Measure twice – Cut once

Bacterial source tracking: Another tool for dealing with water quality impairment

By APRIL GRIPPO

Of the thousands of waterbodies in the United States listed as having impaired water quality, the presence of pathogen-indicating fecal bacteria is often the cause.

In Florida alone, the impairment of over 1,000 miles of rivers and streams is attributed to fecal bacteria.

Charged by federal legislation with improving the water quality of waterbodies on impaired waters or 303(d) lists, governments agencies are obligated to develop Total Maximum Daily Loads that reduce the amount of contamination entering surface waters.

For each waterbody, a TMDL defines the maximum allowable level of a contaminant that a waterbody can assimilate (the limit) and allocates loads or portions of that limit to contributing parties. These parties—both public and private—must then undertake and document activities that reduce their contribution of a contaminant to or below the load that they are allocated.

While reducing fecal bacteria to TMDL-mandated levels is in itself a challenge, trying to do so without certainty of the actual source of the contamination is like shooting in the dark.

Parties with load allocations are therefore best served by first determining the actual source of the bacteria before they begin to balance the costs and effectiveness of load-reducing alternatives.

During the past decade, bacterial source tracking has emerged as a new tool for those dealing with bacteria TMDLs.

Not only can source tracking affirm or counter the believed sources of the fecal contamination, but it also allows those with load allocations to more confidently target BMPs and other technologies to achieve mandated reductions.

A call to action

The passing of the Clean Water Act in 1972 initiated the widespread monitoring of water quality in U.S. waterbodies. As a result of the CWA, there was a significant reduction in the amount of pollutants entering waters by then-existing sources throughout the country.

Through time however, the nation's continuous growth, with tremendous increases in developed lands and industrial production, has produced a net increase in wastewater and runoff pollution entering surface waters.

The CWA legislation also initiated the TMDL program, which required states to identify impaired waters—those that are not able to meet their designated use such as recreation or fishing—and improve the quality of those waters.

Decades passed however, before lawsuits from environmental organizations during the late 1990s spurred states to begin complying with the CWA requirements. All states have now produced their 303 (d) lists of impaired waters and are in various stages of developing TMDLs for all waterbodies on their 303(d) lists.

While fecal bacteria are cited as the reason for impairment of many of the listed waterbodies, fecal bacteria itself is often not the actual problem. Fecal bacteria, a natural bacteria found in the gut of warm-blooded animals, is instead an indicator of the presence of fecal waste in the water.

It is the presence of fecal waste, along with the potential pathogens it brings—specifically other harmful bacteria and viruses—that causes regulators the greatest distress. This distress is further compounded by outcries from the public, which understandably is concerned about pathogens in the waters used for recreation and/or shellfish harvesting.

From whist it came

The source of fecal contamination is especially difficult to pinpoint in urban watersheds, where humans coexist with a variety of animals.

Potential sources of fecal bacteria are generally grouped into four categories: human, livestock, wildlife or domestic pets, such as cats and dogs. With each source producing identifiable strains of enteric bacteria, source tracking helps determine the actual culprit of contamination.

Many TMDLs and load allocations are developed using data from land use pattern—with or without complementary water quality monitoring data. The available land use data is fed into computer models that predict the likely water quality in urban streams.

Yet even if the level of predicted contamination is confirmed by actual monitoring data, the sum total for fecal bacteria could still originate from a combination of sources at levels different than those indicated by the model.

Here again, source tracking can be used to affirm or identify the real culprit.

Source tracking methods currently in use are divided into three groups: molecular, biochemical and chemical.

Molecular methods are based on segregating sources of bacteria by the unique genetic composition of different fecal bacteria subspecies. Referred to as "DNA fingerprinting," current technologies in this group include ribotyping and pulsed field gel electrophoresis, which identify differences between the DNA of different animals.

Biochemical methods detect and measure biochemical substances produced by an organism's genes. Examples of biochemical methods are antibiotic resistance analysis and determination of fecal bacteria ratios. While less costly and able to produce quicker results than molecular methods, biochemical methods are not considered as precise.

Chemical methods determine only whether human wastewater is present or not. These techniques isolate chemical compounds such as optical brighteners (used in laundry detergents) and caffeine, of which humans are the only source. The drawbacks to chemical methods are their high cost and inability to consistently reflect recent pollution.

Only one part of the solution

As with any new technology or testing method, source tracking is still an evolving science. Although there are various source tracking methods in each category, no one method is used in all situations.

Similar to water quality modeling, a "toolbox" approach—using a variety of tools or methods to hone in on the most accurate understanding of a system—is the most useful.

The methods chosen depend on known watershed activities and the types of potential sources for contamination.

The U.S. Geological Survey, in cooperation with a number of other public and private entities, recently conducted a study that tested the accuracy of microbial source tracking methods.

In the published report "Comparison of Seven Protocols to Identify Fecal Contamination Sources Using Escherichia coli," the study revealed that only 20 to 30 percent of samples sent for testing were classified to the correct source-animal species. This contests the 60 to 90 percent accuracy rate cited in by other entities.

The same report does, however, state a number of reasons for the discrepancy in the study's expected and actual accuracy results. Among them, "challenge isolates" (samples of known origin) were prepared nine months after feces samples were collected.

This points to the potential for seasonal variations in the bacteria present in animals' guts.

It is also known that some E. coli strains have been found in more than one animal source, further complicating source tracking analyses.

The report additionally notes the constraints of a small reference library of bacteria strains for each animal species; the USGS study was limited to 900 strains. The expense of building a large reference library—with costs up to $100 to analyze each strain—can limit the number and accuracy of providers of such analysis.

The USGS report does not wholly discount source tracking as a useful tool, but instead explains the need to support such analyses with quality control data.

Indeed, an accurate interpretation—be it the determination of sources for fecal contamination or any modeling of water quality—must be supported by all data sets within the equation.

The final product

Although there is no one method that will be a solution for every watershed, the toolbox approach—combining biochemical and chemical methods along with molecular procedure—is a useful, cost-effective, and timely approach to identifying sources of fecal pollution in a watershed.

When coupled with water quality models, the results of these studies will provide considerable scientific justification for fair and equitable TMDL allocation scenarios.

Essentially, this "measuring" twice to be sure of the source, affords affected parties adequate information for selecting the most appropriate BMP or other technology to "cut" just once and attain the reductions desired.

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