Abstracts

Wednesday, April 30

Session I5: Indicator Bacteria and Predictive Modeling

3:30 – 5:00 pm | Room 233

A Comprehensive Assessment of the Occurrence and Distribution of Pathogenic Bacteria in Great Lakes Tributaries, March-September 2011

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Abstract
From March through October 2011, the U.S. Geological Survey (USGS) Michigan Water Science, in conjunction with USGS Water Science Centers in Indiana, Minnesota, Ohio, New York, and Wisconsin, conducted a study to determine the frequency of occurrence of genetic markers of bacterial pathogens and concentrations of fecal indicator bacteria (FIB) in tributaries to the Great Lakes. As part of the Great Lakes Restoration Initiative (GLRI), this effort was one of the first large-scale studies designed to evaluate bacterial pathogen gene occurrence in major Great Lakes tributaries. A total of 160 water samples were collected at 21 USGS streamgaging locations during a range of flow conditions, and analyzed by the Michigan Bacteriological Research Laboratory located at the MI-WSC. Water samples were analyzed for fecal indicator bacteria concentrations (*Escherichia coli* (*E. coli*) and enterococci), as well as the occurrence of pathogen gene markers for *Shigella spp.*, Campylobacter, Salmonella, and pathogenic *E. coli* including Shiga toxin-producing *E. coli* (STEC). FIB concentrations and bacterial pathogen gene frequencies were analyzed with respect to land use and hydrologic conditions in an effort to describe variability in concentrations. Overall, there was a greater occurrence of pathogen gene markers in samples which exceeded the USEPA (1986) Recreational Water Quality Criteria for both *E. coli* and enterococci. The median densities of FIB were significantly higher in samples collected during high flow conditions than in those collected during normal flow conditions across different land cover classifications. The flow related gene frequencies were affected variably by land cover. Results of this study will be used to improve the understanding of microbiological water quality in Great Lakes tributaries with the future goal of determining the relations between the occurrence of bacterial pathogen genes, FIB, seasonality, water chemistry, and hydrology. Resource managers may use the results of this study to determine the potential risks to human health.

Assessing Enteroccoci in the Nation's Lakes, Reservoirs, Streams and Rivers: Results from the National Aquatic Resource Surveys

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Abstract
Pathogens are disease-causing microbes (bacteria, viruses and protozoa) that usually come from human or animal waste. These microbes enter waterways from both human-caused and natural sources, and can affect human and animal health. Understanding the extent of potential risk to human health from pathogens across the country is important in our efforts to address water quality issues. The National Aquatic Resource Surveys (NARS) are a series of statistical surveys designed to assess the nation's waters. Two of the NARS surveys, the National Lakes Assessment 2007 and the National Rivers and Streams Assessment 2008/09, included collection and analyses of enterococci at a nation-wide scale. EPA recommends enterococci as the best available indicator of health risk in marine water used for recreation and as a useful indicator in fresh water as well. For these surveys, enterococci were analyzed using the quantitative polymerase chain reaction (qPCR) method. In December 2012, EPA issued new recreational criteria which included supplementary values including Statistical Threshold Values and Beach

Action Values for enterococci using qPCR. Using the data from these two surveys, we can provide information about the relationships between enterococci levels across the United States and these values. This presentation will discuss the national and regional results from each of these statistical surveys, including some important considerations related to analysis and interpretation of the data. The presentation will also provide information on additional work being done on enterococci through the NARS.

Improving Predictions of Bacterial Water Quality with Real- Time Networked Sensors and Online Models

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Abstract
The EPA has provided guidelines for the safety of recreational contact with river and beach water based on concentrations of the fecal indicator bacteria *E. coli* and enterococci. However, it generally takes 24 hours to analyze water samples for these bacteria, and concentrations of the bacteria are known to fluctuate dramatically in timeframes of hours. Therefore, water quality warnings based on water sampling are inherently associated with timing mismatches, and are not as effective as they could be. Some monitoring organizations have tried to predict bacteria concentrations by modeling the correlation of bacteria levels with easily measurable hydro-meteorological conditions. This often results in reasonable forecasts that are 80-90% accurate, but this method is still plagued by timing issues because it depends on personnel to measure the variables daily. In this study, we have tested how predictions and public warning systems can be improved by networking real-time continuous hydro-meteorological sensors with online automated water quality reports. Two sites have been studied, the Charles River basin in Boston, MA, and Wollaston Beach in Quincy Bay, MA, both of which are located in populous urban centers and used heavily for recreation. Hydro-meteorological sensors were deployed at both locations. Data from these sensors were combined with data from other real-time sensors, such as USGS flow gauges and NOAA tide gauges, to feed an automated online model and warning system. The results of the study indicate that real-time data can dramatically improve statistical sensitivity of the model, and that the automation delivers powerful improvements in temporal coverage and significance to the public.

Advancing the Use of Predictive Models for Estimating Recreational Water Quality at Beaches

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Abstract
Concentrations of indicator bacteria, such as *Escherichia coli* and enterococci, are used in recreational water-quality monitoring programs to determine whether to post a health advisory or beach closing. Because traditional culture methods for indicator bacteria take at least 18 hours to obtain results, water quality can change during that time. Instead, predictive models have been used at beaches to improve the timeliness and accuracy of recreational water-quality assessments. Beach-specific predictive models use environmental and water-quality variables that are easily and quickly measured, such as turbidity and rainfall, to estimate concentrations of indicator bacteria or to provide the probability that a State recreational water-quality standard will be exceeded. When predictive models are used for beach closure or advisory decisions, they are referred to as "nowcasts."

During the recreational seasons of 2010-12, the U.S. Geological Survey (USGS), in cooperation with 23 local and State agencies, collected data to improve existing nowcasts at 4 beaches, validate predictive models at another 38 beaches, and collect data for predictive-model development at 7 beaches throughout the Great Lakes. Local agencies measured field variables, compiled environmental data, and measured *E. coli* concentrations. Software programs, designed specifically to compile and process data for predictive model development, were used to compile data and develop models by means of multiple linear regression techniques. The models were validated and compared to the current method for assessing recreational water quality-using the previous day's *E. coli* concentration (persistence model). The predictive models performed better than persistence models at most beaches, especially in terms of sensitivity (predicting an exceedance of the standard).

Gaining knowledge of each beach and the factors that affect *E. coli* concentrations is important for developing reliable predictive models. Several years of data spanning a wide range of environmental conditions helps to improve predictive model performance. The USGS is committed to helping water-resource managers collect appropriate data, develop predictive models, and implement nowcast programs at beaches throughout the United States.