DRINKING WATER & RECREATIONAL WATER QUALITY: Microbiological Criteria

KIM A. ANDERSON AND P. MICHAEL DAVIDSON

INTRODUCTION

Protection of drinking and recreational waters from contamination by human or animal waste in sewage, food processing wastes, and storm water runoff is of paramount importance to everyone. Public health concerns include safe water (water that does not contain harmful chemicals or microorganisms in concentrations that could cause illness) and an adequate water supply (one that provides safe water in quantities sufficient drinking and domestic purposes).

University of Idaho College of Agriculture
Cooperative Extension System • Agricultural Experiment Station CIS1069

Introduction cont.

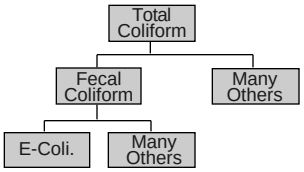
Water is unsafe for human consumption when it contains pathogenic, or disease-causing microorganisms. Pathogenic microorganisms (and their associated disease(s)) may include bacteria, such as *Salmonella typhi* (typhoid fever), *Vibrio cholerae* (cholera), *Shigella* (dysentery, shigellosis), viruses, such as poliovirus or Hepatitis A virus and protozoa such as *Giardia lamblia* (giardiasis) or *Cryptosporidium parvum* (cryptosporidiosis). *Giardia* is a protozoan parasite that infects the upper portion of the small intestine of humans and many other species of mammals. The usual mode of transmission is from person-to-person through what is termed the "fecal-oral route." The least common mode of transmission is waterborne. *Cryptosporidium* is a protozoan parasite, like *Giardia* both humans and animals may serve as sources of environmental contamination and human infection. In 1993-1994, cryptosporidiosis caused by *Cryptosporidium parvum* was the leading cause of illness associated with contaminated drinking water in the United States (MMWR, 1996). Other disease outbreaks during that time were caused by *Giardia lamblia*, *Salmonella*, *Shigella*, *Campylobacter jejuni*, and *Vibrio cholerae.*

Recognition that water was a source of pathogenic microorganisms was made in the late 1800's. Because it was, and still is, very expensive and time consuming to test for all the possible microbial pathogens in water, it was suggested in the late 1800's that a single group of microorganisms that came from the same source as human pathogens (i.e., the gastrointestinal tract) could be used to indicate the presence of pathogens. In 1914, the U.S. Public Health Service adopted the use of coliform bacteria as "indicator microorganisms" to indicate the presence of fecal contamination in water. Ideally, if indicator microorganisms are detected in a substance, it indicates the presence of fecal contamination and therefore possible presence of pathogenic microorganisms in the water. Indicator microorganisms are tested for because they are easier and cheaper to test for than all the possible pathogens that might be present. The most common indicators are total coliform bacteria, fecal coliforms, and *Escherichia coli* (*E. coli*). It is very important to note the presence of coliforms, fecal coliforms, or even *Escherichia coli* in water does not mean that pathogenic microorganisms are present. It only gives an indication that they might be present. Presence of coliform or fecal coliform bacteria does not determine whether a sample will make someone ill.

COLIFORM BACTERIA

Coliform bacteria are not a single species of bacteria but rather are a group of bacteria. They make up around 10 percent of the intestinal microflora of the human and animal intestine. Coliforms are defined as any bacteria capable of fermenting lactose (milk sugar) with the production of acid and gas in 48 hours at 35°C (95°F) under aerobic conditions. This group of bacteria may contain several genera and species of bacteria including *Enterobacter*, *Klebsiella*, *Aeromonas* and *Escherichia coli* (*E. coli*). The presence of coliforms is determined by placing a water sample in a microbiological medium containing lactose and incubating 48 hours at 35°C. As stated above, the presence of coliforms in water is designed to indicate the possible presence of fecal contamination and therefore the presence of pathogens. Since coliforms were adopted as an indicator of fecal contamination in water in 1914, their use has been questioned. That is because, while they are found naturally in the intestines of warm-blooded animals including humans, they may also be found naturally in other sources that are not associated with fecal contamination. However, high levels of coliforms in drinking water supply may indicate contamination from surface or shallow subsurfaces sources such as soil, septic or cesspool leakage, animal feedlot runoff, treatment failures, etc.

