Escherichia Coli as a Water Quality Indicator Organism: A Case for Responsive, Science-Based Policy

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Introduction

Water quality indicator organisms such as *E. coli* are used in the monitoring of recreational waterbodies to indicate the presence of fecal contamination. In 2009, a 1.5 mile stretch of Plum Creek in Stearns County, MN was classified by the Minnesota Pollution Control Agency as impaired due to high levels of *E. coli*. To date no source of contamination has been identified. 2016 study confirmed presence of fecal coliform indicator bacteria, and investigated the influence of naturalized *E. coli* in streambed sediments as the source of impairment. Further research is necessary regarding the influence of sediment *E. coli* on stream *E. coli* in order to establish or maintain policies that protect human health and are fiscally and environmentally effective.

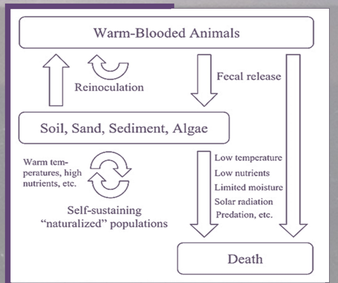

Figure 1. Life cycle of E. coli from from Ishii and Sadowsky 2008

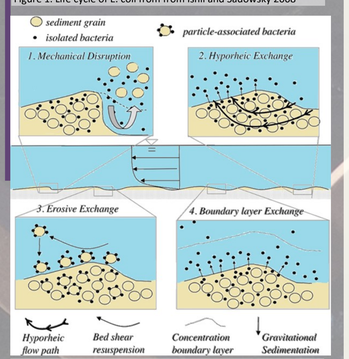

Figure 2. Methods of bacterial exchange between sediment and water. Modified from Grant *et. al.* 2011.

Indicator Organisms

Indicator organisms are used to evaluate the safety of recreational waterbodies. Indicator organisms occur in proportion to pathogens and are easily measured. The criteria for a suitable indicator organisms are:

- Always present in animal and human feces
- Present in high numbers for higher probability of detection
- Persistence in the environment/ drinking water similar to that of pathogens
- Does not multiply in the environment
- Simple, rapid, accurate, and inexpensive methods are available

E. coli, Enterococci, and coliphages are among the most common indicator organisms used in the U.S. and around the world.

Naturalized Populations of *E. coli*

Recent studies have demonstrated *E. coli* can become naturalized to streambed sediments, therefore becoming an unreliable indicator of fecal contamination. Fig. 1 diagrams the lifecycle of *E. coli. E. coli* is released in the feces of warm blooded animals. *E. coli,* requires the availability of nutrients, specific environmental conditions to survive. Without the proper conditions *E. coli* bacteria die. However some *E. coli* may enter soil, sand, sediment, algae from which it can then follow one of three paths; it may be ingested by warm-blooded animals thereby infecting the organism with *E. coli*, it may die, or it may establish a naturalized population within its new environment. This final pathway, in which *E. coli* becomes naturalized may confound the use of the organism as an indicator of contamination.

2016 Study Objectives

- Perform more intensive water sampling to increase spatial and temporal data relative to previous sampling efforts in order to isolate any patterns in *E. coli* distribution and source types.
- Determine whether site and/or date of sampling were reliable predictors of *E. coli* levels in the stream.
- Asses whether naturalized streambed sediment E. coli was a potential source of water-borne *E. coli*.

Figure 3. Photo of student researchers sampling at Warner Lake on September 18, 2016. Photo by Maria Anderson

2016 Study Results

- Consistent trends of increasing *E. coli* concentration in water enroute to the Mississippi River aligns with previous findings
- Samples exceeded regulatory limit (2.10037 log10 (cfu*/100mL)) on 8 occasions at sites 5,6 and 7
- Significant differences in *E. coli* by site were observed and E. coli generally increased from site 1 to 7
- *E. coli* significantly differed within each site across dates sampled
- Spearman correlation analysis found no significant relationship between sediment and stream *E. coli* cfu*
- **cfu=coliform forming unit*

