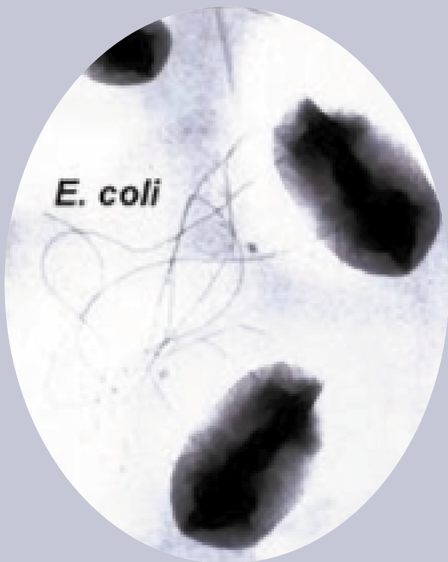
SPECIAL FEATURE

By Danielle Duclos, Foresight Science & Technology



E. Coli

Current and emerging monitoring and decontamination technologies

Which microbes lurk in the clear, crisp water that flows from the tap? The potential answer to this question has spurred millions of Americans to purchase point-of-use and point-of-entry removal technologies as a preemptive strike. However, these units rely heavily on water utilities to remove most, if not all, contaminants that pose a health threat. This article provides a general overview of *E. coli* and drinking water as well as current and emerging monitoring and decontamination technologies.

When sickness occurs from *E. coli* contamination, people often think of food poisoning. Ingestion of *E. coli* tainted meat or dairy products has received wide press coverage over the past 15 years, particularly when mass outbreaks occurred from consuming fast-food hamburgers. Swimming in infected ponds and beaches also has generated attention, and such public information sites as the National Resources Defense Council (www.nrdc.org) list U.S. beaches or entire states that either lack enforcement or regularly enforce monitoring of such pathogens as *E. coli*.

E. coli is not synonymous with drinking water in most Americans' minds. Occasionally, counties will advise residents to boil their tap water as most in-home filters cannot filter *E. coli* out of drinking water, according to the U.S. Environmental Protection Agency (EPA). Such advisories result from an increased risk of contamination due to stormwater runoff from creeks, groundwater, lakes or streams that flow into a town or city's drinking water system. An outbreak in 1998 sickened 157 people when deer and elk feces seeped into a Wyoming aquifer that provided a town's drinking water. The incident highlighted treatment inadequacies in small water systems—the water in this Wyoming system was unchlorinated.

E. coli poses a risk in any untreated water system, particularly wells. In some rural parts of the United States, residents still rely on these sources for their drinking water, and the consequences of ingesting untreated water can be devastating. In 1999, 921 people who attended the Washington County Fair in New York reported diarrhea; two people died. While much of the fair was supplied with chlorinated water, a small section of the fairground had drawn water from a well to boil food and make ice cubes. Environmental cultures from this well revealed high levels of coliforms and *E. coli*.

E. coli is especially dangerous to children, the elderly and immuno-suppressed, but even the healthiest person cannot ward off this pathogen.

Coliform Bacteria vs. Cysts

Bacteria and cysts live in the intestines of humans and animals. However, cysts are classified as protozoa, not bacteria. Cysts have a protective shell, making them generally immune to the effects of chlorine and other chemical agents. That same shell prevents them from changing their shape or size, as bacteria often do, allowing cysts to be effectively removed through filtration and other non-chemical forms of treatment.

– NSF International

While most strains of *E. coli* are harmless and live in the intestines of healthy humans and animals, the strain O157:H7 produces a powerful toxin and can cause abdominal cramps and severe diarrhea that often contains blood. In rare cases, individuals may develop emolytic uremic syndrome, where the red blood cells are destroyed and the kidneys fail.

The EPA long has recognized *E. coli* as a national health threat. The Safe Drinking Water Act (SDWA) is the main federal law that ensures the safety of U.S. drinking water and is overseen by the EPA. All public water systems—defined as systems that operate at least 60 days per year and serve 25 people or more or have 15 or more service connections—are required under the SDWA to monitor for total coliform. Large public water systems that serve millions of people must take 480 samples a month and smaller systems must take at least five samples a month, unless the system has under gone a sanitary survey within the last five years. The survey involves a state inspector examining the system's components and ensuring they will protect public health. Finally, the smallest water systems—those serving only 25 to 1,000 people—typically take only one sample per month. (For more information on *E. coli* and the SDWA, see the EPA's fact sheet on *E. coli* in drinking water at www.epa.gov/safewater/ecoli.html.)