Classification of Coliform Bacteria



Fecal coliform bacteria

Fecal coliform bacteria are a sub-set of the total coliform group. Again, fecal coliforms are not a single microorganism but a group of microorganisms with the same definition as total coliform bacteria except that they grow at 44.5°C (112°F). The reason for testing for fecal coliforms is that they are more restricted in their source to the gastrointestinal tract of warm-blooded animals. Again, their presence in water could indicate fecal contamination and therefore presence of pathogens. Unfortunately, while this group may indicated contamination from feedlots, faulty septic systems, barnyards, pastures, rangelands, manure storage facilities and waste lagoons, faulty wastewater treatment plants, and wildlife, it still is not 100 percent effective in indicating the presence of pathogens. Some microorganisms classified as fecal coliforms are not actually from the gastrointestinal tract of animals or humans.

Escherichia coli (E. coli)

Escherichia coli is a single species of bacteria that is a subset of total and fecal coliform. *E. coli* is normally found in human and animal intestines, and is the most reliable indicator of fecal contamination in water. Its presence in drinking water represents a health concern because they are usually associated with sewage or animal wastes. *Escherichia coli* is now tested for on a regular basis in water microbiological analysis. The reason for this is that it has become much easier in the past 10 years to test for *Escherichia coli* in water samples. It is now a single step

to test for the microorganism compared to multiple steps and lengthy incubation times prior. While some strains of *Escherichia coli* are pathogenic, others are not. Pathogenic strains of *Escherichia coli* include Enteropathogenic, Enteroinvasive, Enterotoxigenic and Enterohemorrhagic. Among the symptoms of illness associated with these strains are diarrhea, bloody diarrhea, and in the case of enterohemorrhagic strains (e.g., *E. coli* O157:H7), hemolytic uremic syndrome. Again, however, presence of *E. coli* does not mean that someone will be ill if they drink the water.

Other indicator bacteria used to determine water quality:

Fecal streptococci

Fecal streptococci are another type of bacteria (not a coliform bacteria) used in water quality assessment. They are often found in the gastrointestinal tract of warm blooded animals although not exclusively.

Enterococcus

Enterococcus is a genus of bacteria that is a sub-group of fecal streptococci. There are a number of species of *Enterococcus* including *E. faecalis*, and *E. faecium*. Enterococcus bacteria have been determined to be a valuable bacterial indicator for determining the extent of fecal contamination of recreational surface water.

DRINKING WATER

United States Environmental Protection Agency's

"Total Coliform Rule" (EPA, 1989)

The United States Environmental Protection Agency (EPA) requires a maximum contaminant level (MCL) goal of zero for total coliforms in a 100 mL sample of drinking water. EPA defines total coliforms as both coliforms and fecal coliforms. The total coliform rule applies to all public water supplies. *Private homeowners are not regulated and therefore are NOT required to monitor their wells for drinking water quality.* An MCL of less than 5 percent total coliform positive samples applies to public water systems that analyze 40 or more samples per month. If the system analyzes fewer than 40 samples per month, no more than one sample may be positive for total coliforms. If coliforms are detected in any sample, the system must collect three repeat samples. In addition, any positive sample must be tested for the presence of fecal coliforms or *E. coli*. When any repeat sample is positive for fecal coliforms or *E. coli*, the system is in acute violation of the MCL for total coliforms and ***the public must be notified.*** If the repeat sample shows the presence of total coliform bacteria, the municipal water system is instructed to take steps to kill the bacteria by disinfection. Systems with acute threats to public health are placed on a "boil water order" until testing indicates it is safe for human consumption.

"BOIL WATER" ORDER

What does it mean?

A "boil water order" is issued as a preventive measure if there is a possibility of contamination of a drinking water system with pathogenic microorganisms. During a "boil water order," any water for drinking, washing foods, brushing teeth, or making ice, should be boiled for at least 5 minutes. Water for cooking, washing clothes, dishes, or bathing need not be boiled. If a person believes that water is making them sick, they need to consult a physician immediately

RECREATIONAL WATERS

Surface water quality is subject to frequent, dramatic changes in microbial quality as a result of a variety of activities. Discharges of municipal raw (untreated) water, treated effluents from processing facilities, storm water runoff, or other non-point source runoff all affect surface waters. Typical levels of indicator microorganisms in water are difficult to predict because of the variability of surface waters and conditions. Large rivers, such as the Missouri River, may have fecal coliforms/100 mL that vary 10,000 fold over a 100-mile stretch (McFeters, 1990).

