Assessing Potential Sources and Influential Parameters of Fecal Contamination at F.W. Kent Park Lake, Oxford, IA

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Introduction
Fecal contamination of Iowa’s Iowa River watershed bodies reduces water quality and poses a threat to human health. Concern for the health effects of waterborne pathogens resulted in 149 beach advisories across 39 state owned beaches in Iowa during the 2015 beach season. While the presence of pollution is often clear, its cause and source is difficult to identify. The current practice in Iowa of sampling once per week provides both beachgoers and managers an inadequate amount of information on which to make informed decisions. As a result, swimmers are potentially exposed to high levels of contamination and various associated pathogens. The objective of this study was to develop a predictive model using Virtual Beach aimed at reducing swimmer exposure to pathogens at F.W. Kent Park Lake Beach in Oxford, IA.

It was hypothesized that major influences of fecal contamination from agricultural areas in the upper watershed, as well as periodic Canada Goose activity at the beach, were to blame for threshold exceedances at the beach. Various environmental variables were considered to assess to which factors were responsible for the dramatic fluctuations in the fecal indicator bacteria, Escherichia coli, observed at the beach.

Site Description
Constructed In 1946, F.W. Kent Park Lake is a 263-acre impoundment located in eastern eastern Iowa, approximately 11 miles northwestern of Iowa City, as seen in Figure 1. The lake has an average depth of 7.5 feet with a maximum depth of 18 feet. Much of the upper part of the lake’s 687.5 acre watershed is agricultural, including cropland and cattle pasture, as seen in Figure 2.

Four sediment retention basins have been constructed within the watershed to reduce pollution inputs. Despite this, 13 of 46 samples between collected at F.W. Kent Park Beach by the Iowa DNR Beach Monitoring Program between 2012 and 2014 exceeded the standard for primary contact recreation water of 235 E. coli per 100 ml of water, an exceedance rate of 28.2%.

Methods
For this study, samples were collected May–October 2015 at the beach and at eight other sites (Fig. 3). Beach samples were collected along three transects, (left, center, right), and at three depths, 0 to 25 cm, 50 to 75 cm, and 100 to 125 cm. In all, 96 samples were collected at all other sites. All samples were analyzed for E. coli using the Colilert-QuantiTray-2000 method (IDEXX Laboratories, Inc.). Field rinses and blanks were used for quality assurance.

The EPA software, Virtual Beach, was used to develop multiple linear regression models for the beach. Due to the left skewness of E. coli concentrations, the data were log transformed prior to analysis. Twenty-six independent variables suspected of contributing to fluctuation in E. coli concentrations were compiled from various sources (Table 1). To maximize linearity between the independent variable and E. coli, each was tested using an array of transformations within the model software.

Model development was completed using an exhaustive search of independent variable combinations. The minimum number of variables to be included in the model was set to 5 and the maximum VIF was set to 3. AIC was used to evaluate model performance. Results were compared using several criteria, including: variable p-values, R-squared values, prediction accuracy, AIC, and mean squared error of prediction values.

Table 1. Independent Variable Sources

Discussion and Conclusions
The increased threshold exceedances observed in Basin 1 and 3 suggest high inflows of bacterial pollution from agricultural areas in the northern part of the watershed. However, the lack of exceedances at the North site, and at other lake sites, except the beach, siged that the bacteria loaded sediment is deposited as the stream widens and loses transport capacity, prior to reaching downstream sites. High E. coli concentrations observed at the beach indicate a secondary source within the beach area contributes to contamination.

The independent variables included in the final model suggest that gear are the main contaminant source via defection. The season at the time of the sample also implicate gear as a contaminant source, as goose droppings are only removed during times of operation. The relationship between bacteria and relative humidity is unclear, but may suggest that atmospheric moisture indicates recent rain events, which flush contamination from the watershed and the beach itself.

While the resulting model successfully predicted 88.15% of E. coli fluctuations, further study is needed to refine and validate the model. A larger sample size over several years will increase model robustness and assist in confirming trends seen in this study.

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References

Legend

Figure 1. F.W. Kent Park Lake Location and Sample Points

Figure 2. 2005 USGS 1:24,000 scale map of Kent Park area

Figure 3. Number of E. coli threshold exceedances per site, May–October 2015

Table 1. Independent Variable Sources

Figure 4. Predicted vs. Observed E. coli. Samples in order of data collected

Figure 5. Model Results