Monitoring Fecal Indicator Bacteria in Shoreline Water and Beach Sand of Lake Michigan

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INTRODUCTION

There is a direct positive correlation between fecal indicator bacteria (FIB) concentration such as *Escherichia coli* (*E. coli)* and Enterococci and the occurrence of gastrointestinal illness of human (Wade et al., 2003). Pathogenic microorganisms cannot be directly monitored as they are of different types and prevalent in water with a very low concentration. Indicator bacteria are used as an alternative for disease causing microorganisms to monitor fecal contamination.

Objectives of the study:

- Examine the concentration and interaction of bacteria in beach sand and water
- Analyze the effects of DI water and PBS eluents to enumerate bacteria from beach sand, and
- Evaluate the impact of algae on bacteria count.

METHODS

Sample collection

Location: Bradford Beach, Lake Michigan, Milwaukee

Sampling: Three transect locations

- Sand sample (Swash zone)
- Sand sample (6m inland)
- Lake water sample

Sampling period: Summer and early Fall of 2013

Testing and Measurement

- Bacteria enumeration using IDEXX Most Probable Number (MPN) method
- Using DI water and PBS eluent for bacteria enumeration from beach sand

Data Analysis

- Analyzing bacteria concentration using EPA CANARY Event Detection System
- Analyzing effects of eluents (DI water and PBS)
- Impact of algal presence on bacteria concentration

Data analysis model: Analysis of bacteria data from beach sand and water were performed using U.S. EPA CANARY (Hager et.al.,2013, Hart et. al., 2007; Haxton et al., 2013) Event Detection Software (EDS).

RESULTS

❑ **Interaction of bacteria in beach sand and water**

Data analysis of bacteria concentration was performed using CANARY EDS software for samples collected during 1st July 2013 to 21st August 2013. Table 1 shows the results from CANARY for each type of bacteria in sand sample with different eluents and in water sample. Results indicated that in sand sample, higher number of events were found for the indicator bacteria than in water sample.

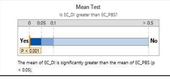
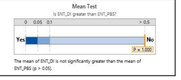
Table 1: Results of CANARY output (number of detected 'Events') for sand and water sample

Bacteria	Swash zone		6 m inland		Sand sample		Water sample
	DI	PBS	DI	PBS	DI	PBS	
E. coli	4	4	4	0	8	4	5
Enterococci	5	4	5	7	10	11	5

❑ **Effect of eluents**

A paired t-test analysis was performed for both bacteria comparing DI water and PBS eluents as shown in Table 2. A hypothesis testing results indicated that for *E. coli*, the mean of log MPN of DI was greater than PBS, while for Enterococci it was the opposite.

Table 2: Results of Paired-t test analysis for bacteria

	E.coli		Enterococci	
	DI water	PBS	DI water	PBS
Mean (log MPN/100g)	1.8385	1.6928	1.2415	1.4562
Standard deviation	0.7548	0.8074	0.7237	0.6612
Number of samples	113	113	127	127
T-value	3.64		3.85	
P-value (differences in mean)	0.000411		0.00019	
Hypothesis testing: (**Mean test**: Is DI greater than PBS?)				

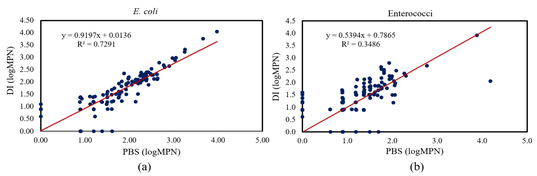


Fig 1: Regression analysis of bacteria concentration between the two eluents

An attempt was made to establish a direct ratio between the two eluents for each group of bacteria as shown in Fig 1. Table 3 also indicates a strong positive correlation for *E. coli* between the two eluents.

Table 3: Pearson's correlation analysis for *E.coli* and Enterococci with different eluents

Sample 1	Sample 2	No. of samples	Correlation	P-value
E. coli (DI)	*E. coli* (PBS)	113	0.854	0.000
Enterococci (DI)	Enterococci (PBS)	127	0.590	0.000

Analysis was made on CANARY to evaluate the potential of freshwater sand as a reservoir of indicator bacteria. This was accomplished by comparing the number of detected events in sand and water sample by CANARY that resulted in anomalous water quality. Fig.2 and Fig.3 show the bacteria data signal plots and the event probability plots in water sample.

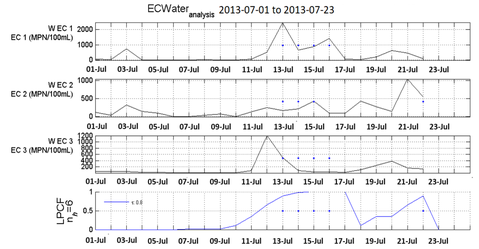


Fig 2:CANARY output for *E.coli* count in water sample at three transect locations. Number of detected 'Events' 5.

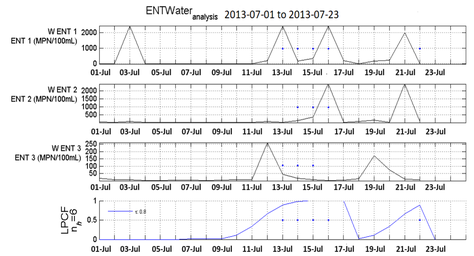


Fig 3:CANARY output for Enterococci count in water sample at three transect locations. Number of detected 'Events' 5.

❑ **Impact of algae on bacteria concentration**

From Table 4, it appears that the gradually increasing rating scale of algae was positively correlated with bacteria average count. However, there was an exception to that relation for Enterococci count in water sample. Fig 4 also indicates a significant correlation between *E. coli* and algae level in water and swash zone sample with p-value <0.05, while for Enterococci the correlation was not statistically significant (p-value >0.05).

Table 4: Average bacteria count with different algae level

Bacteria	Sampling location	Algae level (scale)			
		0	1	2	3
E. Coli (MPN/100 mL)	Water	25	102	262	612
	Swash Zone	126	232	257	618
Enterococci (MPN/100 mL)	Water	7	115	57	507
	Swash zone	15	50	81	1045

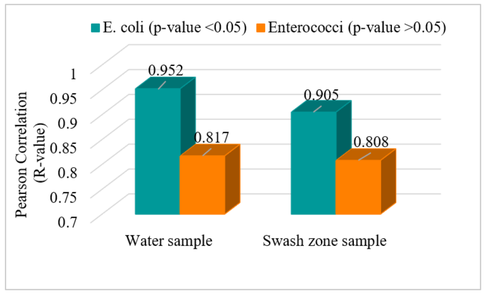


Fig 4: Pearson correlation analysis between algae level and bacteria count at 0.05 level of significance

CONCLUSION

The study was undertaken to analyze bacteria concentration for developing methods to accurately predict public health outcomes as a result of increasing fecal indicator bacterial contamination.

- Results from the statistical analysis indicated a possibility of establishing a relationship between the results developed using the two eluents i.e., DI water and PBS while for Enterococci, the results were less promising due to high variation in ratios of enumerated bacteria between the two methods.
- CANARY may be useful as an early warning system for monitoring beach contamination and may help to identify any abnormal condition.
- This research showed that there were some differences in bacterial counts produced between eluents. The ability to establish a ratio of bacterial counts among eluents would be a convenient tool in order to compare data collected using different eluents.

Literature cited

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