Recreation Management Tech Tips

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Personal Water Treatment Devices

by
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A hiker loosens his pack, kneels beside a babbling brook, and replenishes his canteen. Kids skip rocks across a stream before taking a drink at its inlet. A woman dismounts from her horse and leads it to a pool of clear, refreshing water.

Figure 1—Back-country rangers may spend several days in the field.

What all three scenarios have in common is that the participants are looking for clean, safe drinking water. There was a time when we could assume that water from rivers, creeks, brooks, and springs, especially in the back country, was safe to drink. That assumption is no longer true. Lakes and streams usually contain a variety of microorganisms, including bacteria, viruses, protozoa, fungi, and algae. Most of these occur naturally and have little impact on human health. Some microorganisms, however, can cause disease in humans (Frankenberger 2007).

For these reasons, obtaining adequate supplies of safe drinking water is a challenge for back-country rangers, trail crews, river rangers, and other employees who spend several days at a time in remote locations (figure 1). Not only is water difficult to find, but it is also heavy and bulky to carry. According to the U.S. Department of Agriculture Food and Nutrition Service, active people should drink 2 to 3 liters of water a day. Following this recommendation, back-country rangers need—on average for a 5-day outing—30 pounds of water; or, stated another way, a person would need 15 1-liter bottles of water for a 5-day stay in the back country (figure 2).

Figure 2—Water is bulky and heavy.

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An alternative to packing large quantities of water is to find a back-country water source. Springs, seeps, streams, rivers, ponds, or lakes all may be used for drinking water. However, water from these sources may contain protozoa, bacteria, or viruses, which can cause waterborne gastroenteritis (figure 3). Several different personal filtering and treatment devices are available commercially that can treat enough water for one or two people and protect them from waterborne pathogens, including the ones described below. This publication discusses these filters.

Figure 3—Beaver dam creates a water impoundment (Forest Service, Intermountain Region (R-4) Photo Library, Edward R.J. Primbs.)

Protozoa

Giardia lamblia (giardia) (figure 4) is a protozoan organism carried and transmitted by mammals, including deer, raccoons, foxes, coyotes, beavers, muskrats, rabbits, mice, and squirrels. It causes the gastroenteritis disease giardiasis, or beaver fever. According to the U.S. Food and Drug Administration (FDA), giardia is a frequent cause of nonbacterial diarrhea in North America. When giardia is outside a host, it forms a dormant cyst that can exist for several months in clear, cold mountain water. The giardia cyst has a thick, leather-like outer membrane that makes it resistant to disinfection. The giardia cyst can be filtered out of water or killed by boiling or ultraviolet disinfection.

Figure 4—Giardia trophozoite. Image courtesy of Centers for Disease Control and Prevention (CDC)/ Janice Car.

Cryptosporidium parvum is also a protozoan organism carried and transmitted by many mammals. The cryptosporidium cyst is smaller (figure 5) and harder to kill than the giardia cyst. The cryptosporidium cyst can be filtered out of the water, killed by boiling, or killed with ultraviolet disinfection. The disease cryptosporidiosis can last 1 to 2 weeks in people with healthy immune systems, and may be life threatening in people with compromised immune systems, such as chemotherapy patients, transplant patients, the elderly, or people with HIV/AIDS (Centers for Disease Control and Prevention [CDC]).

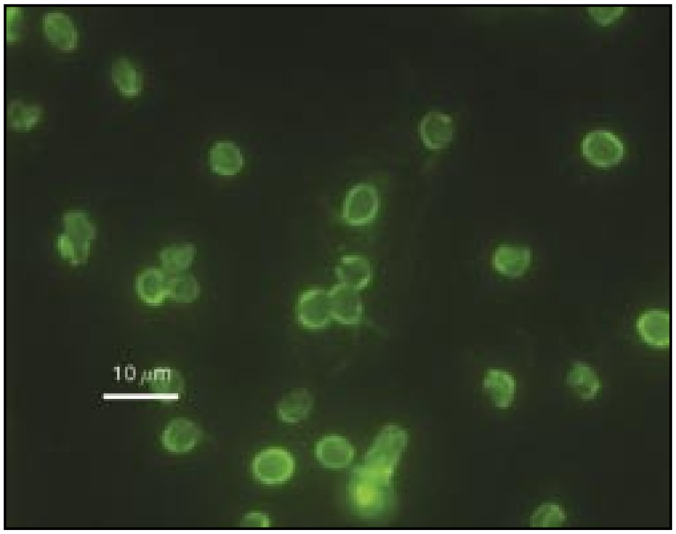

Figure 5—Cryptosporidium parvum oocysts. Image courtesy of H.D.A. Lindquist, U.S. Environmental Protection Agency.

