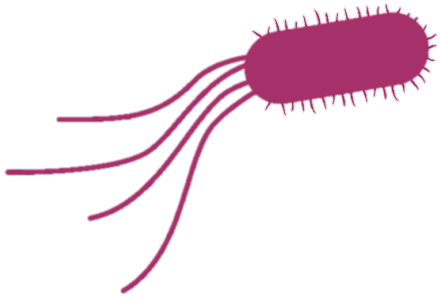
Groundwater Fact Sheet
Bacteria Indicators



Constituent of Concern
Total coliforms, fecal coliforms, and *Escherichia coli*

Synonym
E. coli, *Bacilius coli, Bacterium coli*

Chemical Formula
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CAS Number
M0015 (Total coliforms)
M0012 (Fecal Coliforms)
M0011 or 68583-22-2 (*E. coli*)

Storet Number
31501-31505 (Total coliforms)
31616 (Fecal coliforms)
99906 or 31648 (*E. coli*)

Summary
Coliforms, a group of common bacteria, are generally harmless to humans. However, the presence of coliforms at any concentration is an indication that some harmful micro-organisms may be present. Fecal coliforms such as *Escherichia coli*, and other types of harmful bacteria are found in animal and human wastes, and when detected they are indicators of water supply contamination. Ingestion of water containing coliform bacteria increases the risk of contracting a water-borne illness.

In 1989, (revised in 2013), the US Environmental Protection Agency (EPA) established the Total Coliform Rule (TCR) to help reduce pathogens in public drinking water. The TCR established a maximum contaminant level (MCL) based on the presence or absence of total coliforms in public water systems and required public water systems to conduct sanitary surveys. The EPA published the Ground Water Rule (GWR) in 2006, which required groundwater systems that are at risk of fecal contamination to take corrective action to reduce cases of illness and deaths due to microbial pathogens exposure.

REGULATORY WATER QUALITY LEVELS[1]

BACTERIA INDICATORS

Type	**Agency**	**Concentration**	
Federal MCL[3]	EPA[2]	5.0% of all samples taken in a month is total coliform positive (TC+)	
State MCL	SWRCB[4]	> 40 samples per month	5% of samples are TC+
		< 40 samples per month	1 sample is TC+
		all systems	any repeat sample is fecal coliform positive (FC+) or *E. coli* positive (EC+), or when any repeat sample following a FC+ or EC+ routine sample is TC+
Federal MCLG[5]	EPA[2]	No coliforms in drinking water	

[1] These levels are related to public water supplies and do not address domestic wells as they are not under EPA regulation.
[2] EPA – United States Environmental Protection Agency
[3] The number of samples collected per month is based on the population served. If a sample is TC+, a set of repeat samples must be collected within 24 hours. If a repeat sample is TC+, the sample will also be analyzed for fecal coliforms or *E. coli*. The following FC+ or EC+ result is an acute MCL violation, which requires rapid public notification.
[4] SWRCB - State Water Resources Control Board
[5] MCLG - Maximum Contaminant Level Goal

ANALYTICAL INFORMATION		
Approved EPA methods	1604	600-R-00-013
Detection Limit	Total coliform and *E. coli* tests are usually presence/absence only. Most Probable Numbers (MPN) methods may provide a robust estimate based upon statistical derivation.	
Notes	The EPA has approved several methods to test for the presence of total coliform bacteria. These methods include Multiple Tube Fermentation (MTF), membrane filtration (MF), and enzyme substrate tests. Testing methods for *E. coli* verification follow these same basic methodologies. Additional tests (not listed below) are available for bacteria (e.g., *Enterococci*) that are not part of the coliform group and for potentially harmful proterozoa such as *Cryptosporidium* and *Giardia*.	
Known Limitations to Analytical Methods	Interference from heterotrophic (harmless background) bacteria may occur. High total dissolved solids (TDS) may interfere and result in false positives.	
Public Drinking Water Testing Requirements	Tests for *E. coli* may be conducted in lieu of fecal coliforms, when allowed. The presence/absence of coliform bacteria is used as a bacteriological indicator for the presence of additional harmful microorganisms. Repeat analyses that test for the presence of fecal coliform or *E. coli* are required upon detection of total coliforms.	

Bacteria Indicators Occurrence

Natural Sources

Coliforms are a group of common bacteria that live in the soil, water, and in the digestive tracts of humans and animals. Most common coliforms are harmless and are important components of the digestive system. Fecal coliform bacteria live specifically in the gut and feces of warm-blooded animals. Fecal coliforms are considered a more accurate indication of animal or human waste contamination than total coliforms. *E. coli* is a type of fecal coliform. It is considered the best indicator of fecal pollution and signs that additional pathogens may be present. Inadequate treatment of supply water, animal manure, and septic systems are major sources of coliforms in drinking water and groundwater.

History of Occurrence

Bacterial microbes and other food and water-borne pathogens can provoke severe illnesses. Incidents have resulted in serious widespread sickness, including some that were fatal. Recent outbreaks related to contamination of drinking water supplies in Ohio (2005) and Ontario, Canada (2004) resulted in the illness of 1,450 and 1,346 persons, respectively. The Ontario outbreak resulted in the death of seven people. The Centers for Disease Control (CDC) reported that in the US between 1991 and 2000, contaminated groundwater resulted in 68 outbreaks and 10,926 illnesses. It is estimated that only 1 in 25 episodes of gastroenteritis associated with ingestion of contaminated water is reported, suggesting that the total number of illnesses is much higher.

