



# Extension FactSheet

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## Fecal-Oral Pathogens in Water

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### Introduction

Pathogens are microorganisms that infect a host (humans, animals, plants, or each other) and cause disease. The disease can be unnoticed, cause illness, or result in death to the host. Once the disease has run its course, the pathogen must have a way to get from the spent host to a new host. Routes of infection to a new host include skin surface contact, puncture, inhalation, and/or ingestion.

Fecal-oral pathogens are a group of microorganisms that share one such mechanism for passage to a new host. The fecal-oral route of transmission for human-pathogenic viruses, bacteria, and protozoa requires transfer from the feces of one host to another host, via ingestion, to spread disease. Fecal-oral pathogens frequently cause gastroenteritis, often manifested as diarrhea, which allows them to be spread in great quantity to the environment. Once in the environment, they infect a new host through contaminated drinking water or food. Poor sanitation is one of the underlying reasons for such disease transmission. Although fecal-oral pathogens are the most commonly targeted health risk in water, other pathogens—such as those that cause ear infections and skin rashes—also can be transmitted by water.

### Diseases and pathogens

Many diseases are spread by the fecal-oral route. Viral pathogens are small (0.02 to 0.30 micrometers<sup>1</sup>) and cannot do anything without a host—they are non-living agents made of DNA or RNA, often covered by a protein capsule. Fecal-oral pathogenic viruses include polio, an enterovirus; hepatitis A, also an enterovirus; and

Norwalk virus, a norovirus. Enterovirus, adenovirus, and norovirus are classes of virus that vary in shape, size, and composition of the capsid and the nucleic acid content. Bacteria are larger than viruses (0.2 to 5 micrometers) and are single, living cells with intracellular structures. Fecal-oral pathogenic bacteria include *Salmonella enterica*, *Campylobacter jejuni*, and some types of *Escherichia coli* that express toxins, such as *E. coli* 0157:H7. Protozoa are larger than bacteria (10 to 100 micrometers) and they have complex internal structures. Many protozoa form cysts or oocysts that are resistant to adverse environmental factors and help the organism survive during transfer between hosts. Fecal-oral pathogenic protozoa include *Cryptosporidium parvum*, which caused widespread and sometimes fatal diarrhea in Milwaukee, Wisconsin, in 1993, and *Giardia lamblia*, which contaminated the Scranton, Pennsylvania, water supply in the mid-1980s and caused widespread illness.

Contamination from human feces (for example, sewage) is expected to be associated with serious health risk; however, many microorganisms pathogenic to humans also are spread by animal feces. Therefore, direct contact with fecal contamination from all sources, including animal manure, should be avoided.

### That's gross!

True, the idea of the fecal-oral route of transmission is gross. Good hygiene stops most direct fecal-oral transmission of pathogens. Sometimes there is an intermediate step that is hard to control. In some cases, insects act as the agent to move feces (on their legs) from the barnyard to the picnic. Fecal pathogens are even known to have been carried in dust. Most often, however, water is the vehicle that accomplishes fecal-oral transmission.

<sup>1</sup> One thousand micrometers are in one millimeter.

**Table 1. Fecal-indicator microorganisms used to monitor various water resources**

Organism	Type	Where found	Regulations
<b>Total coliforms</b>	Gram-negative, lactose-fermenting bacteria	Feces and many other environments	Drinking water, ground water
<b>Fecal coliforms</b>	Subset of total coliform bacteria that are heat tolerant	Feces and few other environments	Shellfish-harvesting water, inland recreational water
<b><i>Escherichia coli</i></b>	One species of fecal coliform bacteria	Feces and rare other environments	Coastal fresh recreational water, ground water (proposed)
<b>Enterococci</b>	Gram-positive, salt- and pH-tolerant bacteria	Feces and leaf surfaces	Coastal fresh and marine recreational water; ground water (proposed)
<b>Coliphages</b>	Bacteriophages (viruses) that infect coliforms	Feces	Ground water (proposed)

## Is this water safe?

Because it is difficult and expensive to test a water sample for the presence of even one pathogen type among hundreds, public-health workers test water for fecal-indicator microorganisms (Table 1) to decide whether there is an unacceptable risk of fecal-oral pathogens in a particular water resource. Fecal-indicator microorganisms are easy to detect, almost always are present in feces, almost always are present in high concentrations when fecal-oral pathogens are present, and generally survive in the environment for as long as or longer than pathogens. Although the fecal indicator system for detecting public health risk is imperfect—because sometimes the general assumptions don't hold true—use of fecal-indicator microorganisms has been a useful tool to protect public health for decades. A list of fecal-indicator bacteria is given in Table 1.

## Laws and regulations

Water-quality standards are incorporated into laws and regulations to protect public health. In Ohio, local health departments and the Ohio Environmental Protection Agency enforce these laws and regulations.

