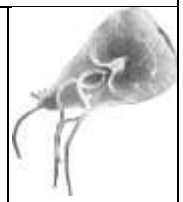
Water Treatment Methods

Harmful Microorganisms Where	Symptoms	Incubation	Notes
Protozoa			
Giardia lamblia (aka beaver fever) Worldwide	Diarrhea, abdominal cramps, bloating, fatigue, weight loss, flatulence, anorexia, and nausea, in various combinations. Fever and vomiting are uncommon	1 to 14 days (average of 7 days)	
Cryptosporidium (aka Crypto) Worldwide	Cryptosporidium enteritis: diarrhea, loose stool, cramps, upset stomach and often a slight fever. Folks with weakened immune systems are at risk of developing cryptosporidiosis, which can become chronic and can be fatal.	2 to 10 days (average 7 days) after becoming infected with the parasite	
Entamoeba histolytica (aka amebic dysentery, amebiasis) Worldwide	It causes a breakdown of the host's tissue and can lead to amebic colitis, liver abscesses, rupture of lungs, brain abscesses and death. The amebic colitis presents itself with fevers, weight loss, severe abdominal pain and bloody diarrhea.	2-4 weeks but ranges from a few days to years	
Bacteria			
Escherichia coli (E-Coli)	Worldwide, produces a powerful toxin and can cause severe illness and even death		0.2 and 10 microns
Campylobacter jejuni	Worldwide, Campylobacteriosis symptoms usually vanish within 5 days		
Brucella melitensis	Brucellosis (undulant fever)		
Leptospira icterohaemorrhagiae (spirochaetales)	Leptospirosis (Well's disease)		
Pasteurella tularensis	Tularemia		
Pseudomonas pseudomallei	Melioidosis		
Salmonella typhosa, S paratyphi, S. schottinulleri S. hirschfeldi C.	Typhoid Fever		
	Paratyphoid fever		
Shigella flexneri, Sh. dysenteriae, Sh. sonnei, Sh. paradysinteriae	Bacillary dysentery		
Vibrio comma, V. cholerae	Cholera		
Viruses	Viruses are extremely small (0.004 to 0.1 microns) and can cause a great many diseases. There are more than 140 enteric viruses known to infect humans waiting for you out there. These include hepatitis A, rotavirus, Norwalk virus and poliovirus. Worldwide	(0.004 to 0.1 microns) Short lifespan when exposed to UV light	
Chemicals and other toxins	Manmade chemicals, radioactive waste, heavy metals or other pollutants caused by man can be found downstream of farms (fertilizers, pesticides, herbicides), factories, mines or any populated areas. Radioactive waste in water can be found in some parts of the world and small amount can cause thyroid failure and other problems. Toxic bacteria can grow in shallow water and cause all sorts of potential problems		

Water Treatment Methods

Method and Types	Description
Filter and Purifier Types	***Filters able to filter out to 0.2 microns are preferred over those that can't
Hand Pump Filters Ceramic, Membrane, Fiber Fabrics, Osmosis, reverse osmosis?	Water filters that use a hand pump to force water through filters are the most common type of filter system for portable backpack filters. They may require a little priming, but are pretty simple to use. High quality units can be a bit bulky and surprisingly expensive Some units combine filtration with Iodine.
Gravity Filters (Siphon Filters) Playtapus Gravity System, MSR Autoflow Gravity	Gravity filters usually need to be hung from a tree or other appropriate high point so that the weight of water on top of the filter provides enough force to push water through it without the need for manual pumping. Siphon filters work in a similar manner, using the gravity to pull water through a filter from a higher point to a lower point. It may take a bit of time to filter a days worth of water in this manner, but requires little effort other than setup. These setups are better suited for base camp use where there is no hurry to filter water.
Bottle Filters	There are several products that incorporate a filter into a water bottle. They sound great in concept but generally are only capable of filtering out protozoa and large sediment at best. These are generally not suitable for filtering out bacteria or viruses
Sippy Filters (Survival Straw)	A few filters are set up so that you can suck water through a filter. These are ok for filtering small amounts of water. Many of these have large pored filters that allow you to suck water through them without injuring yourself, but are only effective against protozoa at best
Cloth or Coffee filter	Prefiltering with a cloth or coffee filter doesn't safely remove enough microorganisms on its own to justify use as a sole water treatment in itself, but does remove many of the larger particles in water. This removal of larger particles from water does have an impact on amount of microorganisms in water but it more importantly makes water more palatable and makes water easier to treat with chemicals or UV light and decreases the frequency of clogging of water filters