The CDC estimates that 900 to 1,000 people die each year as a result of microbial contamination of drinking water.

Contaminant Transport Characteristics

The presence of microorganisms in groundwater is heavily dependent upon geologic conditions such as flow pathways and mechanisms, sunlight, temperature, pH, and soil properties.
The type, size, and activity of the microbial community are also important factors that influence the transport of microorganisms.

Remediation and Treatment Technologies

Bacteria can be removed from water by disinfection and/or filtration. While filtration alone may not be effective in completely removing bacteria, it does improve the performance of disinfectants by eliminating sediment that may house bacteria.

Disinfecting methods include chlorination, iodization, ozonation, ultraviolet (UV) light and physical methods such as boiling or steam sterilization. Depending on the source and use of a water supply, disinfection can be used occasionally over short periods or continuously.

The following treatment methods are simple and do not require special equipment or setup:

- Boiling water for one minute.
- Adding two drops of unscented household bleach to each liter (quart) of water and let the water/bleach mixture stand for 30 minutes.
- Using water purification tablets that release iodine or chlorine.

Several devices can be installed within the main water supply system that can treat water prior to distribution:

Chlorinators: Chlorination is the most common water treatment process used worldwide. Chlorine kills most bacteria and viruses but may be less effective on waterborne parasites such as *Giardia* and *Cryptosporidium*. Chlorine may also react with organic material present in the water, releasing byproducts such as trihalomethanes (THMs). Some chronic health risks are associated with THMs.

Iodinators: Iodine is effective but should be used for emergency or occasional use only. Iodine is physiologically active and ingestion in high concentrations may be harmful over long time periods.

UV Devices: Exposure to UV light is effective in eliminating bacteria, viruses, and protozoa. However, UV light does not ensure the safety of the water beyond the exposure area.

Filters: Ceramic or glass fiber filters can remove bacteria and protozoa, but not viruses. Filters should be used in conjunction with disinfection.

Ozonators: Ozone is effective in eradicating pathogens over a short time. Ozone breaks down fast and cannot be used to maintain disinfection throughout a large public distribution system.

Reverse Osmosis: Reverse osmosis (RO) systems are effective in eliminating bacteria and most viruses. However, bacteria may grow within the system itself, and in general RO systems are not recommended as the sole method of disinfection.

Distillation: Distillation is effective in reducing the level of all pathogens in drinking water.

Health Effect Information

The detection of coliform bacteria can be an indication of the presence of organisms that can cause diseases, including harmful strains of coliforms, parasites such as Giardia and Cryptosporidium, and non-coliform bacteria. These organisms can cause intestinal infections, dysentery, hepatitis, typhoid fever, cholera, gastroenteritis, and other illnesses. Intestinal infections and dysentery are generally considered minor health problems in otherwise-healthy adults. However, such illnesses may be fatal to infants, the elderly, and those who are already ill. The E. coli strain O157:H7 can cause serious illness, although this strain is more frequently observed in food than in drinking water supplies.

Not all coliform bacteria cause illness in humans. However, the EPA has determined that the presence of any coliforms is a possible health concern. When detected in drinking water, the presence of coliforms is usually attributed to inadequate water treatment, problems, or leaks within the water distribution system, and/or contamination from septic tank seepage and livestock activities.

The symptoms of waterborne illness are abdominal cramping, fever, vomiting, nausea, headaches, fatigue and possibly jaundice and diarrhea, possibly leading to severe dehydration, malnutrition, kidney failure, and death.

Key Resources

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3. Department of Health and Human Services Center of Disease Control and Prevention, https://www.cdc.gov/healthywater/drinking/public/index.html
4. Department of Health and Human Services Center of Disease Control and Prevention, http://www.cdc.gov/ecoli/2006/september/response/
6. Messner, M., Shaw, S., Regli, S., Rotert, K., Blank, V., Soller, J. 2006. An approach for developing a national estimate of waterborne disease due to drinking water and a national estimate model application. Journal of Water and Health, v. 4 (Suppl 2): 201-40 https://doi.org/10.2166/wh.2006.024
7. U.S. Environmental Protection Agency, 2007, Total Coliform Rule. http://water.epa.gov/lawsregs/rulesregs/sdwa/tcr/regulation.cfm#tcr2012
9. U.S. Environmental Protection Agency. Office of Water. Ground Water Rule, Source Water Monitoring Guidance Manual, Compliance Help. http://water.epa.gov/lawsregs/rulesregs/sdwa/gwr/compliancehelp.cfm#quick
10. U.S. Environmental Protection Agency, EPA Method 1604: Total Coliforms and Escherichia coli in Water by Membrane Filtration Using a Simultaneous Detection Technique (MI Medium). EPA 821-R-02-024. https://www.nemi.gov/home/
11. U.S. Environmental Protection Agency, 2015. Approved CWA Microbiological Test Methods for Ambient Water, http://www2.epa.gov/cwa-methods/approved-cwa-microbiological-methods-ambient-water
12. USGS, Bacteria and *E. Coli* in Water. https://www.usgs.gov/special-topics/water-science-school/science/bacteria-and-e-coli-water