Abstract: Enhanced Removal of Pathogens in Stormwater through Filtration with Iron-Amended Media

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Stormwater contamination is a major concern for public health and is a problem that is increasing in magnitude. Major contaminants of stormwater include pathogens such as viruses, bacteria, protozoa and helminthes—contributors to gastrointestinal disease. Of particular concern are fecal indicator bacteria (FIB) such as total coliforms, fecal coliforms, and *Escherichia coli (E. coli)* and *Enterococcus faecalis (E. faecalis)* (Pitt and Clark, 2012). These pathogens come largely from sewer leaks and/or feces from local animal populations (Sercu et al., 2011). Currently, stormwater runoff pollutes "an estimated 13% of river segments, 18% of lakes, and 32% of estuaries surveyed" with this number expected to increase over time (US EPA, 2009). Increased urbanization has magnified the issues of stormwater contamination. With a greater amount of land made impervious to water, flooding and stormwater flow levels have increased in turn (US EPA, 2000).

A current best management practice for stormwater has been the use of bioretention basins (NRC, 2008; US EPA, 2009). These basins are large depressions in the ground which increase soil permeability and assist with collecting, storing and infiltrating flows. These basins are typically composed of conventional bioretention media (CBM), which is a combination of soil, sand and compost. In the past, people have primarily used bioretention basins to address the issue of water quantity but now, there has been a movement towards examining water quality as well. Prior research has shown that CBM has potential for pathogen removal, reporting short-term removals of 91.5% for fecal coliform (Rusciano and Obropta, 2007) and 84% for E. coli O157:H7 (Zhang et al., 2010).

Research conducted at UC Berkeley this summer under the ReNUWIt REU examined how different kinds of iron oxides may influence pathogen removal. The mechanism behind this removal has to do with the charges of the oxides and the contaminants. When iron oxidizes, it exhibits a positive charge at neutral pH while most bacteria and viruses have a negative charge. The presence of iron may increase pathogen removal because of how bacteria and viruses may bind to the iron instead of getting washed out with the effluent water.

The experiments conducted at Berkeley examined this relationship through the use of both column and batch tests. The former is a more accurate representation of a bioretention system and is composed of a hollow tube packed with media. Through this, synthetic stormwater spiked with *E. coli* and the bacteriophage MS2 is allowed to flow downwards through the system for infiltration. A measurement of the removal of pathogens is conducted through comparing the number of pathogens in the influent and after treatment. A batch test, on the other hand, is a less intensive measurement of contamination. In this, the media and synthetic stormwater are placed in a vial and slowly spun to allow for contact time and pathogen removal.

The bulk of my time working at Berkeley this summer under Professor Kara Nelson and my graduate student mentor Andrew Torkelson involved getting trained and familiarized with different laboratory techniques with the intent of making me a more independent and resourceful scientist. I learned how to grow and enumerate bacteria colonies and virus plaques, how to measure iron in a sample through spectrophotometric analysis, and how to measure total organic carbon. Additionally, I learned the intricacies of preparing for both column and batch tests. Once I became acquainted with the lab, I was assigned work that had two main components: the design of an improved column and an initial batch test of coated sands.

The original columns that my mentor had used in the past were costly at an estimated price of about $17 each. Since he wanted to run a long-term experiment in the future which would require at least 40 columns, it was in our best interest to develop a more cost-effective design. Ultimately, we were able to design a column out of clear PVC and appropriate tubing that brought the cost down to $12.67 each. This yielded a savings of more than $170. Additionally, through creating our own columns, we were able to have greater control over our experiments in terms of the amount of head space, the speed of the flow rate and so on. In the past, the columns had been ordered from another source and were not tailored to our particular experiments.

The second component of my work took place towards the end of my term. Initially, I was to compare ferrihydrite coated sands against goethite coated sands of different pHs. However, due to time constraints, I was only able to compare the ferrihydrite against a blank. My initial batch tests demonstrated that there was a difference between ferrihydrite and a blank in terms of pathogen removal. However, further testing would be required to actually compare the different sands against one another.

Works Cited:

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