Bacteria

Shigellosis (shi-ghel-O-sis) is an infectious disease caused by a group of bacteria known as Shigella. According to the CDC, shigellosis is one of the most contagious types of diarrhea caused by bacteria. It is a common cause of waterborne-disease outbreaks in the United States. Escherichia coli (figure 6), salmonella, campylobacter, and plesiomonas also can cause waterborne gastroenteritis. Bacteria may be filtered out of water or killed by boiling, ultraviolet light, or chemical disinfection.

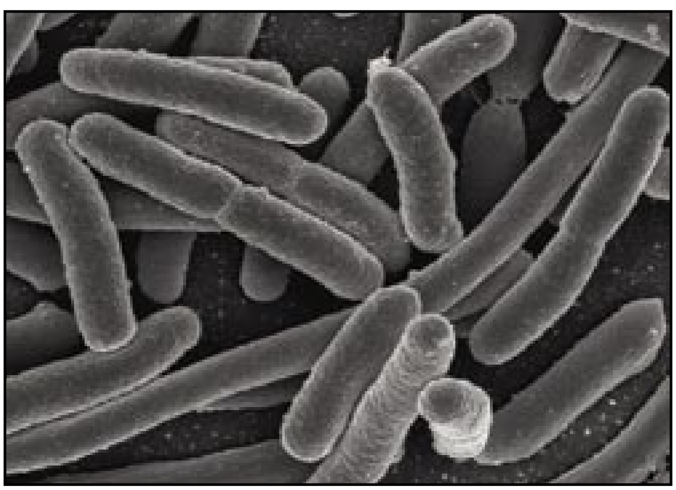

Figure 6—Scanning electron micrograph of Escherichia coli. (Photo courtesy of U.S. Department of Health and Human Services, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratories.)

Viruses

Norovirus (figure 7) is the leading cause of viral gastrointestinal illness in the United States, according to the CDC. It is transmitted by food, water, and person-to-person contact. Filtration alone does not remove viruses from water. Viruses may be killed by boiling, ultraviolet light, or chemical disinfection.

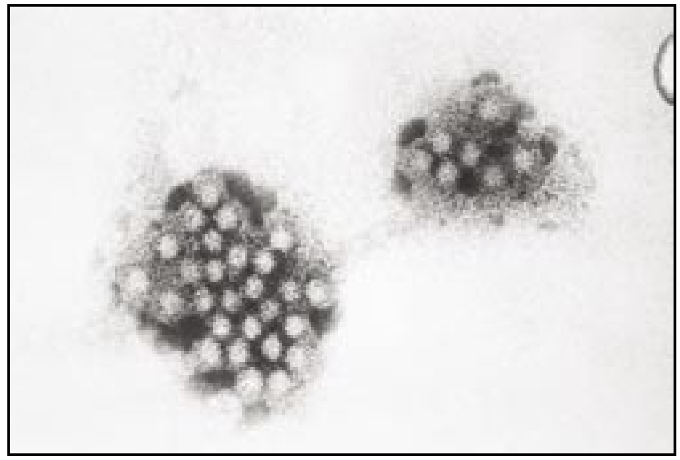

Figure 7—An electron micrograph of the norovirus (Image courtesy of CDC).

During the 2003–2004 surveillance year, the CDC confirmed 202 cases of gastrointestinal illness, including protozoan, bacterial, and viral illnesses, caused by ingesting lake or river water. The CDC suspects that the number of cases is much higher.

Preventing Waterborne Disease in the Back Country

According to the CDC, boiling is the most reliable way to ensure safe drinking water from an untreated source, such as a lake or stream. Boiling water as recommended will kill bacterial, parasitic, and viral causes of diarrhea. Boil water vigorously for 1 minute, or 3 minutes at elevations above 6,500 feet (2,000 meters). If boiling water is impractical, filtering and disinfecting is a safe alternative.

