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Water Quality and Fecal Indicator Bacteria

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How can you tell if water is fit to drink? Color and taste aren't reliable guides for water safety. Clear water can be contaminated with chemicals or microorganisms the senses can't detect. One of the principle qualities of potable (drinkable) water is its freedom from microbial contaminants. This article will describe some criteria and methods that are used to determine the microbial quality of water.

Benjamin Franklin once said, "We don't appreciate the value of water until the well runs dry." Likewise, we tend to take the purity of our water for granted until some event briefly reminds us that, for most of us, water travels a long road before it reaches the tap. Cities rely on chemical treatment to make water fit to drink. When that fails, as it recently did in Milwaukee, it's big news. In the country, rural residents may think their well water travels a much shorter route since it might not pass through a municipal water plant. In fact, deep wells may collect water that could be hundreds, if not thousands of years older than city water because it has reached the well only after slowly percolating through soil and rock. We rely on the dilution and the purifying effects of soil and time for the same purpose as we rely on chemical treatment.

Table 1. Frequency of E. coli and MUG negative E. coli in groundwater samples from 10 agricultural watersheds in Kentucky

Location	*Isolates Examined*	*Confirmed E. coli*	*MUG negative E. coli*
Site 1	192	145	1
Site 2	30	24	0
Site 3	123	86	3
Site 4	21	19	1
Site 5	40	28	0
Site 6	12	11	0
Site 7	109	84	5
Site 8	68	43	1
Site 9	100	79	2
Site 10	207	152	4
Total	**902**	**671**	**17**

There are lots of water-borne microbial pathogens that can cause serious disease problems. Hepatitis, is caused by a virus; *Giardia* and *Entamoeba* are protozoa that cause gastroenteritis; *Vibrio*, *Salmonella*, and *Shigella* are all bacterial pathogens in contaminated water that cause cholera, food poisoning, and shigellosis, respectively. Testing for all these organisms in water, would be time-consuming, expensive, and not always successful. With infrequent sampling, these disease-causing agents could enter the water without being detected.

Consequently, public health officials employ a different strategy in testing for the microbial quality of water. They look specifically for fecal indicator bacteria, bacteria that are virtually always associated with fecal contamination of water, but aren't very harmful themselves. These bacteria are normally found at much higher concentrations than pathogenic organisms, and are much easier to detect (they can be identified in a matter of hours rather than days). If fecal indicator bacteria are detected, it's possible that the water source was contaminated by fecal material and needs to be treated. Since fecal indicator bacteria are present in much greater numbers than pathogens, treating water when fecal coliforms are found usually means that pathogens won't be numerous enough to cause disease. Although treating water based on the detection of fecal indicator bacteria doesn't insure that pathogens won't be present, it does reduce the probability that they will cause disease.

Fecal indicator bacteria that are commonly used belong to three groups: the fecal streptococci, the total coliforms, and the fecal coliforms. All three are types of bacteria usually associated with fecal material (though they may also be found naturally in soil and water).

Fecal streptococci include *Streptococcus avium*, *Streptococcus bovis*, *Streptococcus equinus*, *Streptococcus facium*, and *Streptococcus faecalis*, among others. Fecal streptococci are small spherical bacteria that look like pairs or short chains of balls when viewed under a microscope. *Streptococcus avium*, *Streptococcus facium*, and *Streptococcus faecalis* are members of a subgroup of fecal streptococci called the enterococci. The enterococci are useful indicators of fecal contamination at marine and fresh water bathing beaches. Although enterococci are found in fecal material, they're also present in insects, soil, and on the surface of leaves, so detecting them is not necessarily a specific indicator of fecal contamination of watersheds.

According to the definitions used by bacterial taxonomists to classify bacteria, a coliform is a gram negative, lactose fermenting non spore-forming rod. Based on these characteristics, there are several bacteria that can be called coliforms: *Escherichia*, *Citrobacter*, *Enterobacter*, and *Klebsiella* are some of their names. Unfortunately, some of these coliforms (*Citrobacter* and *Klebsiella* in particular) are commonly found in soil, or on the surface of leaves, and aren't associated with fecal contamination at all. If they make up most of the coliforms in a water sample, which they sometimes do, it gives a false indication of water quality.

To get around this problem, health officials look specifically at one type of coliform, *Escherichia coli* (*E. coli* for short). This is the fecal coliform you may have heard about. It is called a fecal coliform because, unlike the other coliforms, *E. coli* is almost always found with some type of fecal waste. If health officials find one or more fecal coliforms in 100 mL of drinking water, it must be considered as being contaminated.

Escherichia coli metabolize a compound called MUG (short for 4-methylumbelliferyl-β-D-glucuronide) that other coliforms do not. Health officials use this to their advantage in making a quick and specific test to determine if fecal coliforms are present in water. If any fecal coliforms are present, they transform MUG and release a fluorescent compound from it. An ultraviolet light will detect the compound (the sample will glow bright blue). It takes less than eight hours for the presence or absence of fecal coliforms to be detected by this test. If a water sample is MUG positive, it is reason enough to treat the water as though it were contaminated.

The MUG test isn't absolutely reliable. Fecal coliforms that are stressed (exposed to temperature extremes or antimicrobial compounds) frequently give a MUG negative test (no fluorescence). A few types of fecal coliforms are inherently MUG negative. One such *E. coli* strain, designated O157:H7, releases a toxin that causes severe, sometimes fatal, kidney damage. It was responsible for the deaths of four children in Seattle in 1993 when they ate contaminated meat.

Overall, about 0.5% of cattle nationwide are infected with this pathogenic *E. coli* strain. We have found that fecal coliforms in natural waters in Kentucky have a very low frequency of MUG negative strains (less than 2.5%) making it unlikely that any water sample truly contaminated with feces would be overlooked by using the MUG test (Table 1).

Modern techniques in molecular biology may one day change our approach to water quality monitoring. Currently, we look at fecal indicator bacteria because they're present in fecal wastes in sufficient numbers for reliable detection by culture techniques. But, to detect them, you have to grow them in the laboratory, and this takes time. By using polymerase chain reaction techniques (PCR for short) scientists can take a piece of genetic material from a known pathogen in water and make millions of copies of it. It becomes very easy to detect this genetic marker with so many copies present. Consequently, molecular techniques will soon make it feasible to look specifically for known pathogens in water, and the traditional use of fecal indicator bacteria may become a thing of the past. For the present, however, because of the cost and technical expertise required to reliably do PCR, it remains a technology whose widespread use lies in the future.

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