mobilized sediment contained in site runoff is routinely deposited within creeks, rivers, lakes, and other nearby surface waters, adversely affecting the habitat of important aquatic species, reducing water clarity and transporting other potentially harmful pollutants such as adsorbed *Escherichia coli* (Wood and Armitage, 1997). Determining relationships between the presence, transport and fate of sediment-associated bacteria is of primary concern in South Carolina as the 2008 Section 303(d) list of impaired waterbodies indicates more contamination from fecal coliform than any other single pollutant (SC DHEC, 2008).

INTRODUCTION

Bacteriological water quality criteria have existed for decades within the United States as well as other developed nations. Such standards are largely based on concentration estimates of designated indicator species correlated with gastrointestinal illness rates in paired beach swimming studies (US EPA, 1986). Occurrence of food- and water-borne illness related to certain specific pathogens has measurable economic impacts associated with medical costs and decreases in job productivity. In 2007 alone, an estimated $460M was lost resulting from a single strain of shiga toxin-producing *E. coli* (Frenzen, 2007). More recent comprehensive reviews of research conducted since criteria were first established in 1986 confirm that published results continue to support the use of *enterococci* and *E. coli* as useful predictors of epidemiological health for recreational waters (Wade *et al*., 2003). Establishing or maintaining robust monitoring protocols is essential to protecting public health and economic well-being.

Bacteria are principle components of naturally occurring carbon and nutrient cycling in the environment. Genotypic and phenotypic diversity allows these organisms to survive under a broad range of physical, chemical and biological conditions (Winfield *et al*., 2003; Maier *et al*., 2000). Ishii and Sadowsky (2008) suggest the ability of certain enteric bacterial species like *E. coli* to survive long-term outside a host environment is likely due to their ability to acquire energy by various means. In essence, *E. coli* can become “naturalized” into the broader microbial community because it can exist under aerobic and anaerobic conditions, survive in a variety of temperatures, while needing only simple nutrients and trace elements to grow (Davis *et al.*, 2005; Byappanahalli *et al.*, 2003; Gagliardi *et al.*, 2002; An *et al.*, 2002).

A developing body of research has shown that if established in the natural environment, *E. coli* can persist throughout the year, serving as a continuous bacterial source (Whitman *et al*., 2006; Byappanahalli *et al*., 2003; Gagliardi *et al.*, 2002). Because a significant fraction of bacteria are associated with soil, runoff laden with newly eroded and suspended sediment can serve as a secondary source of higher *E. coli* concentrations to receiving-waterbodies (Wu *et al.*, 2009; Jamieson *et al*., 2005). Characklis *et al*. (2005) found microbial adsorption varies by microorganism, with 20-30% of viable *E. coli* showing consistent affinity for settleable particle sizes.

Once mobilized, the fate of sediment-associated bacteria is determined in large measure by site-specific hydrologic conditions. Regional studies have found significant correlation between elevated sediment loads and correspondingly high concentrations of fecal coliform bacteria in Piedmont stream systems (Jolley, 2005). Jolley determined indicator bacteria and other waterborne pathogens adsorbed to sediment particles survive following deposition and further, that bacteria existing within this substrate environment can be resuspended and transported following perturbation. Certain pathogenic bacteria in bottom sediments have been found to survive significantly longer than populations found in overlying water columns (Burton *et al*., 1987).

There is a long-established link between sediment and correspondingly high levels of bacteria in lentic systems. Bottom sediments have been shown to act as reservoirs of indicator bacteria and other waterborne pathogens (Davies and Bavor, 2000; Howell *et al*., 1996; LaLiberte and Grimes, 1981). Davis *et al*. (2005) concluded that pond sediments can sustain viable populations of *E. coli* for several months with no external input and that these bacteria may be resuspended back into the water column by turbulent flow associated with storm conditions.

Specifically, construction site sediment basins have been shown to raise ambient stream total suspended solids (TSS) in receiving waters under storm conditions (Ehrhart *et al*., 2002). Ehrhart demonstrated that preferential settling within the basin of larger eroded particles produced effluent containing a higher proportion of finer suspended sediments downstream, as measured by particle size distribution. While certain practices such as baffles or skimmers can further reduce suspended material in basin discharge (Thaxton and McLaughlin, 2004), some fraction of sediment, both newly eroded and resuspended, will be contained within the effluent. Controlled research over 8 years conducted in experimental sediment basins found that on average, 24% of sediment lost through discharge represented resuspension of previously deposited bottom sediments (Jarrett, 2001; Fennessey and Jarrett, 1996). Beyond trapping efficiency, hydrodynamic modeling and evaluation of sediment-specific discharge impacts on downstream biota, construction site sediment basins have not been the subject of ecologically focused research. To address state regulations, construction site sediment ponds are engineered in South Carolina to capture a minimum 80% of TSS in order to meet the settleable solids criteria of the Stormwater Standards and Sediment Reduction Regulation (SCDHEC, 2002).

Given the association between eroded soils, suspended sediments, bottom sediments and the ubiquitous nature of enteric bacteria in natural ecosystems, research was needed on excavated basins used to control sediment from construction sites. The purpose of this research was to evaluate *E. coli* densities in construction-derived runoff in the Piedmont of South Carolina; assess whether these basin systems created for controlling sediment and stormwater in the region are acting as sources, sinks or reservoirs for potential pathogens; and examine relationships between these observed bacterial concentrations and corresponding environmental variables.

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