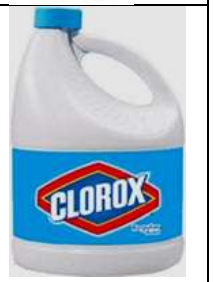
Hand Pump Filters	**Gravity Filters**	**Bottle Filters**	**Sippy Filters**	**Cloth or Coffee filter**

http://zenbackpacking.net/WaterFilterPurifierTreatment.htm

Water Treatment Methods

<table>
<tr><th colspan="4">Boiling and Pasteurization</th></tr>
<tr><td>Sterilization</td><td colspan="2">In order to sterilize water, and render all organisms ineffective, you will need to boil your water for a minute or so (varies between recommendations and altitude). Some recommendations include boiling water for 5, 10 or even 20 minutes to eliminate all bacterial spores that may be present in water. This unfortunately requires a significant amount of fuel, which can become a major consideration when in the outback (unless local wood, electricity, solar power or fuel sources are options). Heating water to this extent is also unnecessary, unless you need this water for surgery.</td><td rowspan="5"> </td></tr>
<tr><td>Pasteurization</td><td colspan="2">Luckily, not all of the organisms found in water are harmful when ingested. Significantly less heat is needed to inactivate harmful microbes than is necessary to bring water to a boil. Inactivation of these microbes actually starts as low as 5°C (9°F) but requires a significant amount of time to kill harmful pathogens. The consensus is that regular pasteurization requires heating of water to 65°C (149°F) for 5 minutes to kill 99.99% of harmful organisms, to include Giardia, cryptosporidium, endameba, the eggs of worms, cholera, enterotoxogenic strains of E. Coli, salmonella, causative organisms for typhoid, shigella, Hepatitis A, and rotavirus. This doesn't require as much fuel as sterilization, but requires a thermometer, heat gauge or test kit.
Safe and simple rule recommended by the WHO is to simply bring water to a rolling boil. This will heat it up sufficiently to kill any harmful microorganisms that may be present in your water and is an easy way to gauge whether or not your water was hot enough to be effective.</td></tr>
<tr><td></td><td>Microbe</td><td>Temerature</td></tr>
<tr><td></td><td>Worms, Protozoa cysts (Giardia, Cryptosporidium, Entamoeba)</td><td>55°C (131°F)</td></tr>
<tr><td></td><td>Bacteria (V. cholerae, E. coli, Shigella, Salmonella typhi), Rotavirus</td><td>60°C (140°F)</td></tr>
<tr><td></td><td>Hepatitis A virus</td><td>65°C (149°F)</td></tr>
<tr><td>UV Radiation SteriPEN
SteriPEN claims to be effective against bacteria, viruses and protozoa. They have multiple compact and portable units for backpacker use.</td><td colspan="2">UV radiation works by damaging the DNA in microorganisms. It has long been used in commercial and municipal water treatment and is sometimes used to sterilize operating rooms and surgical equipment. The susceptibility to UV radiation varies greatly between various pathogens and protozoan cysts tend to be very resistant to UV radiation.
Since this form of water treatment is dependent on the UV light penetrating the water, you may need to prefilter cloudy water. Other downsides of UV light purification devices include, expense, the need for batteries and the possibility of electronic failure. UV treatment also doesn't leave a chemical residual for continued protection.
Small portable units are available to backpackers and claim to be effective against protozoa such as Giardia and cryptosporidium as well as against bacteria and viruses.
Small portable units may need a good supply of batteries or rechargeable batteries and a charger (manual, solar, car or 110/220V) for longer travels. This can really add to the bulk, weight and complexity of this option of water treatment</td><td> </td></tr>
<tr><td colspan="4"></td></tr>
</table>

