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WATER QUALITY, *E. COLI* AND YOUR HEALTH

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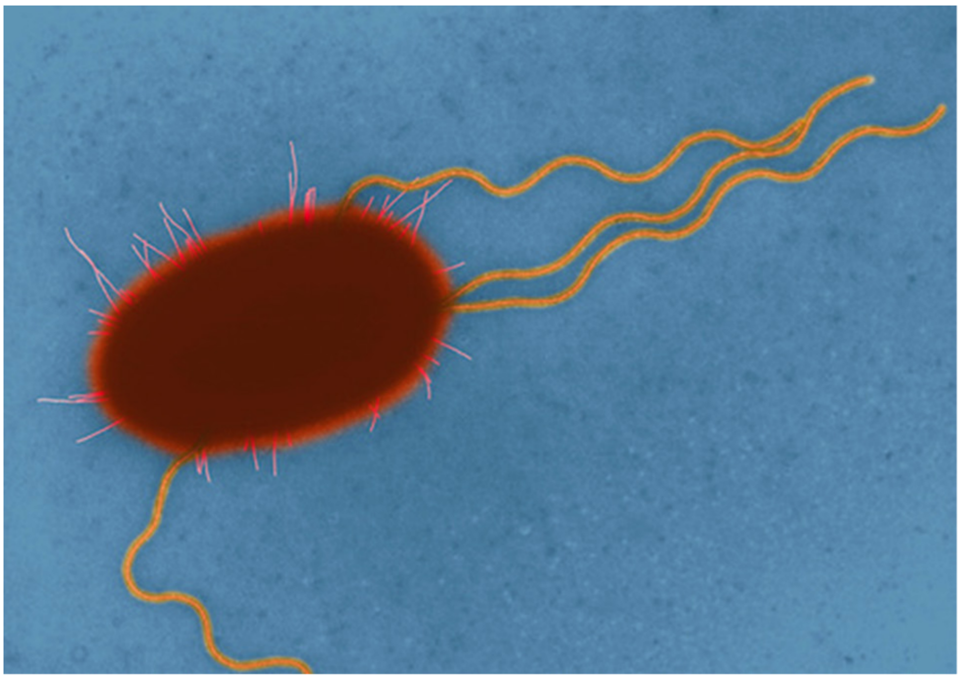

Figure 1. *E. coli* - Gram-negative, facultatively anaerobic, rod prokaryote; with multiple flagella and fimbriae. E. coli can cause urinary tract infections, traveler's diarrhea and nosocomial infections. (Dennis Kunkel Microscopy, Inc./Visuals Unlimited, Inc.)

What is Water Quality?

Water quality refers to the chemical, physical or biological characteristics of water. Water quality is a measure of the condition of water relative to its' impact on one or more aquatic species like fish and frogs or on human uses such as drinking and swimming. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water. Water quality protection programs in Arizona are based on federal and state law and are administered by the U.S. Environmental Protection Agency (EPA) or Arizona Department of Environmental Quality (ADEQ) to keep ecosystems and people safe.

What is *E. coli*?

Escherichia coli (E. coli) are gram-negative bacteria and are a type of fecal coliform bacteria commonly found in the intestines of animals and humans (Figure 1). *E. coli* are so small they can't be seen without a microscope; however, their growth can be seen as colonies on agar media (like JELL-O) under special conditions (Ingerson and Reid, 2011). Most *E. coli* do not cause illness but if a person becomes sick from *E. coli,* the primary site of infection is the gastrointestinal tract and symptoms can include nausea, vomiting, diarrhea, and fever. This bacterium lives and grows naturally in the gastrointestinal tract of humans and animals but if it gets in the wrong place in the body, for example, the kidneys or blood, it can cause illness. According to Ingerson and Reid (2011), the infection may spread within the body (to blood, liver, and nervous system). These microorganisms are shed in fecal material, or feces, hence their spread is termed the "fecal-oral" route of transmission. Contaminated food and water are the most common ways to be exposed to *E. coli.* There are specific types (also called "strains") of *E. coli* that can cause disease and there are also harmless types. Some of the harmful types of *E. coli* are classified into the following groups: Enterotoxigenic (ETEC), Enteropathogenic (EPEC), Enterohemorragic (EHEC) and Enteroinvasive (EIEC). ETEC, EPEC and

