# WATER DISINFECTION

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## PREAMBLE

Before we get into the good stuff, we'll start with the bad. There are 4 billion cases of diarrhea each year, and 2.5 million cases end in death, most among children under 5. This is equivalent to one child dying every 15 seconds or 20 747s crashing every day. Water purification is not something to be taken lightly.

## THE BAD STUFF IN WATER AND WHAT IT CAN DO TO YOU:

### A. GIARDIA LAMBLIA & CRYPTOSPORIDIUM

You can call them giardia and crypto. These two protozoa are the guys you hear about all the time. When found in water, both are *oocytes*, a dormant phase of some microbes where they take on a hard outer shell. Once ingested, they come to life and attach themselves to your intestine, causing diarrhea and other gastrointestinal problems.

Giardia is spread through contaminated feces. An interesting thing about this little guy is that it can vectored from other animals. So, if you're drinking water from a river where infected beaver lives, the river is thus contaminated. Symptoms of giardia infection (giardiasis) include loss of appetite, lethargy, fever, explosive diarrhea, loose or watery stool, stomach cramps, upset stomach, bloating, and flatulence.

With the flatulence comes a foul and sulphurous-tasting burp that I'm told is so nasty that it causes additional nausea and vomiting. Symptoms typically begin 1–2 weeks after infection and may wane and reappear cyclically. If gone untreated, symptoms may last 6 weeks. Common treatment is Flagyl, rehydration, and an occasional Imodium tablet. The good news is only about 40% of people infected actually exhibit symptoms. Recent archaeological data has shown that giardia was a leading cause of death among Crusaders at the Siege of Acre during the Third Crusade.

Cryptosporidiosis starts and ends faster. Symptoms begin 2-10 days after ingestion and last for about two weeks. Symptoms include watery diarrhea, cramps, and a low fever. The only available treatment at this time is supportive care with re-hydration and an occasional Imodium tablet. I know that some people are asymptomatic when they contract cryptosporidiosis, but I don't have any hard numbers on this.

Both of these little buggers exist in water sources EVERYWHERE. As I said, both are spread through contaminated feces, so wash your hands. One of the recent crypto outbreaks is believed to have started at a daycare center when an employee changed a diaper and didn't cleanup properly.

### B. BACTERIA

Common harmful bacteria include Salmonella, Campylobacter jejuni, and E. coli. In some parts of the world, water may contain bacteria that can cause cholera, dysentery, and typhoid. Some harmful bacteria is small enough that it will pass through a 0.2 micrometer filter. This is mostly a concern in undeveloped countries.

## C. VIRUSES (VIRII)

The most common viruses that live in water that I can think of are hepatitis A, norovirus, and rotavirus, though I'm sure there are many others. Most virii that humans can get from contaminated water will be vectored from other humans, so out-of-the way lakes and streams are statistically better places to find virus-free water.

## D. CHEMICAL CONTAMINANTS

Pesticides, fertilizers and other agricultural chemicals can contaminate water sources, and God knows what other stuff might be intentionally put in there. Chemicals can be difficult to remove, so if you suspect contamination you should find a different water source. An easy (but not all-encompassing) test is to check for life in the water source. If there are fish, frogs, and whatnot living in the water, chances are good it is free from chemical (and toxic metal) contamination.

## C. TOXIC METALS

Iron, manganese, aluminum, beryllium, chromium, lead, etc. These aren't so much an immediate health concern as a long term one. Generally the water will look and smell funny if there is a seriously toxic dose of metal in it. For example, when Quantico Creek was contaminated with sulfur and iron in the mid-90s, you could smell a hint of rotten eggs from a mile away.

## D. ALGAE, FUNGI, PARTICULATE MATTER AND OTHER NASTIES

These can impart an odd or foul taste to your water or cause other health issues. Another problem with particulate matter is that it impedes chemical purification.

# Alright, now on to the good stuff…

Methods of filtering, purifying, disinfecting or decontaminating your drinking water:

## A. HEAT

Heat kills microorganisms, and virtually all enteropathogens are readily killed at temperatures well below the boiling point. The process of heating water to a boil makes it hot enough long enough to disinfect it, even at higher elevations. There is no need to boil water for 5, 10, 20 minutes as some say. Bringing water to a good rolling boil is adequate for disinfection.

One caveat, at extreme altitude (20,000 feet plus), it is advisable to allow the water to boil for a few minutes due to the low boiling temperature at that pressure. The boiling temperature at extreme altitude, even up to the vertical limit, is still hot enough to kill virtually all enteropathogens. The issue is whether the water has been hot enough, long enough, to kill the bugs.

