Treating Water

Traveler Summary

Key Points

- Travelers cannot always be assured of the availability of safe water and must be prepared to treat water to make it safe.
- Disinfection removes or destroys germs (e.g., bacteria, viruses, parasites) and purification removes chemical pollutants and particulate matter.
- Boiling is a highly reliable single-step method of disinfection. Any water brought to a boil is considered adequately disinfected but continue to boil vigorously for 1 minute for a margin of safety.
- Chemical disinfection is an alternative to boiling but should be combined with filtration for optimal protection.
- Chlorine (household bleach) and iodine are equally effective against bacteria and viruses given adequate concentration and contact time (at least 30 minutes), but some waterborne parasites are poorly inactivated.
- Chlorine dioxide is as effective as chlorine and iodine against bacteria and is far superior for viruses and parasites; it requires a 4-hour contact time to be effective.
- Filters are not guaranteed to make drinking water safe but do provide an additional level of treatment when used with chemical disinfectants. A good quality microfilter (pore size 0.1-0.4 microns) will effectively remove bacteria and parasites, but not viruses. An ultrafilter (pore size 0.01 microns) will also remove viruses.
- Ultraviolet (UV) lights work best with clear water and kill bacteria, viruses, and parasites. Strain water through a fine cloth or coffee filter before using a UV light.

Introduction

Although the typical traveler going to the developing world can access safe purchased or prepared water, the availability of pure water cannot always be guaranteed. In this situation, travelers should be prepared to treat water by 1 or more of the methods described below; manufacturer's instructions should be followed as applicable. Disinfection is the process of removing or destroying harmful germs (bacteria, viruses, and protozoan parasites) through heat, chemicals, filtration, or UV light but does not remove chemical pollutants. Purification, sometimes used interchangeably with the term disinfection, is the process of removing chemical pollutants and particulate matter to make the water safe from chemical exposure and to improve color, taste, and odor, but it does not necessarily remove germs.

Table 1: Drinking Water Treatment Methods' Effectiveness for Different Germs

Germ	Heat/Boiling	Chemical Disinfection		Filtration	UV Light in Clear Water	Combined Filtration and Disinfection
		Chlorine or Iodine	Chlorine Dioxide			
Bacteria	++++	+++	+++	++	+++	++++
Viruses	++++	+++	+++	-	+++	+++
Parasites (e.g., ***Giardia***)	++++	+ to ++	+++	+++	+++	++++
Parasites (e.g., ***Cryptosporidium***)	++++	-	+ to ++	+++	+++	++++

- not effective; + low effectiveness; ++ moderate effectiveness; +++ high effectiveness; ++++ very high effectiveness

Heat/Boiling

High temperatures kill most germs quickly. Boiling is always a reliable single-step method for killing all common intestinal germs found in water without imparting additional taste or color; however, boiling does not improve taste, smell, or appearance of the water. Urban travelers may choose an immersion coil for boiling water (a plug adapter and current converter might be necessary). Any water brought to a boil is considered adequately disinfected but continued boiling for 1 minute (from the time the water begins to bubble) allows for a margin of safety. Although the boiling point decreases at higher altitudes, at common travel

elevations, the water temperature remains adequate to kill intestinal germs. Boiling does not prevent recontamination during storage.

Chemical Disinfection

If boiling water is not possible, chemical disinfection with chlorine compounds, chlorine dioxide, or iodine is an alternative. Many (but not all) intestinal germs are susceptible to chlorine and iodine, and given adequate concentrations and contact time (approximately 30 minutes at 25°C [77°F]; double contact time for each 10°C [10°F] less than 25°C), both have similar effectiveness against bacteria and viruses but some waterborne parasites are poorly inactivated. Chlorine dioxide is at least as effective as chlorine and iodine for killing bacteria and far superior for virus and parasite inactivation, but it requires a much longer contact time of up to 4 hours to be effective. Because not all parasites are inactivated with chemical disinfection, preceding it with filtration will provide optimal protection for all situations. Both chlorine and iodine impart a taste and odor to the water, but both can be easily removed; once the treated water has sat for at least 30 minutes, filter the water through activated charcoal or add a 25 mg tablet of vitamin C or 5 to 10 drops of 3% hydrogen peroxide per liter of treated water and shake briefly.

Chlorine

Chlorine (sodium hypochlorite), the active ingredient in household bleach, is the primary recommended disinfectant and the dose can be easily adjusted for larger volumes of water. Chlorine compounds (such as calcium hypochlorite and sodium dichloroisocyanurate) are also effective. However, chlorine's germicidal activity varies greatly with temperature and other factors and therefore is less reliable than iodine. Chlorine has no known toxicity at concentrations used for water disinfection. Chlorination prevents recontamination during storage and water can be stored long-term in a tightly sealed container.