Table 1. Harmful strains of *E. coli*

Strains of *E. coli*	Modes of Transmission	Disease
Enterotoxigenic (ETEC)	Food or water ingestion	ETEC causes diarrhea without fever. It is common in infants and is often the cause of travelers' diarrhea
Enteropathogenic (EPEC)	Food or water ingestion, direct and indirect human contact	EPEC causes watery, sometimes bloody diarrhea. It is a common cause of infantile diarrhea in underdeveloped countries.
Enterohemorragic (EHEC)	Food/ingestion, direct or indirect human contact	EHEC strains cause bloody diarrhea and can sometimes damage the kidneys and progress to the potentially fatal hemolytic uremic syndrome (HUS). EHEC has caused many large food-borne outbreaks worldwide; O157:H7 is the best known strain.
Enteroinvasive (EIEC)	Food and water ingestion	EIEC causes watery, dysentery like diarrhea. Fever is another common symptom.

EIEC are all generally transmitted through contaminated food and water (Gerba et al., 2009 and Vieira et al., 2007). Table 1 summarizes the harmful types of *E. coli,* mode of transmission, and disease outcome. A more well-known type or strain of *E. coli* is O157:H7 which is found under the EHEC group and is commonly the cause of contaminated foods such as spinach and meat but has also been implicated in outbreaks where water was the source of contamination.

E. coli in Our Water

The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination. It is important to note that *E. coli* and waste can get in our water in many different ways. For example, during rainfall and snow melt, *E. coli* may be washed into creeks, rivers, streams, lakes, or groundwater (Griffith et al., 2003, Roslev and Bukh, 2011) from the land surface. Other ways consist of natural wildlife, failing septic systems, recreational activities and local land use practices (for example, manure used as fertilizers, livestock, concentrated feeding operations). Human and animal sources of fecal pollution represent a serious health risks because of the high likelihood of the existence of pathogens also in the fecal waste. A pathogen is a microorganism that can cause disease and make someone sick. Cattle, swine, and chickens also carry pathogens that can be transmitted from animals to humans causing disease. Therefore introduction of any animal or human waste in water is of high concern.

Numerous studies have been conducted around the world to assess the connection between water quality and serious health effects to people who come into contact with that water through recreation (swimming, wading, fishing, etc.). Although not all *E. coli* bacteria are typically pathogenic, extensive studies have demonstrated that *E. coli* concentrations are the best predictor of swimming-associated gastrointestinal illness (diarrhea). In addition to gastrointestinal illness (GI), illnesses such as eye infections, skin irritations, ear, nose, throat infections, and respiratory illness are also common in people who have come into contact with water contaminated with feces. Some studies have pointed out that the rates of some serious health effects, such as those mentioned above, are higher in swimmers when compared to non-swimmers (Soller et al., 2010).

The presence of *E. coli* may be indicative of contamination with other bacteria, viruses or protozoa that can make you sick. *Salmonella* is a bacterium commonly implicated in contaminated food and water. *Salmonella* can cause diseases such as typhoid fever from consumption of contaminated water and Salmonellosis from eating contaminated beef and poultry. A person consuming contaminated food or water can experience nausea, vomiting, abdominal cramps, diarrhea, and fever. Another common water-borne (spends all or part of its life in water) pathogen, *Cryptosporidium,* is a protozoan parasite affecting the gastrointestinal tract of humans and animals and it is shed in the feces in the form of an oocyst. This oocyst consists of a hard outer shell that protects it from degradation in the environment. *Cryptosporidium* is highly resistant to chlorine commonly used in drinking water treatment, and has been implicated in several waterborne disease outbreaks in the past. One such outbreak took place in Milwaukee on April 1993, which infected over 400,000 people and killed more than 100 (Gerba, 2009). Heavy rains flooded agricultural plains in Wisconsin and produced substantial runoff into a river that provided the City of Milwaukee with drinking water. The drinking water treatment facility was not able to adequately treat or "kill" the high levels of *Cryptosporidium* in the water due to their highly resistant outer shell. The Milwaukee outbreak is an example of the dangers protozoa can pose in drinking water. To date, the Milwaukee outbreak is the largest outbreak to be documented in the United States. As demonstrated by the number of people infected in the Milwaukee outbreak, consequences of consuming fecally contaminated water may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems.

Because contaminated water poses such a large threat to human health, water managers and regulatory agencies have designed tests to tell us our water is safe. We commonly use *E. coli* to indicate that fecal contamination is present in water. Although, we do not want to find *E. coli* in our water, these bacteria can be easily tested and quantified by simple methods. Detection of these bacteria in water means that fecal contamination has occurred and suggests that enteric pathogens, like the ones mentioned above, may be present. This also means that humans and animals should not come into contact with the contaminated water until the presence of *E. coli* is no longer detected, and the water is considered safe.

