In cooperation with the Cuyahoga Valley National Park

Escherichia coli in the Cuyahoga River within the Cuyahoga Valley National Park

Why is *Escherichia coli* important?

There are several measures of how "clean" a natural body of water is, including concentrations of indicator bacteria, the amount of dissolved oxygen in the water, and the level of nutrients. *Escherichia coli* (*E. coli*) is a bacterium that lives in the intestinal tract of warm-blooded animals, such as humans, deer, cows, and dogs. *E. coli* is described as a fecal-indicator organism because when it is found in the environment it indicates the presence of fecal contamination and therefore the *possible* presence of pathogenic organisms found in feces. Most strains of *E. coli* are not harmful and are in fact beneficial to humans by helping in the digestive process. A few strains, such as the O157 strain, produce toxins that can cause gastrointestinal illness, but incidence of this strain in the environment is not common.

The U.S. Environmental Protection Agency (USEPA) recommends using *E. coli* to monitor fresh waters and sets criteria for the level of bacteria that can be in the water with minimal effects on human health. Often, the waters of the state are given a recreational use designation, such as bathing, primary-contact, or secondary-contact waters (see **box 1**), that is used to set standards based on USEPA criteria. The Cuyahoga River within the Cuyahoga Valley National Park (**fig. 1**) is designated as primary-contact recreation. In Ohio, the single-sample standard for primary-contact recreation is 298 colony-forming units per 100 milliliters (CFU/100 mL) of *E. coli*. When concentrations are measured above this standard, the water is considered unsafe for recreation.

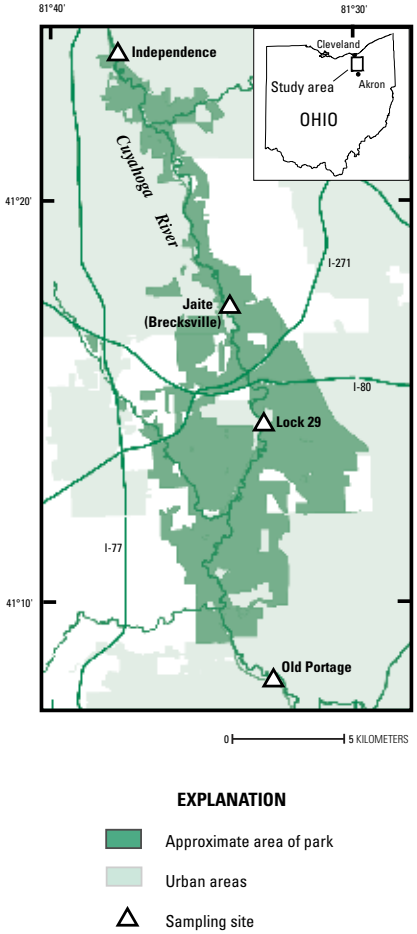
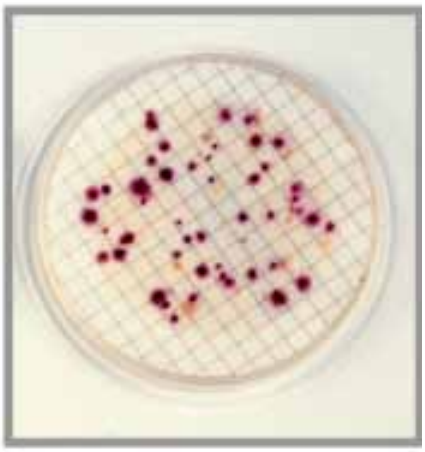


Figure 1. Map of park.

How is *Escherichia coli* detected in water samples?

Current, approved methods for detecting *E. coli* concentrations in water take between 18 to 24 hours to obtain results. A liquid or solid growth media provides nutrients that allow *E. coli* bacteria to grow and multiply during incubation at warm temperatures. After the set incubation period, *E. coli* can be visualized and counted to determine concentrations. However, water-conditions quality can change within the time frame required to obtain results. Therefore, results from the previous day's sample may not be representative of water-quality conditions on the day when the results become available. Possibly resulting in unneeded no-swimming alerts and lost recreational opportunities or—more unfavorably—unintended exposure for recreationists to waters that do not meet recreational standards if an alert is warranted but not issued.



Photograph of modified mTEC agar plate with bacterial growth.

Has *Escherichia coli* been found in the River within the Cuyahoga Valley National Park?

The U.S. Geological Survey, in cooperation with the Cuyahoga Valley National Park, has completed several studies regarding recreational water quality on the river. During 1991-93, field studies were completed to examine how concentrations of fecal-indicator bacteria change with time and distance downstream from sources (Myers and others, 1998). This research determined that, at the time of these studies, natural processes of decay and dispersion of fecal-indicator bacteria would not be enough to reduce concentrations below recreational water-quality standards in reaches of the river frequented by recreationists. Further research done in 2000 and 2002 (Bushon and Koltun, 2004) examined concentrations of *E. coli* in conjunction with detections of other microbes, including a limited number of pathogenic microorganisms. In samples with elevated *E. coli* concentrations (greater than the single-sample standard for secondary-contact recreation), pathogenic microorganisms were detected more often than in samples

Box 1. Use Designation Definitions for Ohio Waters

- Bathing waters: waters that are suitable for swimming where a lifeguard and/or bathhouse facilities are present; E. coli single-sample standard is 235 CFU/100mL
- Primary-contact: waters that are suitable for full-body contact recreation, such as swimming, canoeing, and scuba diving; E. coli single-sample standard is 298 CFU/100mL
- Sceondary-contact: waters that are suitable for partial body contact recreation, such as wading; E. coli single-sample standard is 576 CFU/100mL

with *E. coli* concentrations that were not elevated.