If, for some reason you do not have sufficient heat to boil water, keeping it at a temperature of 160° F for 30 minutes will kill just about everything. Heat only kills living things, thus chemicals and all that stuff will still be there.

## B. IODINE

Iodine has been used for almost a century to disinfect drinking water, and many of the expensive store bought disinfection products are just iodine in tablet form. Iodine will kill or inactivate virii, bacteria, and most protozoa. It is considered "OK" at killing giardia and somewhat ineffective at killing crypto, due to their hard shells. Iodine comes in many different forms, and disinfection is temperature dependent, so I'll give you some guidelines.

**Preparation/Iodine Concentration/Amount per liter:**

Iodine Topical Solution/ 2% / 8 drops
Iodine Tincture / 2% / 8 drops
Lugol's Solution / 5% / 4 drops
Povidone-Iodine (Betadine®) / 10% / 4 drops
Tetraglycine hydroperiodide (Globaline, Portable Aqua, EDWGT) / 8mg / 1 tablet

**If your water is clear, use these disinfection times:**

60F/15C or higher: 15 minutes
40F/5C: 30 minutes

If the water is cloudy, double the time.

**If you're using a solution that isn't listed above**, the concentration you're looking for is 8mg of iodine per liter of water.

In general, if you are in a hurry double the chemical dose and halve the contact time; if you want better flavor halve the dose and double the contact time.

If you pass your water through a 0.4 µm filter or smaller, you can use an iodine concentration of 1mg per liter of water to kill any remaining virii or small bacteria. This equals 1 drop for most liquid formulations.

Povidone is a binding solution that allows higher concentrations of iodine in water. Although the overall concentration of Betadine is 10% per bottle, the Povidone content makes it difficult to gauge the concentration per drop. That's why you add the same number of drops for a bottle of 10% Povidone-Iodine as you do for a 5% bottle of Lugol's.

If you have an iodine prep-pad in your first aid kit, cut the pad in half and drop it in the water and follow normal disinfection times. A whole prep-pad will create a good solution for wound cleaning.

Ascorbic acid neutralizes iodine. If you wish, add flavoring to your water after the required contact time. In the absence of flavoring, a vitamin C tablet can be a good substitute. Iodine should not be used by persons with an allergy to iodine, persons with active thyroid disease, or pregnant women.

## C. HOUSEHOLD BLEACH

Chlorine bleach contains about 5 or 6 percent sodium hypochlorate. It is effective in killing most microbes, EXCEPT crypto. The calculated solution is much easier than iodine. 3 drops per liter at normal temperature, clear water, 30 minutes contact time. 5 drops per liter if cloudy or cold, 60 minutes contact time. There should be a slight hint of a chlorine smell. If there isn't, treat again.

The use of chlorine bleach to disinfect water is very dependent on the pH of the water. Water that has not been filtered may have organic particles that will absorb chlorine, either nullifying its ability to disinfect or releasing it very slowly. Without a chemical test kit, the only viable way to make sure the chlorine hasn't been absorbed is to add it until you can smell it. Of course, don't use household bleach that has fragrance, soap, or other additives.

## D. CHLORINE DIOXIDE (ALSO CALLED STABILIZED OXYGEN)

Commercially available with MSR's Miox purifier, AquaMira tablets, and Katadyn Micropur M**P**-1 tablets. I don't know of any other commercial preparations. Effective at killing microbes including giardia and crypto. Follow the manufacturer's instructions.

The Micropur M**P**-1 tablets available in the US are chlorine dioxide based, the M**T**-1 or "classic" tablets available abroad contain silver nitrate; actually a combination of ClO2 and silver salts. Using silver is a disinfection method I may discuss at a later time.

## E. UV LIGHT AND OXYGENATION (SODIS METHOD AND STERI-PEN)

Giardia and crypto, as well as several other microbial nasties, have been shown to be somewhat sensitive to UV light. The process is simple, but only works with clear water. If the water is cloudy, it must be filtered until clear. The SODIS method uses a combination of UV-A/UV-C exposure and heat to disinfect.

Place water in a clear plastic or glass bottle (label removed), cap, and shake for 1 minute. Remove cap and place in on sheet of corrugated iron or on a rooftop in direct sunlight for 6 hours on a clear or up to 50% cloudy day. Greater than 50% cloudiness requires 2 full days of exposure. Precipitation diffuses UV light, so no disinfection will take place if it's raining. In very hot areas, if the water temp rises to 120F, only 1 hour in the sun is needed.

A few notes on the bottles. PET (Polyethylene Terephthalate) diffuses UV-A light less than PVC, so PET is preferred. To tell the difference, PVC bottles usually have a bluish gleam. If burnt, PVC smells strongly like smoke, while PET smells sweet. Also, since water diffuses UV, bottles greater than 5 inches in diameter should not be used. Most 12oz soda bottles should be fine. Also, the due to ambient temperatures, this process is best viable if you're located between 35N and 35S latitudes.