Several commercial personal water filters are available. When selecting a personal water filter, ensure that it has been tested to the EPA's "Guide Standard and Protocol for Testing Microbiological Water Purifiers" (The Standard).

In 1984, the EPA assembled a task force to develop The Standard as a general guide for determining the microbial removal/inactivation effectiveness of certain water treatment units on waters of unknown quality. The Standard requires removal/inactivation of giardia and (more recently) cryptosporidium cysts to 99.9 percent, Klebsiella terrigena (bacteria) to 99.9999 percent, and poliovirus and rotavirus to 99.99 percent in all required water conditions. NSF International (NSF) published The Standard as P231.

NSF does not currently test personal water treatment devices. Several universities and independent laboratories will test the devices to The Standard.

The Standard is incorporated into the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) protocol for personal filters, P248. NSF maintains P248 for the Army. In addition to The Standard for microbiological evaluation, P248 also looks at size, durability, weight, maintainability, and several other parameters of the device. USACHPPM also reviews the extent to which the devices are tested to The Standard, and continues to review and update its database of personal water treatment devices. Current information is available at: http://usachppm.apgea.army.mil/WPD/Updates.aspx

Treatment Devices

Cyst Reduction

A one-micron-absolute filter only meets The Standard for protozoa-cyst reduction. A cyst filter has larger pores and does not foul as fast as a microfilter, so it will filter more water. Protozoan cysts are resistant to disinfection. By removing protozoan cysts and other particulate matter from the water first, large quantities of water can be disinfected quickly.

Microfilters

A microfilter is a device that meets The Standard for both protozoa-cyst reduction and bacteria reduction. It does not remove viruses. A disinfectant must be used to kill any viruses present in the water.

Purification System

A purification system, or purifier, meets The Standard for cyst, bacteria, and virus reduction. Additional treatment is not required when using a purifier according to the manufacturer's directions.

For any treatment device, read the claim carefully. Some labels are misleading, such as one that states: "Removes: … viruses attached to … particles" (this does NOT meet The Standard for virus reduction). Follow the directions for the use, maintenance, and storage of the device. Some devices are to be drained and stored dry. Others are to be stored in the freezer to prevent bacterial growth on the filter.

Treatment Devices

The capacity of these treatment devices varies substantially, depending on the quality of water being treated. In side-by-side evaluations of these treatment devices, personal preference varied. Some people preferred the lever-action pump; some people preferred the vertical-plunger pump. Some people liked more sturdy construction; some people were more concerned with weight. As long as the treatment device is certified to meet The Standard and is used and cleaned according to the manufacturer's recommendations, any of these devices can prevent a waterborne illness.

Mountain Safety Research (MSR)

The MiniWorks™ Microfilter uses a ceramic filter with an activated-carbon core to reduce taste and odors. It is field-serviceable and has a sizing gauge for an "end-of-device useful life" indicator. It is not designed for virus reduction and should be used with a disinfectant. It weighs 16 ounces and costs about $85.

The WaterWorks® EX (figure 8) Microfilter is similar to the MiniWorks™ but has a second-stage filter for additional protection. It weighs 19 ounces and costs about $150.

Figure 8—MSRs WaterWorks® has a lever-action pump.

The SweetWater® Microfilter (figure 9) has a pump handle that folds down compact for carrying. It weighs 11 ounces and costs about $65.

Figure 9—MSRs SweetWater® Microfilter lever-action pump handle folds for compact carrying and storing.

The SweetWater® Purifier System consists of the SweetWater® Microfilter, chlorine solution, and 2-liter container for chlorine-contact time. This system received a high rating from USACHPPM. With the addition of the disinfectant, the system claims to be a purifier. It weighs 14 ounces and costs $80.

The MIOX® Purifier (figure 10) does not include a filter. It uses a chemical disinfectant to treat the water. To inactivate cryptosporidium requires eight times the normal dose and 4 hours contact time. When used with a cyst filter, it takes 15 minutes to inactivate bacteria and virus. It weighs 3.5 ounces and costs about $140.