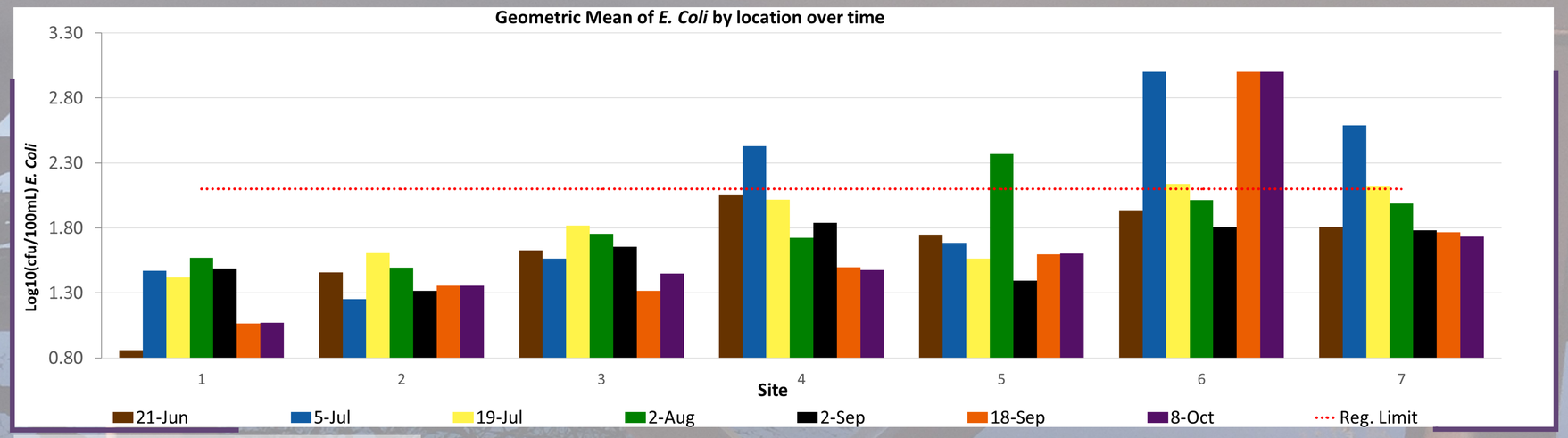

Figure 4. Graph of geometric mean of E. coli levels at each site on each sampling date in 2016.

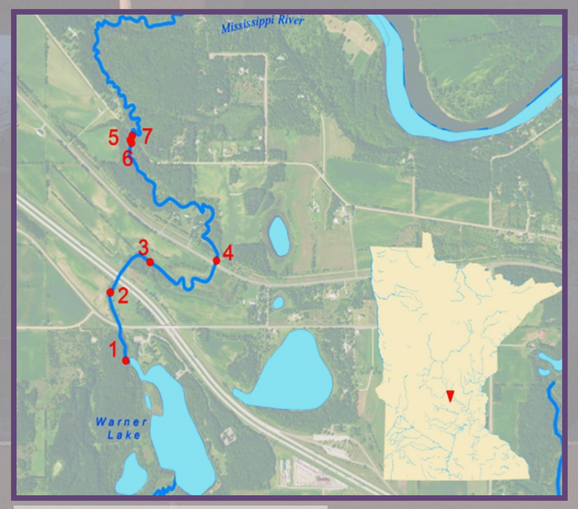

Figure 5. Map of Plum Creek 2016 study sampling sites

Conclusion

The estimated cost of the Plum Creek study likely amounts to tens of thousands of dollars. After intensive study in 2016 there remains no evidence to indicate a source of fecal contamination threatening to human health. The most plausible source of *E. coli* in Plum Creek is a naturalized population exchanged between sediment and water. The discrepancy between the financial cost and human health benefits of the Plum Creek impairment listing raises questions regarding the effectiveness of E. coli as the primary indicator organism under current monitoring guidelines. It is imperative the efficacy of E. coli as an indicator organism is reevaluated so as to maintain effective policies. **"The continuing practice of implementing fecal indicator organisms without understanding their persistence and survivability in the environment has hindered the ability to determine their significance in water and to accurately assess human health risks."**

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