During 2004 through 2009, a series of studies were done to investigate ways of predicting same-day recreational water quality. The studies completed during 2004-06, examined a rapid analytical method for detecting *E. coli* concentrations (Brady, 2007; Bushon and others, 2007). This method worked well at predicting concentrations. However, an easier-to-measure water-quality parameter, turbidity, was found to rise and fall with *E. coli* concentrations in the Cuyahoga River (**fig. 2**). Turbidity is a measure of how cloudy the water is and is measured by an instrument called a turbidimeter that measures the amount of light that is refracted through an aliquot of sample. Further studies during 2007-08 continued the research regarding the use of a turbidity model for predicting *E. coli* concentrations in the river.

How are statistical models created and used to predict recreational water quality?

Several years of data are collected prior to preparation of statistical models to ensure many types of environmental conditions are sampled and can therefore be represented in the model. Then, researchers examine the data to look for environmental and (or) water-quality variables (explanatory variables) that tend to rise or fall with or in contrast to the variable of interest; in this case, the variable of interest is *E. coli*. Once the explanatory variable or variables are identified, further work is done to ensure that the variables do not interact with one another. For example, streamflow may be wholly or partially influenced by rainfall, and the two variables together might interact in the model and not provide the best results. Best practice would be to choose one or the either variable for use in the model. Final model selection involves several steps, including comparison between potential models and examination of how well potential models would work to predict *E. coli* concentrations during an independent sampling period (data not included in preparation of the model).

After selection of the final model, daily estimates of the current day's *E. coli* concentration can be calculated. There are two ways of predicting the recreational water quality above or below the state standard. First, the predicted *E. coli* concentration may be used, and if the predicted concentration is below or above the standard, then the water body is predicted to be safe or not safe for recreation, respectively. However, these predicted *E. coli* concentrations tend to have a lot of variability, and may not be very accurate. A second method for predicting recreational water quality uses the probability that the estimated *E. coli* concentration will exceed the standard. This is similar to a weather forecast when a meteorologist predicts the likelihood of rainfall (for example, a 60 percent chance of rainfall). However, to determine whether the water body is safe or not safe for recreation, a threshold probability is used. A threshold probability is determined through further data analysis of the model data set that determines at which probability the number of correct predictions is maximized and the number of incorrect predictions is minimized. Then, if the probability for that day is below or above the threshold probability, then the water body is predicted to be safe or not safe for recreation, respectively.

Where can I find more information?

During the recreational season (May through August) of 2009, the Ohio Nowcast website (*www.OhioNowcast.info*) was used to allow the public to access same-day predictions of the recreational water quality of the Cuyahoga River at one site centrally located within the park (at Vaughn Road, Brecksville, OH). This service is expected to continue during the recreational seasons of upcoming year.

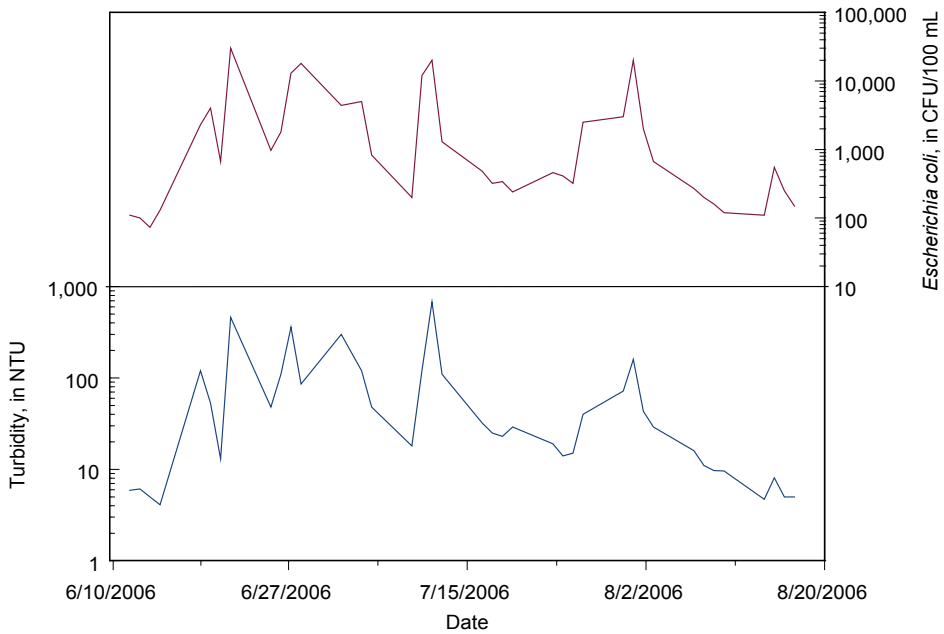


Figure 2. *Escherichia coli* and turbidity in the Cuyahoga River at Jaite (Brecksville), Cuyahoga Valley National Park, 2006. The lines are used for visual purposes only and do not imply that the variables were measured continuously.

References

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