Chlorine Dioxide

Unlike chlorine and iodine, chlorine dioxide (solution or tablet form) kills most waterborne germs, including resistant parasites, but requires a 4-hour treatment time. Chlorine dioxide is unstable and water undergoing treatment must be protected from sunlight. A lasting residual is not produced; therefore, it does not impart additional taste or color, but it also does not prevent recontamination during storage.

Iodine

Iodine (in solution or tablet form as tetraglycine hydroperiodide) can be used to disinfect water, leafy vegetables, and fruits. Iodine reacts less readily with organic compounds and is less affected by pH, making it more stable and persistent than equivalent concentrations of chlorine. Iodination prevents recontamination during storage and water can be stored long-term in a tightly sealed container. However, because of potential adverse effects on the thyroid, use of iodine should be limited to less than 1 month. Travelers who have thyroid problems (even if controlled on medications), strong family history of thyroid disease, iodine allergies, or who are pregnant should not use iodine for water disinfection.

In many countries, potassium permanganate (iodine containing) solutions (always purple in color) are readily available and can be used according to instructions to disinfect fruits and vegetables, but data are insufficient to recommend it for primary water disinfection in the field.

Table 2: Chemical Disinfection Doses

Disinfection Method	Amount to Add to 1 L (1 qt) of Water	Time to
2% Iodine solution	0.2 mL (5 drops)	30 min
10% Povidone-iodine solution	0.35 mL (8 drops)	30 min
Iodine tablets (e.g., tetragycline hydroperiodide)	1/2 tablet	30 min
Sodium hypochlorite (household bleach 5%)	1 drop	30 min
Chlorine dioxide	1 tablet	4 hrs (away from sunlight)

Filtration

Portable filters are not guaranteed to make drinking water safe but may improve the taste and appearance of the water; most authorities make no recommendation regarding their use due to lack of independent verification of efficacy. However, filters may be helpful (when used with chemical disinfection) in situations where boiling all drinking water is not practical. A good quality microfilter with an absolute pore size of 0.1 to 0.4 microns will effectively remove bacteria and parasites but may not adequately remove viruses, which is a major concern with high levels of fecal contamination; the water should then be chemically treated as well. Ultrafilters (absolute pore size of 0.01 microns) will effectively remove all germs, including viruses. Nanofilters (absolute pore size of 0.001 microns) will also remove chemicals. All filters require pressure to force water through the filter element; the smaller the pore size, the more pressure required. Filtration alone does not prevent recontamination during storage.

Filters rapidly clog if the source water is cloudy or contains large amounts of sediment. Filtration effectiveness can be improved by first removing suspended particles through the process of coagulation-flocculation (clumping of smaller particles into larger particles) with alum. Mix 1/8 tsp alum per 4 L (1 gal) water and stir or shake briskly for 1 minute, then agitate gently and frequently for 5 minutes. This process clumps the suspended particulates and allows them to settle after approximately 30 minutes, allowing for easy removal of the sediment by pouring the water through a fine cloth or coffee filter; repeat if the water is still cloudy. Flocculation removes most, but not all germs, so a second disinfection step is still necessary.

Ultraviolet Light

UV light can kill all waterborne bacteria, viruses, and parasites, but the water must be clear and free of particles to allow the UV light to reach all the organisms. Battery-operated, portable units that deliver UV doses are available and may be useful for disinfecting small quantities of clear water. Whether an adequate UV dose is being delivered is difficult to determine so extra doses can be used for added assurance with no adverse effects. UV light treatment does not improve taste, smell, or appearance of the water or prevent recontamination during storage.

Solar Disinfection

Solar disinfection (SODIS) may be used in austere emergency situations to disinfect relatively clear water. Place clean, clear plastic PET or glass bottles (up to 3 L [3 qt] volume) filled with water on a dark surface in the sun for at least 6 hours (2 days if cloudy) and agitate periodically. If unable to read large text through the bottle of water (looking at the bottom of the bottle through the neck at the top), flocculation or filtration should be performed before SODIS is used. Treated water should be kept in and either drunk directly from the bottle or poured into a cup immediately before drinking to prevent recontamination.

Other Products

Silver, hydrogen peroxide, and citrus juice are marketed in commercial products, but none have sufficient data to recommend them for primary water disinfection in the field.