If the customer's well tests positive for *E. coli*, make sure water is boiled for at least one minute in order to use it. Wells should be disinfected. If the contamination is a recurring problem, either a new well should be dug or a point-of-entry disinfection unit, which can use chlorine, ultraviolet light or ozone, can be installed.

– U.S. Environmental Protection Agency

With the responsibility of public health squarely on their shoulders, cash-strapped public water treatment systems must employ the most cost-efficient monitoring and disinfection technology to meet regulations. Common monitoring technologies include culture, enzyme-linked immunosorbent assays, fluorescence in-situ hybridization/confocal laser scanning microscopy and polymerase chain reaction (PCR).

EPA-approved analytical methods for coliform assay are published in the Federal Register under the Total Coliform Rule. To comply with the provisions of the rule, public water systems must conduct analyses using one of seven analytical methods (these methods can be viewed at www.epa.gov/OGWDW/methods/tcr_tbl.html).

Most water quality monitoring involves a multistep process that cannot be conducted at the actual site from which the water sample is taken. Instead, samples should be sent to your lab for an analyzation process that involves culturing bacteria in an incubator or

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passing water through a membrane filter, to see if the targeted bacteria such as *E. coli* and other harmful fecal coliform are present in the water sample. This method can take anywhere from six to 30 hours.

Real-time detection technologies are emerging from research and development at universities, small companies and the Federal Small Business Innovation Research (SBIR) program. (For more information on SBIR, visit www.zyn.com/sbir.) Biosensors promise to detect live and dead bacteria, fungi, viruses and more. Some employ several sensors to determine minute quantities of biological materials such as protein or DNA to detect an array of pathogens. Rugged, durable and reliable new technologies such as biosensors promise to give accurate results in less time in both the laboratory and field settings.

There are a variety of treatment processes available to remove contaminants from public water including flocculation/sedimentation, filtration, ion exchange, adsorption and disinfection, used alone or in combination. Under each of these processes are a number of products employing different technology. For instance, disinfection of water can be achieved both by chlorination and ozonation. Filtration enhances the effectiveness of disinfection by removing remaining particles from the water supply.

Filtration technologies are becoming more sophisticated and, eventually, may be used on their own to treat drinking water. Argonide Nanomaterials, an Orlando-based manufacturer of nanoparticles and nanofiltration products, has developed NanoCeram, which is capable of filtering 99.9 percent of viruses at water flow rates several hundred times greater than virus-rated ultra porous membranes. The product's performance is attributed to its nano-size alumina and a highly electropositive surface that attracts and retains sub-micron and nanosize particles more effectively than larger ones. Tests have revealed successful attraction and adhesion of pathogens and successful adsorption of viruses in the presence of salt and sewage-contaminated water.

Specifically, chlorine, ultraviolet light or ozone can kill or inactivate *E. coli*. Ion Physics Corp. of New Hampshire is developing a new process to destroy or deactivate microbes. The process is similar to the pulsed electric field (PEF) process but requires less energy at a lower cost because equipment is correspondingly smaller and less expensive. The developers believe this all-electric process will prove advantageous over chemical processes, as it produces no toxic or carcinogenic byproducts. Its small size, ability to treat quickly and robustness should surpass ozonation, UV treatment and chorination.

Due to the vast array of products, treatment operators make purchasing decisions based on highest effectiveness at lowest cost, making this a best value market. Decisions regarding treatment also are made on a system by system basis as size, location and source of water (groundwater or surface water) affect a treatment system's needs. Regulations governing water systems also force purchasers to choose technologies that meet standards, but cash-strapped utilities rarely will pay more for a technology that treats drinking water to lower than established EPA limits.

For those homeowners still concerned about *E. coli*, EPA suggests boiling drinking water before consumption. There are several products on the market today claiming to effectively remove *E. coli* and other contaminants from home drinking water, employing different types of filter technology. Some devices are NSF certified for reduction of bacteria including *E. coli*. However, certification currently is limited to Class A UV devices, said Tom Bruursema, general manager of the NSF Drinking Water Treatment Units Program. It also is understood that distillation devices can reduce bacteria, but there are none that are NSF certified today for a microbiological performance claim. NSF still is working on microbiological standards for other technologies (e.g., mechanical, ozone and halogen technologies).

The safety of the nation's drinking water continues to be a concern, and federal and state regulations as well as current and emerging technology promise to keep our drinking water virtually disease free. WQP

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