Methods to sample *E. coli* in foreshore sand and pore water

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RESTORE: Research for Subsurface Transport and Remediation

Introduction

- *E. coli* is often orders of magnitude higher in sand/pore water near the shoreline than shallow lake waters [1].
- This bacteria reservoir can act as a non-point source for contaminating lake waters [2].
- Health units do not sample this reservoir [3].
- Study objectives were to (i) compare different methods used to quantify *E. coli* in the reservoir and (ii) compare the abundance of *E. coli* in different components of the reservoir.

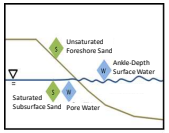


Figure 1: Reservoir Components

Methods

- Samples were collected at 6 beaches in Southern Ontario (Figure 2).
- 4-5 transects were sampled on 3-4 occasions at each beach using methods shown in Figure 3.
- Data was log transformed and analyzed using ANOVA, and if significant, further analyzed using Tukey's pot hoc test.

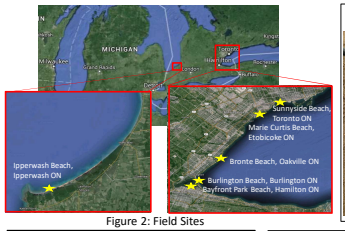
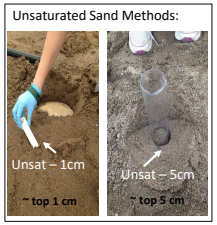
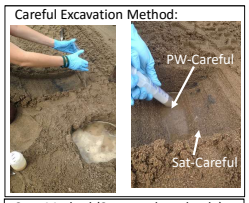


Figure 2: Field Sites





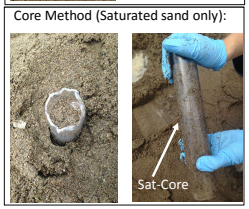


Figure 3: Sampling Methods

Results

Comparing methods for pore water

- PW-Shovel method resulted in statistically higher concentrations in the pore water than the PW-Drivepoint method (p=0.025). PW-Careful resulted in concentrations in between the two (Table 1).
- Although the methods did not result in statistically different variances (p = 0.354), the PW-Shovel method had a lower variance than the PW-Careful and the PW-Drivepoint method.

Table 1: Summary of results for different sampling methods

	N	Mean (log CFU/100mL) or (log CFU/g)	Standard Deviation (log CFU/100mL) or (log CFU/g)	Grouping
Pore Water				
PW-Shovel	78	3.47	1.11	A
PW-Careful	78	3.33	1.30	A , B
PW-Drive Point	75	2.95	1.27	B
Saturated Sand				
Sat-Shovel	75	1.31	1.05	A
Sat-Careful	75	1.40	1.36	A
Sat-Core	76	1.70	1.35	A
Unsaturated Sand				
Unsat-1cm	78	2.23	1.30	A
Unsat-5cm	17	1.63	0.84	B

Comparing methods for unsaturated sand

- Unsat-1cm had statistically higher and statistically more variable concentrations than Unsat-5cm (Table 1).

Comparing methods for saturated sand

- There was no statistical difference between the saturated sand collection methods (Table 1). This may be due to the large variations in each sampling method.
- Saturated sand collected using the Sat-Shovel method resulted in significantly lower variability in *E. coli* concentrations than collecting sand using the other methods (p=0.047).

Comparing methods for all components

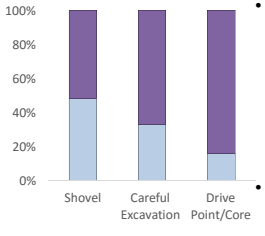


Figure 4: *E. coli* distribution on volumetric basis between saturated sand and pore water.

- Statistically (p<0.001), the shovel method had the highest percentage of *E. coli* in the pore water as well as the lowest percentage of *E. coli* attached to the sand, followed by the careful excavation method, which was followed by the drive point/core method (Figure 4).
- Disturbance caused by digging with a shovel may cause *E. coli* to detach from the sand resulting in higher pore water concentrations and lower sand concentrations.

Results continued

Comparing the different components of the reservoir

Table 2: Correlations between reservoir components

	Pore Water	Saturated Sand	Unsaturated Sand	Ankle-Depth Water
Pore Water	1	0.953 (<0.001)	0.682 (<0.001)	0.262 (0.027)
Saturated Sand	1	1	0.695 (<0.001)	0.300 (0.011)
Unsaturated Sand	1	1	1	0.579 (<0.001)
Ankle-Depth Water	1	1	1	1

*Results are shown as r (p) where:
r = regression value and p = significance (p<0.05 is significant)

- A very strong significant correlation was observed between the saturated sand and the pore water (Table 2).
- The component that was most representative of the ankle-depth water was the unsaturated sand (Table 2).
- After an ANOVA was shown to be significant (p<0.001), Tukey's post-hoc test showed that when converted into volumetric units, the unsaturated sand statistically had the highest *E. coli* concentrations, followed by the saturated sand, which was followed by the pore water.
- Pore water was statistically less variable than unsaturated and saturated sand (p<0.001).

Conclusions and Future Work

- Sampling pore water using a shovel results in the highest observed *E. coli* concentrations and lowest observed variability.
- Sampling the top 1 cm of unsaturated sand results in higher and more variable concentrations than sampling the top 5 cm of sand.
- There was no observed difference in *E. coli* concentrations when using different methods to sample saturated sand.
- The sampling method used affects the distribution of *E. coli* between the pore water and saturated sand.
- The unsaturated sand has the highest amount of *E. coli* in the foreshore reservoir, while the pore water has the lowest amount of *E. coli* and is the least variable.
- Future work is required to determine if these results apply for other types of beaches.

References

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[2] Edge, T. A. and S. Hill (2007). "Multiple lines of evidence to identify the sources of fecal pollution at a freshwater beach in Hamilton Harbour, Lake Ontario." Water research 41(16): 3585-3594.
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