GROUNDWATER INFORMATION SHEET

Bacteria Indicators

The purpose of this groundwater information sheet is to provide general information regarding a specific constituent of concern (COC). The following information, compiled by the staff of the Groundwater Ambient Monitoring and Assessment (GAMA) Program, is pulled from a variety of sources and relates mainly to drinking water. For additional information, the reader is encouraged to consult the references cited at the end of this information sheet.

GENERAL INFORMATION	
Constituent of Concern	Total coliforms, fecal coliforms and *Escherichia coli* (*E. coli)*
Aliases	None
Chemical Formula	None
CAS No.	N/A
Summary	Coliforms, a group of common bacteria, are generally harmless to humans. However, some coliforms may cause illness in humans, and the presence of coliforms at any concentration is an indication that other harmful micro-organisms may be present. *E. coli*, fecal coliforms, and other types of harmful bacteria are found in animal wastes, and when detected are indicators of water supply contamination. Ingestion of water containing coliform bacteria increases the risk of contracting a water-borne illness. In 1989, the United States Environmental Protection Agency (US 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 conduct sanitary surveys. The US 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. This rule does not address private (domestic) wells since they are not subject to US EPA regulation. Domestic well owners are individually responsible for testing and maintaining their water supply.

REGULATORY AND WATER QUALITY LEVELS		
Type	**Agency**	**Concentration**
Federal MCLG[1]	US EPA	No coliforms in drinking water
Federal MCL	US EPA	Public water systems must not find total coliforms in over 5.0% of all samples taken in a month, where the number of samples collected per month is based on the population served. If a sample tests positive for total coliforms a set of repeat samples must be collected within 24 hours. If a repeat sample detects total coliforms, the sample will also be analyzed for fecal coliforms or *E. coli*. A positive result for fecal coliform or *E. coli* samples is an acute MCL violation, which requires rapid public notification.
State MCL	California Department of Public Health (CDPH)	The MCL is based on the number of samples collected per month. For systems collecting more than 40 samples per month, the MCL is exceeded when: • More than 5% of samples in a month are total coliform positive For systems collecting less than 40 samples per month, the MCL is exceeded when: • More than 1 sample per month is total coliform positive For all systems, regardless of sample size, the MCL is violated when: • Any repeat sample is fecal coliform-positive or *E. coli*-positive. • Any repeat sample following a fecal coliform-positive or *E. coli*-positive routine sample is total coliform-positive.

[1]MCLG = Maximum Contaminant Level Goal

[2]MPN = Most Probable Number of coliform

ANALYTICAL INFORMATION		
Analytical Description	The US 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. Tests for *E. coli* may be conducted in lieu of fecal coliforms, when allowed. 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. 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.	
Method Detection Limits	Some total coliform and *E. coli* tests are presence/absence only. MPN methods may provide a robust estimate based upon statistical derivation.	
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.	
Methods	**Method Technology Type**	**Target**
EPA Method 1604	Membrane Filtration	Total coliform and *E. coli*
SM[3] 9223B	Enzyme Substrate	Total coliform and *E. coli*
SM 9221F	Multiple Tube Fermentation	*E. coli*
SM 9221B	Multiple Tube Fermentation	Total coliform
SM 9221G	Multiple Tube Fermentation	*E. coli*
Additional methods may be found on-line at: http://www.epa.gov/microbes/micrometh.htm		

[3]SM = Standard Method

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 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	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 United States between 1991 and 2000, contaminated ground water 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 actually 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.

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 US 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.

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 agents include chlorination, iodization, ozone, 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 letting the water/bleach mixture stand for 30 minutes.
- Using water purification tablets that release iodine or chlorine.

There are several devices that 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 thihalomethanes (THMs). There may be some chronic health risk 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 short time period. Ozone breaks down fast and cannot be used to maintain disinfection throughout a large public distribution system.
- Reverse Osmosis: Reverse osmosis 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.

KEY REFERENCES

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FOR MORE INFORMATION, CONTACT: John Borkovich, SWRCB (916) 341-5779