IOWA'S WATER

Ambient Monitoring Program

Bacteria in Iowa's Water Resources

People who swim, boat and water-ski in Iowa's waters are exposed to many risks. The greatest risk is drowning due to cloudy water or lack of supervision. Contact with water also brings a small risk of contracting a waterborne illness from microorganisms. While most microorganisms are harmless, others (called **pathogens**) can cause disease.

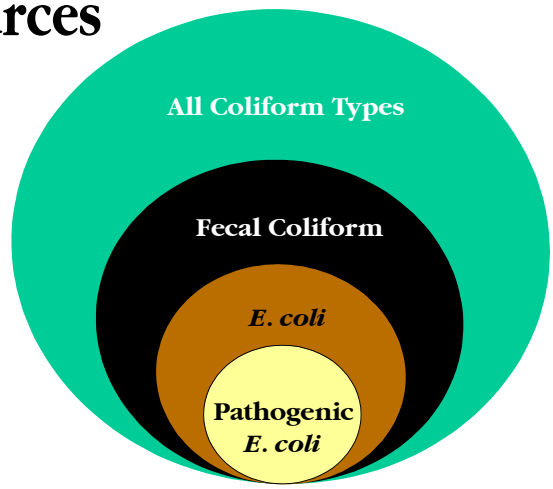

Figure 1. *Coliform bacteria group. Size does not represent the actual percentage of each subset.*

Pathogens

Many different kinds of bacteria, viruses and parasites live in the intestines of warm-blooded animals, including humans. A small portion of these microorganisms are called pathogens because they can cause disease. For instance, pathogenic *E. coli* is a small portion of the larger coliform group, but not all *E. coli* cause disease (Figure 1). When people come into contact with or swallow pathogenic organisms in water, they may develop symptoms that include fever, sore throat, diarrhea and abdominal cramps, as well as ear, skin and respiratory infections.

Pathogen testing in water is difficult and expensive. Not many laboratories in the United States have the capability to test for pathogens from environmental sources (e.g. water, soil, air). Pathogens tend to occur in low concentrations in water, therefore large volumes of water are needed to find them. For example, many gallons of water are needed to test for *Giardia*, a type of parasite. Laboratory costs make these tests quite expensive. In addition, several types of pathogens could exist in contaminated water and it would be cost prohibitive to test for each pathogen. Therefore, testing for pathogens is not recommended by health scientists and officials to assess recreational water safety.

Indicator Bacteria

To overcome these difficulties, **fecal indicator bacteria** are used to "indicate" the presence of fecal material in the water and indicate the likelihood that enteric (fecal) pathogens are present. Fecal indicator bacteria are generally harmless and usually present

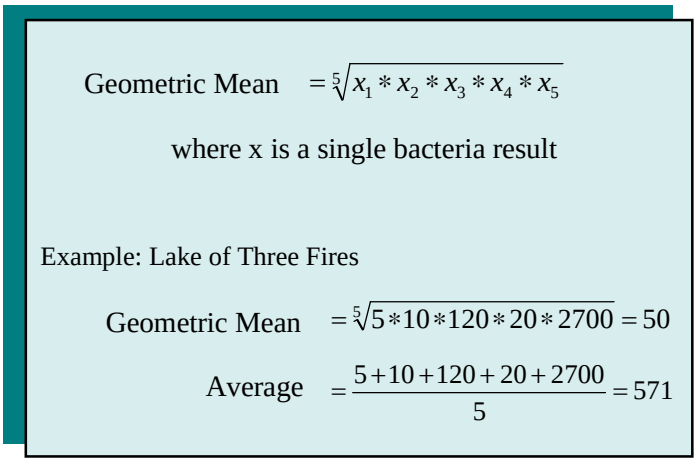

Figure 2. *Geometric mean formula and example.*

when pathogens are present. A higher level of fecal indicator bacteria signifies a greater level of contamination from fecal matter and a greater chance that pathogenic microbes may be present. Fecal indicator bacteria occur in greater numbers than pathogens and are easier to isolate in a laboratory, so it is more cost effective to test for them. Also, fecal indicator bacteria are present when fecal material is present, which is not always the case with enteric pathogens. Iowa's Ambient Water Monitoring Program tests for three types of fecal indicator bacteria at each of the 35 state-owned beaches: fecal coliform, *E. coli* and enterococci.

Sources and transport

Water can become contaminated with fecal material in a number of ways. Human sources include leaking sewage lagoons, malfunctioning septic systems, sewage treatment plant discharges, dirty diapers, and boating or swimming fecal "accidents." Sources of fecal material from animals include overflowing lagoons, manure spills, runoff from fields after manure application, storm water runoff from lands with wildlife or pet droppings, and fecal material expelled by animals standing in the water.

Fecal material from these sources can be transported to rivers, streams and lakes either directly or through runoff from the land surface. Data collected by the Iowa DNR shows bacteria levels (in most areas of Iowa) tend to increase dramatically after heavy rainfalls. This indicates that runoff from the land surface is a significant transport mechanism for bacteria and fecal material in Iowa's waterways.