Water Treatment Methods

Chemicals		
Chlorine Dioxide via Sodium Chlorite and Phosphoric Acid Solutions AquaMira	AquaMira uses a stabilized 2 part liquid system for chlorine dioxide. Part A contains a 2% sodium chlorite solution and Part B contains 5% phosphoric acid solution. Seven drops of each are mixed and added to a quart (liter) of water. You will need wait several minutes for the two components to react prior to adding it to your water. This two part liquid form chlorine dioxide is EPA registered, which is different than being approved as a purifier	
Chlorine Dioxide in Stabilized Liquid Form	KlearWater has a 0.15% activated liquid chlorine dioxide in deionized water packaged in a portable glass bottle. The advantage of this system is that it doesn't require a mixing and a reaction time prior to adding it to your water. The solution itself can also be used as an antiseptic. One ml of fluid is used to treat one quart (liter) of clear water and a measuring system is built into the cap. This solution has an 8 month shelf life once opened and refrigerated and about half the self life is kept in a cool dark place. The color of the solution should be yellow when you first use this product, which indicates when it is active. When the yellow color is no longer noticeable, it's time for a new bottle or different treatment system.	
Bleach	Regular chlorine bleach (without additives, soaps, fragrances, etc) can be stored in a properly relabeled eye dropper bottle for easy packing and use. It is cheap, easy to find and makes a great contingency water purification option in times of natural disasters or when other disinfection options (such as boiling water) are not available. Unfortunately, chlorine is lost when bleach is agitated, which is more or less unavoidable for backpackers. Since it is difficult to determine how much chorine is left remaining after several days of trekking and transport, unused bleach should be replaced with fresh bleach when possible and practical. When using bleach, make a not of the concentration being used. Depending on brand and what part of the world you are in, concentration can range from 2-15% sodium hypochlorite. Simply use 2 drops of (6% sodium hypochlorite) per quart (liter) for clear water and 4 drops per quart (liter) for murky water	
Halazone tablets	These are relatively inexpensive ad have been used since World War II. These tablets require crushing and shaking to mix in your water. Once the tablets contact water, chlorine is release into it. Because of questions of efficacy, Halazone was pulled from the US market by its manufacturer. Earlier Halazone dosing recommended 2 tabs per quart (liter), but 6 tablets per quart (liter) and 1 hour of contact time is more likely needed to adequately treat water under most conditions. A dosing of 5 tablets per quart gives you a concentrations of 7.5mg/liter.	

Water Treatment Methods

Iodine

Iodine is a chemical treatment alternative to chlorine and is considered more reliable than chlorine for highly polluted water and what travelers may encounter. Compared to chlorine, it works faster, is effective over a wider range of pH, resists inactivation by organic matter and comes in several more stable preparations. It is also relatively easy to use and many prefer the iodine taste over chlorine taste.

Liquid Iodine

Iodine Preparations

Preparation	Strength	Amount/Quart (Liter)
Iodine Tincture	2%	8 drops
Lugol's Solution	5%	4 drops
LifeSystems Iodine Drops	12%	3 drops
Povidone-Iodine	10%	4 drops
Tetraglycine hydroperiodide	8 mg	1 tablet
Iodine Crystal/water solution	Saturated	13 ml
Titratable Iodine	1%	16 drops
Titratable Iodine	2%	8 drops
Titratable Iodine	3%	6 drops
Titratable Iodine	4-5%	4 drops
Titratable Iodine	6-7%	3drops
Titratable Iodine	8%	2drops
Titratable Iodine	16%	1drop

Tetraglycine hydroperiodide 16.7%
Globaline, Potable Aqua, Coghlans Drinking Water Tablets

This is the most commonly used form of iodine used for water purification. Add the recommended number of tables as necessary. Watch the shelf life of this product. If in the field, check the tablets appearance to determine if they are still effective. If the tablets are gray or dark brown in color, they are still likely to be effective. If they are light green or yellow, it means they are probably no longer effective. The tablets are very sensitive to moisture. Take care that moisture does not get inside the Potable Aqua bottle.