The Steri-Pen produces UV-C light to deactivate giardia, and crypto. Your water container must not be larger than one liter and it must be wide-mouth. CamelBak bladders and reused soda bottles will not work. You dip the Steri-Pen in your water, activate and stir for two minutes. The stirring oxygenates the water and moves the contents close enough to the lamp for the UV to kill any nasties. As with the SODIS method, the water must have very low turbidity or it will diffuse the UV and fail to disinfect.

## F. FILTRATION

This is not going to be an all-encompassing study on various filtration methods. We're going to stick to compact pump systems and improvised filtration systems.

Backpacking style pump systems vary across the board. Most will remove protozoa (giardia and crypto, specifically), bacteria, particulate matter and have SOME effect on the levels of toxic metals and chemicals. Pump filters have no effect on virii, the little buggers are MUCH smaller than the filter material. Most manufacturers have good info on their websites regarding what their filters will, will not, and might do. No manufacturer claims 100% reliability. You want a filter that has an *absolute* pore size of 0.4 µm (micrometer) or smaller. Some manufacturers claim smaller pore sizes although it is only an average.

All filters will eventually clog, and will clog more frequently if you're filtering cloudy water. To avoid this, wrap the source hose with a coffee filter or a bandana. This will pre-filter the large particulate matter which causes major clogs.

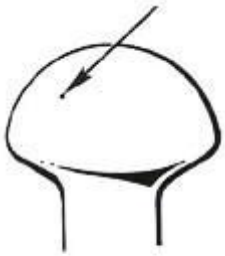
To make somewhat of an improvised filter, you can punch holes in the bottom of a coffee can, line it with a coffee filter, and then place layers of sand, crushed charcoal, sheets of paper, and more coffee filters. Use your imagination. This is not a

substitute for a real filter, but in many cases something is better than nothing. If you're using just a chemical treatment option, you can cover your container with a bandana or coffee filter to reduce cloudiness. It doesn't seem like it would work, but simple cloth filters have been used in India to noticeably reduce Vibrio cholera, the bacteria that causes cholera. As I said before, something is better than nothing.

For reference, here are some size examples of stuff you might find in your water:

| | |
|---|---|
| Filter pore size: | 0.2-0.3 µm |
| Giardia cyst: | 6.0 µm |
| Crypto cyst: | 4.0 µm |
| Bacteria: | 1.5-3.0 µm |
| Viruses: | 0.004-0.03 µm |

**µm** = **micrometer** = 1 *millionth* of a meter



A Micron-Size Dust Particle on a Pin Head

Some more expensive filters come with an iodine element to kill microorganisms that make it through the filter, and then a charcoal filter to remove the iodine. ***DO NOT WASTE YOUR MONEY***. Temperature variations in the water combined with the short contact time with the iodine element make it unreliable at killing nasties. Also, none of these systems have an indicator to notify you when the iodine has expired.

## G. POTASSIUM PERMANGANATE

Potassium Permanganate (herein referred to as KMnO4) has a lot of mixed data associated with water purification. There is not a lot of hard, modern scientific data readily available to me because it has not been used to treat water in developed countries for some time, partly due to its high cost, relative weakness compared to other chemical alternatives, and the fact that it turns treated water pink. It can be found at chemistry shops and some pool supply stores. Shipping will incur a HAZMAT fee.

KMnO4 takes the form of deep purple crystals. The treatment method is to add individual crystals until the water turns a light pink color, and let stand for a 30 minute contact time. It should not require more than 3-4 crystals per liter. This formulation has been proven effective against bacteria and virii, but after several weeks of checking at the library and the web, I can find ZERO studies or even slight mention of its effectiveness on protozoa.

Adding 6-10 crystals to one liter of water (or until the water turns purple) will create a combination wound disinfectant, hand sanitizer, and a soak treatment for canker sores, dermatitis, pompholyx, and fungal infections. At this concentration the water will also make a good dye for snow or water to create a survival signal. It is not advisable to drink this solution.

## That all sounds pretty scary, huh? *Well it's actually not.*

If you're out in the woods and you come across a stream, you have a halfway decent chance of not drinking anything nasty. On top of that, you have the chance that your immune system will take care of any nasties that you ingest. On top of THAT, following the 72hr rescue theory, you have a VERY GOOD chance of being rescued and under the care of a physician before any symptoms occur. So if you *need* to drink, drink. As a survival instructor once said, "I don't wanna hear about any of my students dying next to a stream because they didn't have any iodine." Or something like that.