

Investigating bacterial water quality problems

Background

When a water body fails to meet water quality standards for bacteria, the federal Clean Water Act requires the Washington Department of Ecology (Ecology) to take action. Actions to identify sources of bacteria pollution include:

- A total maximum daily load (TMDL or water quality improvement project) analysis or specific source-identification study.
- A bacteria source study that meets Washington's data quality and reporting standards.

The usual approach for Ecology is to conduct a TMDL analysis of a polluted water body to determine how much bacteria is in the water, the general source areas, and whether the pollution is worse at certain times of year. The main goal of the study is to determine how much the pollution needs to be reduced to meet water quality standards.

Washington State has water quality standards for bacteria so citizens will not get sick after using water for swimming, harvesting shellfish, and other recreational activities. You can find information on water quality standards and impaired waters at: <http://apps.ecy.wa.gov/wqawa2008/viewer.htm>

Typical bacteria sources

Fecal coliform bacteria represent a wide range of microbial families, including *Echerichia coli* (*E. coli*), that live in the intestines of warm-blooded animals and people. People can suffer health problems after coming into contact with water containing high levels of these bacteria.

Fecal coliform can come from industrial or sewage treatment plant discharge pipes, often called "point source" pollution. It can also come from an array of diffuse, hard-to-trace sources from people's activities on the land, or "non-point" pollution.

Sources of non-point pollution can include:

- Failing septic systems or a high density of septic systems in a small geographic area.
- Stormwater carrying pet waste.
- Improper storage and handling of farm waste.

WHY IT MATTERS



Bacteria from human and animal waste can make people sick and cause the closure of shellfish harvesting beds. People can help keep bacteria out of the water. Scoop, bag and trash dog poop. Check your on-site sewage system to make sure it is maintained and working properly. Manage your livestock manure.

More information about MST

- Thurston County Public Health, 2002. Bacteriological Contamination Source Identification Study <http://www.co.thurston.wa.us/shellfish/publicationsmedia.htm#dnatest>
- U.S. EPA guidance http://www.water.rutgers.edu/Source_Tracking/MicrobialSourceTracking/MicrobialSourceTrackingGuideDocument.pdf
- Institute for Environmental Health www.iehinc.com

- Livestock.
- Poor management of manure used as a crop fertilizer.
- Wildlife.

How does Ecology identify non-point sources of bacteria?

Ecology in partnership with a local community will develop a TMDL or other equivalent study (usually a city or county source identification program) to identify where bacteria is coming from. This work generally starts with the collection of samples across a broad part of a watershed, and then focuses in on suspected sources based on the initial water quality sample results. A good investigative study design and conventional methods can identify many bacteria sources.

Once the study narrows down the general location of bacterial sources to specific areas, Ecology works with local communities to look more closely at potential sources in those areas and find ways to remove or reduce the pollution sources.

What happens if wildlife is a major source of bacterial pollution?

Most bacterial pollution by wildlife is considered a natural contribution that cannot be controlled. Sources that we can control must still be reduced enough for the water to be safe for uses we enjoy, such as commercial shellfish harvest, swimming, and fishing. Bigger wildlife contributions mean the rest of us must contribute less pollution.

Source tracking methods

Scientists use source identification tools for locating the less obvious sources of bacterial contamination. Conventional source tracking is the primary method, but may be augmented with a technique called “microbial source tracking” or MST.

Conventional bacterial source tracking

One of the most economical methods of identifying sources is to conduct intensive upstream-downstream water quality monitoring. This should include flow measurements to identify specific stream reaches, land uses, or tributaries that are a problem. Ecology scientists test water samples by cultivating fecal bacteria in the sample and counting the number of bacteria colonies present in the sample.

Experts use this type of monitoring, coupled with good field observation and land use information, to identify sources of bacteria that contribute to the problem. They can also sample chemical indicators of fecal sources to determine the presence of human and animal fecal contamination. Studies demonstrate that human and veterinary pharmaceuticals in surface waters can be an indicator of human and animal waste, while certain hormones or antibiotics can indicate the presence of livestock waste.

Dye testing is another technique to determine if on-site sewage treatment systems in an area are functioning properly. Fluorescent dyes, coupled with water quality sampling, can identify the septic system source.