USP-grade resublimed Iodine Crystals

This system incorporates a bottle of poorly soluble iodine crystals and is one of the best systems for treating small amounts of water, since it is relatively effective and has an indefinite shelf life. This is probably the most reliable iodine treatment system available to backpackers and is widely used by mountaineers traveling abroad.

Glass is the only appropriate material for storing aqueous iodine solutions. The main disadvantage of this is the potential of a full bottle freezing an breaking. This can often be avoided by placing the bottle in your shirt, sleeping with it in your bag or only half filing it prior to nightfall.

The bottle is filled, shaken and left to stand for at least one hour. Once water is added to your crystals, the water quickly (up to an hour) becomes saturated with iodine. This saturated iodine solution is then added to your drinking water.

Because of the poisoning potential, this system should not be entrusted with children

Temperature of Solution	Capfuls per Quart (Liter)
95° F (35° C)	1.2
86° F (30° C)	1.3
77° F (25° C)	1.5
68° F (20° C)	2
59° F (15° C)	2.5
50° F (10° C)	3.5
41° F (5° C)	4

Mixed Oxidants MSR MIOX	Electrolysis is used to produce hypoclorite or mixed oxidants from water and salt. The mixed oxidants is a slurry of free chlorine, chlorine dioxide, and ozone and is often referred to under the company name MIOX. This mix is effective against bacteria and viruses as well as Giardia and cryptosporidium oocyst with appropriate dose levels and treatment times. MSR makes a portable MIOX system that requires table salt and small batteries. It is EPA approved as a purifier and claims to treat Giardia in 30 minutes and crypto in 4 hours. These times like the ones stated for chlorine dioxide are most likely very conservative and other testing shows a contact time of an hour as sufficient for cryptosporidium. This device may be economically ideal over chlorine dioxide tablets for treating large amounts of water or for long periods of time. Some testing suggests that using the overkill option (8x regular dose) and a 4 hour wait time is required to consistently treat for Crypto	

Water Treatment Methods

	Viruses	Bacteria	Protozoa	Particulate Matter	Notes
Water filtration (1 micron or less)	—	—	+++	+++	
Water filtration (0.2 micron or less)	—	+++	+++	+++	
Water Purifiers	++	+++	+++	+++	Not always effective against viruses
Boiling water	+++	+++	+++	—	
UV light	+++	+++	++	—	Effective against protozoa if given enough exposure to UV or if water is heated high enough to pasteurize
Chlorine Dioxide	+++	+++	+++	—	Slow acting against protozoa
MIOX	+++	+++	+++	—	Slow acting against protozoa
Chlorine	+++	+++	+	—	Not effective against Cryptosporidium
Iodine	+++	+++	++	—	Not effective against Cryptosporidium Not recommended for long term use

	Advantages	Disadvantages
Boiling water	Available worldwide	Requires fuel or power No residual protection
Chlorine Dioxide	Very compact Inexpensive for short term use Residual protection after treatment	Expensive if used a lot Long treatment time needed for cold murky water
MIOX	Inexpensive for long term use Residual protection after treatment	Expensive initial cost Long treatment time needed for cold murky water Anything electronic can fail
UV light	Simple to use	Expensive initial cost Requires Batteries Anything electronic can fail No residual protection
Water filtration (1 micron or less) and chlorine or iodine Or Water Purifiers	Filters out suspended mater and helps with taste/odor Residual protection after treatment	Bulky Effort required to pump or set up filter Chemical aftertaste Filters require periodic maintenance or replacement Many water purifiers don't work as well as advertised