How do we make sure our water is safe?

Numerous government and state agencies as well as local watershed groups test water quality to ensure it is safe or if there are potential problems with contamination. Water quality testing and data reporting in the past were based on bacterial groups called total and fecal coliforms. Coliforms can be found in the aquatic environment, in soil, and on vegetation; they are universally present in large numbers in the feces of warm-blooded animals. While coliforms themselves are not normally causes of serious illness, they are easy to culture and their presence is used to indicate that other pathogenic organisms of fecal origin may be present. Today, water quality testing has evolved and is now based on the concentration of *E. coli*. *E. coli* is one of the types of bacteria within the fecal coliform group and is a predictor of fecal contamination. Water that is consumed for drinking water purposes is tested for the concentration, or level, of *E. coli* that is deemed safe for human consumption. Similarly, wastewater that has been treated and then recycled for irrigation purposes and/or discharged to surface waters must also meet certain levels of *E. coli* to be considered safe. Rivers that are used for recreation, such as fishing and swimming, are required to meet certain levels of *E. coli* or they can be deemed "impaired" (Rivera and Rock, 2011). Table 2 outlines the various acceptable levels/concentrations of *E. coli* of the different water uses mentioned above. The concentrations of *E. coli* used in regulation are based on assessment of the volume of water a person consumes during different practices and the likelihood the person would become sick after coming into contact with the contaminated water. In circumstances where the contact or ingestion of the water is high (swimming) the concentration of the *E. coli* that is deemed acceptable is lower. In situations where the contact with the water is low (irrigation) the levels of *E. coli* considered acceptable may be higher because there is a lower risk of a person becoming sick.

E. coli is currently the most reliable indicator of fecal bacterial contamination of surface waters in the U.S. according to water quality standards set by the EPA. EPA bacterial water quality standards are based on a level of *E. coli* in water above which the health risk from waterborne illness is unacceptably high. Due to the many associated health risks the presence of pathogens and other microorganisms can pose, regulators such as the US EPA and ADEQ have implemented ways to reduce contact with impaired waters by defining various water use categories. Two of these categories are partial-body contact (PBC) and full-body contact (FBC). According to the US EPA, partial-body contact refers to the human body coming in contact with surface water used for recreational activities, but not to the point of full-body submergence (2009). Levels of *E. coli* cannot exceed 575 colony forming units (CFU) per 100 mL of water for partial body contact (US EPA, 2009). The term CFU refers to the number of living bacterial cells in a water sample. Therefore, this measure is used to tell us the degree of contamination in samples of water or the degree of the infection in humans and animals. For full-body contact, *E. coli* levels cannot exceed 235 CFU per 100 mL of water. Full-body contact refers to the human body being completely underwater in activities such as swimming or other recreational activity (US EPA, 2009).

What can you do in your community to protect water quality?

Essential to human beings and ecosystems, water is closely linked with human life. Numerous activities that occur within your community can ultimately impact surface water quality. Here are some ways you can help keep rivers, lakes and streams safe for both people and ecosystems.

- Learn about your local water body or watershed
- Identify ways you can help prevent polluted runoff from your home, ranch, or farm
- Pick up pet waste in and around your neighborhood
- Keep domestic animals and/or livestock out of waterways (or reduce their exposure)
- Properly maintain your septic system and have it inspected when appropriate
- Join a local watershed group or volunteer organization active in environmental issues in your community

Table 2. Level of *E. coli* permitted for Different Types of Water (ADEQ, 2010 and EPA, 2009)

Purpose	Level of *E. coli*
Drinking Water	Zero
Surface Water Full-Body Contact (swimming)	235 cfu/100 mL
Surface Water Partial-Body Contact (Fishing, boating, etc…)	575 cfu/100 mL
Wastewater (irrigation or discharge)	< 2.2cfu/100 mL < 1.0 cfu/100 mL

- Volunteer during clean up events targeting pollution near surface waters
- Do not throw trash into rivers, lakes, and streams (while the trash may not contain fecal matter or waste, it may attract wild or domestic animals which may introduce fecal contamination near water bodies and causing pollution)
- When camping or hiking, properly dispose of waste and trash to reduce the attraction to animals

Water is a very precious resource; by doing your part to protect our water sources we can ensure benefits to future generations and to the safety of its users.

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