A certain amount of fecal bacteria is present in our lake water throughout the year. Research shows their survival can be influenced by water temperature and sunlight. Bacteria levels follow a seasonal trend with higher levels occurring in the summer months of June, July, and August and lower levels occurring during the winter months of December, January and February. The ultraviolet radiation in sunlight helps to disinfect water by killing fecal bacteria. While rainfall can increase bacteria levels by transporting more bacteria to water, a few sunny days can decrease the bacteria count.

Bacteria Standards

To protect the public, the state has adopted bacterial standards for "Class A" primary contact water bodies, which include those used for swimming. The Iowa Administrative

Code states, "Class A waters shall have a geometric mean for fecal coliform of less than 200 organisms per 100 ml of water during the recreation season" (April 1 to October 31). The **geometric mean** is recommended as a guideline by the U.S. Environmental Protection Agency (EPA) and is calculated using five samples over a 30-day period (Figure 2). The geometric mean accounts for the wide fluctuation in levels of indicator bacteria in water samples and thus minimizes the influence of a one-time high result (see calculations for Lake of Three Fires in Figure 2). Therefore, to generate a high geometric mean, the water body typically must have chronically high bacteria levels.

Figure 3. *Fecal coliform and E. coli levels at Rock Creek State Park in 2002. Monitoring data in Iowa show fecal coliform and E. coli levels are closely related.*

The state standard for fecal coliform is based on guidelines developed in 1968 by the Federal Water Pollution Control Administration of the Department of the Interior. More recent epidemiological studies conducted by EPA have demonstrated that *E. coli,* in fresh waters, shows a stronger correlation to swimming-related illness than fecal coliform. The EPA has developed new guidelines for *E. coli* based on an acceptable illness rate of eight illnesses in 1,000 people. The *E. coli* guideline recommended by EPA is a geometric mean of 126 organisms per 100 ml of water. Iowa is currently in the process of revising its Class A definitions and moving toward an *E. coli* standard. Water monitoring data in Iowa show fecal coliform and *E. coli* levels to be closely related (Figure 3).

Health Concerns

Epidemiological studies conducted by EPA have demonstrated that an increased amount of indicator bacteria suggests an increased risk of waterborne illness. However, to date, no confirmed cases of waterborne illness from our lakes have been reported in Iowa. The lack of documented cases could be because water-borne illnesses are under-reported and because many people with symptoms do not seek medical attention. In addition, many of these EPA studies were completed in other parts of the country. More research is needed to assess the risk of illness due to high levels of indicator bacteria in Iowa's rivers and lakes.

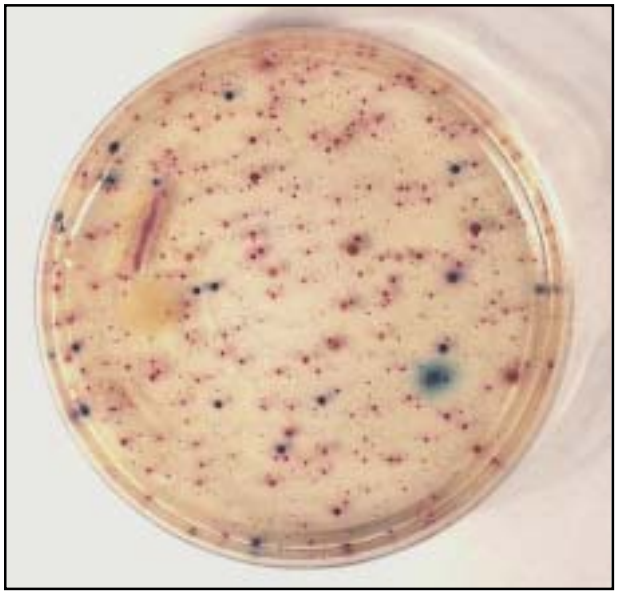

Figure 4. *Bacteria cultured in a Petri dish.*

Emerging Technology

A new technology may assist the DNR in tracking bacteria sources. This method, called ribotyping, is a molecular "fingerprinting" technique that can identify bacteria based upon differences in a portion of the DNA molecule. Researchers have shown that different types of animals have different *E. coli* DNA fingerprints. A fingerprint database will need to be established from known animal *E. coli* cultures. Once a substantial amount of *E. coli* cultures are collected and fingerprinted, unknown samples from streams or lakes can be compared to known patterns in the database to assess the potential sources of contamination. At this point, analyzing these samples is quite costly and labor intensive, however, new techniques of analysis may make the method feasible in the future.

The process of source-tracking will assist the state and individual citizens in making sound land-management decisions to minimize the impact of bacteria on the environment and to decrease the risk of waterborne illness. The investigation of sources of bacteria (and their associated pathogens) improves our understanding of the transport and survival of bacteria in the environment, and allows the Iowa DNR to better protect the public.

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Water Monitoring Program Web Site – www.igsb.uiowa.edu/water

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