Microbial source tracking techniques (MST)

MST includes a group of techniques aimed at identifying, and in some cases quantifying, source(s) of fecal contamination in water. Currently, Ecology considers these techniques to be research because no MST methods have been approved by the U.S. Environmental Protection Agency (EPA).

Some watersheds are using genotyping (DNA “fingerprinting”) where conventional source tracking ends with inconclusive results. Genotyping can involve different types of genetic analysis. Techniques can involve comparing unknown bacteria samples with a “library” of known DNA fingerprints. DNA libraries are developed by collecting feces from known hosts or environmental sources in the watershed. Other MST techniques do not depend upon a DNA library, but instead look for genetic markers specific to certain groups of animals.

It is important to choose the appropriate microbial source identification method and to use it only after conventional methods have been exhausted. Even if done correctly, it is possible that not all microbial source types will be identified or, with some techniques, that sources will be misidentified.

Does Ecology use this MST technology?

Ecology does not typically use MST to develop TMDLs to reduce bacterial pollution. There are a few areas in the state where local governments have done MST studies in a watershed where Ecology is developing a TMDL (for example, Henderson Inlet in Thurston County and Clarks Creek in Puyallup). Ecology usually collaborates with local governments conducting studies that can add value to TMDL outcomes.

There are many cases where large amounts of money have been spent on MST (these studies cost as much as \$100,000 or more) when major sources can be determined with conventional methods. When sources are obvious, actions can be taken right away to reduce pollutant loading without extensive testing.

What are some of the concerns Ecology has with MST?

- Laboratory cultures of E. coli bacteria can consist of hundreds of bacteria “colonies,” but the DNA of only a few are actually analyzed. So, the results may not represent, or even include, the actual sources in the environment. It cannot, with certainty, determine the relative amount of bacteria in the water from each species.
- Field work is intensive because MST requires numerous water samples, and fresh fecal samples from all possible sources must be collected to build a DNA library.
- Laboratory analysis is very intensive.
- It has not been determined how accurate DNA libraries are over time because bacterial DNA does not remain constant but evolves over time and may lead to false-negative results.
- These are research techniques and have not been formally approved as an EPA laboratory method.

Does MST hold some promise for future needs?

There can be a strong need to differentiate sources of bacterial contamination where significant sources are not easily identified. Using proper quality assurance requirements, MST could provide additional information for bacterial source investigations. We recognize the potential of this method and are actively engaged in exploring its usefulness. We continue to monitor the state of the science, and are involved in numerous local and national discussions on the topic.

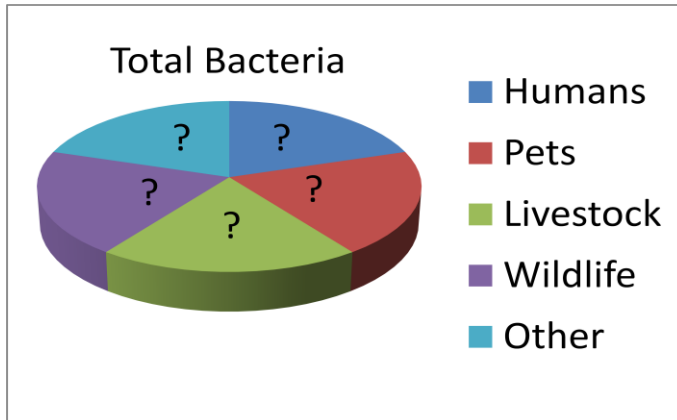


Figure 1: Example pie chart showing presence of different source types in a water sample, but specific quantities for each type (how big each “slice” is) cannot be determined with current MST techniques.

What is required for a MST study?

Ecology requires environmental data used for regulatory purposes to be analyzed by an accredited lab. Currently, there are no labs that are accredited for MST techniques because there is no EPA-approved method.

To ensure that specific quality assurance guidelines will be met by proposed MST studies, the following data quality requirements **must be included** to be accepted by Ecology:

- The laboratory Quality Assurance (QA) manual and standard operating procedure documents for the test method used.
- QA/Quality Control (QC) samples will include negative controls (blanks), laboratory duplicates, and positive controls (known source spikes).

Please contact Ecology’s Quality Assurance Officer or MST specialist if you are considering an MST study to collect data that will be used by Ecology.



Figure 2: Cow manure near a stream, as a result of poor livestock management.

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