Drinking-water supplies are regulated under the Safe Drinking Water Act, last reauthorized in 1996. Public water supplies must monitor for indicator bacteria in drinking water to limit the risk of spreading waterborne disease through drinking water. Detection of even one total coliform bacterium per 100 mL of finished water is grounds for introduction of more stringent sampling schedules. Detection of one *E. coli* bacterium per 100 mL of finished water makes that water non-potable. Water utilities must also measure the cloudiness, called

turbidity, of drinking water to insure that drinking-water treatment and disinfection systems are effective at eliminating pathogens that may be associated with tiny suspended particles.

Private wells and ponds (and sometimes even storm-water drainage ditches) are used for drinking water or recreation, but they are not regulated or typically monitored on a routine basis. It is up to property owners to test their drinking water and recreational areas to ensure the safety of their families, neighbors, and guests. Although the drainage ditch in front of a home might not be a recreational area, children and pets often play in and around ditch water.

Shellfish concentrate toxic chemicals and microorganisms, and therefore also pathogens, from contaminated water because they feed by filtering large volumes of water. The Food and Drug Administration regulates shellfish-harvesting waters and uses fecal coliforms as the fecal indicator to test and manage shellfish beds. The fecal coliform standard has more risk for wrongly closing shellfish harvesting waters than the *E. coli* standard because the presence of fecal coliforms does not always indicate contact with fecal materials. However, the fecal coliform standard is used because it is thought to be more protective.

Recreational waters used for swimming, fishing, and boating are monitored and are closed if fecal bacteria indicate a health threat. The Beaches Assessment and Coastal Health Act (BEACH Act) of 2000 standardized testing of coastal recreational waters in the United States. Enterococci and *E. coli* are the indicators of fecal contamination specified in the BEACH Act. Table 2 lists the standards recommended by U.S. EPA to protect swimmers and other users of recreational waters.

**Table 2. Threshold levels of fecal indicator bacteria based on U.S. EPA criteria for recreational waters\***

Fecal indicator bacteria	Acceptable swimming-associated gastroenteritis (incidence per 1000 swimmers)	Steady-state geometric mean (5 sample; cells per 100 milliliters)	Single-sample concentration (cells per 100 milliliters)			
			Designated beach areas	Moderate full-body contact	Lightly used full-body contact	Rare full-body contact
Fresh water						
Enterococci	8	33	61	78	107	151
<i>E. coli</i>	8	126	235	298	409	575
Sea water						
Enterococci	19	35	104	158	276	501

\*State regulations are based on U.S. EPA criteria but are not required to be exactly the same; therefore, regulations vary somewhat among states.

## Protection of public health

Sewage systems are a source of pathogens, so care must be taken to properly site, construct, and maintain wastewater-treatment systems and wells. Animal wastes, such as livestock manure and pet waste, also require careful management.

- According to the Ohio Department of Health “Sewage disposal requirements” rule, available at [http://www2.odh.ohio.gov/Rules/Final/Chap29/Fr29\\_02.PDF](http://www2.odh.ohio.gov/Rules/Final/Chap29/Fr29_02.PDF), septic systems must be sited in deep, permeable soil to remove pathogens from household wastewater. OSU Extension Bulletin 896, *Suitability of Ohio Soils for On-site Wastewater Treatment*, summarizes how the soil renovates wastewater and presents wastewater treatment options for Ohio’s diverse soil types.
- Curtain drains around septic systems have been shown to discharge water contaminated with fecal indicator bacteria to ditches, drainage systems, and storm sewers. Although they sometimes prevent sewage from surfacing in yards, these drains also can move pollutants to Ohio’s drainageways and streams.
- Sewer systems are not supposed to leak or overflow raw sewage. However, in many Ohio cities, antiquated

and undersized sewer systems discharge sewage into Ohio’s streams. Sewer-system upgrades in progress for many Ohio cities are intended to reduce discharge of raw and partially treated sewage.

- Care is advised with wastes from pets or livestock. OSU Extension Bulletin 604, *Ohio Livestock Waste and Wastewater Management Guide*, presents best waste management practices for animal wastes.
- The Centers for Disease Control and Prevention, in a fact sheet on private well-water testing recommends that wells be tested annually for indicators of fecal contamination (available at <http://www.cdc.gov/ncidod/dpd/healthywater/factsheets/wellwater.htm>). OSU Extension publications AEX 314, “Water Testing,” and AEX 315, “Where to Get Your Water Tested,” present information on testing private wells in Ohio.

To find these publications and more on water supplies and wastewater treatment, contact a local OSU Extension office. You can also refer to the web site <http://setll.osu.edu> to view these and other publications on water and wastewater.

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