Quality criteria for recreational waters have been established since the 1950's. Evidence correlating illnesses, such as gastroenteritis, with total coliform bacteria or other indicator bacteria in recreational waters, has been documented since the 1940's.

Idaho recreational water quality criteria for bacteria

The Idaho Water Quality Standard and Wastewater Treatment Requirements (section 250.01.a.i) use two classifications for recreational water (Idaho Dept. Health & Welfare, no date). Primary contact recreation water criteria is used when persons are likely to be fully immersed in the water. Secondary contact recreational water criteria is used by the public for less than full immersion (e.g., wading in small streams).

The quality criteria for each are as follows:

Primary Contact Recreational Water

- Fecal coliforms not to exceed 500/100 mL at any time.
- Fecal coliforms not to exceed 200/100 mL in more than 10 percent of total samples over 30 days.

Secondary Contact Recreational Water

- Fecal coliforms not to exceed 800/100 mL at any time.
- Fecal coliforms not to exceed 400/100 mL in more than 10 percent of total samples over 30 days.

EPA recreational water quality criteria for bacteria

The following compliance protocol is recommended by EPA for monitoring recreational waters (EPA, 1989). The basis for these recommendations came from studies on the effect of environment on survival of bacterial indicators

along with the inherent imprecision of the bacterial enumeration techniques. EPA found that *E. coli* and enterococci are excellent indicator bacteria for recreational waters. Their presence and concentration correlated well with swimming-associated illnesses. The following criteria have been established by EPA for a single sample of recreational waters:

Freshwater designated beach areas (Primary Contact)

- *Enterococcus* maximum allowable 61/100 mL.
- *E. coli* maximum allowable 235/100 mL.

Freshwater moderate contact (Secondary Contact)

- *Enterococcus* maximum allowable 89/100 mL.
- *E. coli* maximum allowable 298/100 mL.

FURTHER READING

Centers for Disease Control. 1996. Surveillance for Waterborne-Disease Outbreaks - United States, 1993-1994. *MMWR CDC Surveillance Summaries* 45(SS-1):1-33.

Environmental Protection Agency. 1986. Ambient Water Quality Criteria for Bacteria-1986. Environmental Protection Agency, Office of Water Regulations and Standards, EPA 440/5-84-002, January.

Environmental Protection Agency. 1989. Safe Drinking Water. *Federal Register*, June 29, 1989 (or *Code of Federal Regulations* Title 40, Parts 141 and 142).

Idaho Department of Health and Welfare. Idaho Water Quality Standards. Idaho Dept. of Health and Welfare, Division of Environmental Quality.

McFeters, G.A. (Editor). 1990. Drinking Water Microbiology. Springer-Verlag, New York.

Prescott, L.M., J.P. Harley, and D.A. Klein. 1993. Microbiology, 2nd Edition. W.C. Brown Publishers, Dubuque, IA.

INFORMATION ON THE INTERNET

http://www.epa.gov

http://www.cdc.gov/epo/mmwr/mmwr.html

http://www.wqa.org/WQIS/Glossary/Ecoli.html

SAFE DRINKING WATER HOTLINE

US EPA 1-(800)-426-4791

OTHER CONTACT SOURCES

Idaho District Health Dept.

Idaho Health & Welfare

Idaho Division of Environmental Quality

ACKNOWLEDGEMENTS

The authors thank Elizabeth Ann Marshall and Patricia Talcott.

ABOUT THE AUTHORS

Kim A. Anderson is an assistant professor (adj.) in the Department of Food Science and Toxicology and Chief Chemist at the Analytical Sciences Laboratory at the University of Idaho. kanderson@uidaho.edu.

P. Michael Davidson is a professor in the Department of Food Science and Toxicology at the University of Idaho. davidson@uidaho.edu