Figure 10—The MIOX® Purifier converts salt into a disinfectant that can eliminate pathogens.

Katadyn
The Pocket Filter (figure 11) has a durable filter body with a lifetime warranty. It is field serviceable and has an end-of-life gauge. It is not effective against viruses and should be used with a disinfectant. It weighs 21 ounces and costs about $200.

Figure 11—The Pocket Filter has a plunger-type pump.

The Hiker Microfilter (figure 12) is compact and lightweight. It is not effective against viruses and should be used with a disinfectant. It does not have an end-of-life indicator or pressure-relief valve. The filter is not serviceable and must be replaced when clogged. It weighs 11 ounces and costs about $60.

Figure 12—The Hiker Microfilter is durable and lightweight.

The Guide Microfilter is not effective against viruses and should be used with a disinfectant. It does not have an end-of-life indicator or pressure-relief valve. The filter is not serviceable and must be replaced when clogged. It weighs 14 ounces and costs about $80.

The Mini Ceramic Filter is field serviceable and has an end-of-life gauge. It is not effective against viruses, and should be used with a disinfectant. It weighs 8 ounces and costs about $90.

General Ecology

The General Ecology First-Need Water Purifier (figure 13) does not use chemicals to achieve purifier status. It has a proprietary matrix-filter media that traps cysts, bacteria, and viruses. It is backwashable. When backwashing does not restore flow, the filter cartridge must be replaced. It weighs 15 ounces and costs about $85.

Figure 13—The General Ecology First-Need Water Purifier uses a chemical-free treatment to disinfect the water.

Disinfection

The EPA recommends the following chemical disinfectants for water of unknown quality. Only clear water should be used. Filter cloudy water before adding a chemical disinfectant.

- Chlorine—Use 8 drops of unscented 5.25-percent household bleach (figure 14) for each gallon of clean water (do not use scented, or nonchlorine bleach) and let stand 30 minutes. If the chlorine taste is too strong, pour the treated water between clean containers several times to lower the chlorine concentration. A carbon filter will remove the chlorine from the water, as will a few drops of liquid vitamin C. Chlorine is not effective against cryptosporidium.

- Tincture of iodine—Use 5 drops of 2-percent tincture of iodine for each quart of clean water and let stand 30 minutes. Iodine is not effective against cryptosporidium or giardia. A few drops of liquid vitamin C will remove the iodine taste from the water.

- Chlor-Floc tablets (for use with cloudy water)—contain flocculating agents (e.g., aluminum sulfate) to clarify the water and sodium dichloroisocyanurate, a form of chlorine, to provide disinfection. This device comes with 30 tablets, 1 plastic bag, and 3 filter pouches. Directions call for the user to fill the plastic bag with 1 liter of water, add 1 tablet, close the bag and shake until the tablet dissolves, then swirl the bag for 10 seconds. Let the bag sit for 4 minutes, swirl again for 10 seconds, then let the bag sit an additional 15 minutes. After 15 minutes, pour the water through one of the filter pouches and into a separate container (i.e., a canteen), taking care not to pour the sediment into the filter pouch. Rinse the sediment from the plastic bag and save the bag for future treatment.

Figure 14—Unscented household bleach.

Tablets of chlorine, iodine, vitamin C neutralizer, chlorine dioxide, and Chlor-Floc are available from sporting goods stores or drug stores. Follow the directions on the label.

Conclusion

Water is a basic necessity of life. Springs, seeps, streams, rivers, ponds, or lakes may all be used as a source for drinking water in the back country (figure15); however, some sources may not be safe to drink. Clean, safe water may be obtained from these sources by boiling. If boiling is not practical, the water may be treated by a device tested to The Standard or to USACHPPM P248. When a tested device is used, maintained, and stored according to the directions, it can provide water safe from microbial contamination.

Figure 15—Water may be available in the back country to treat for drinking.
Photo from the Intermountain Region (R-4) Photo Library, courtesy of the Bridger-Teton National Forest.

Reference

Frankenberger, J. (2007). E. Coli and Indiana Lakes and Streams [Online]. Available: http://www.ecn.purdue.edu/SafeWater/watershed/ecoli.html [2007, March 30].

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