Water Treatment for Backpacking and Camping in Upstate NY (March 2017)

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This material is based on a number of resources, especially books such as "NOLS Wilderness First Aid" and similar publications. I am not a medical scientist, but have read a number of primary research papers on this topic, including laboratory reviews on effectiveness of various methods of killing microbes and some of those data are attached. Some of the relevant data and tables are attached to the end of this handout. I feel these have real value and add reality and validity to the discussion of water treatment. As scout leaders, our main charge is health and safety of our groups, and understanding water treatment is a key part of this. When backpacking, it is mandatory to collect and use "wild water"…you cannot carry all the water you need. Understanding the methods, pros and cons, costs, and techniques for each method are important.

Introduction to Water

Why is water needed?

Water is essential for all life. Humans are about 68% water. Water is required for all metabolic activity.

Water is needed for three reasons:

- To replace sweat (direct water loss)
- To replace water loss from urination, defecation and especially diarrhea (if ill)
- To replace water loss from breathing and skin respiration

!!! We need to drink lots of fluid (mainly water) when hiking, backpacking, doing snow sports, etc. !!!

What quantity of water does a scout need to drink?

- Old but good rule: "8 by 8": Eight, 8 oz. cups of water per day (about 2 liters or quarts). Significantly more is needed due to strenuous activity (see below)

Symptoms of inadequate hydration?

- Headache, irritability, lethargy, thirst (onset of heat exhaustion)
- Dark urine (normally, urine should be clear and colorless if well hydrated) (onset of heat exhaustion)
- Lack of sweat (heatstroke: this is a dangerous condition!) and indicates a fundamental failure of the group in monitoring its members!!

How to maintain hydration?

- Drink lots of water! During hikes or backpacking, drinking at least 1-2 cups of water per hour is probably OK, but can vary per person. Encourage drinking! At every break in the hike, everyone drinks. Actively ask scouts if they are drinking, and get them to ask each other. This builds good expedition behavior. Bottom line: Confirm they are drinking!

- Many people use Camelbacks or similar (hydration bladders), and are great for convenience, but they do make it more difficult to really monitor consumption since you can't actually see the reservoir. Other people just use a Nalgene or other plastic bottle. Try both, and do what is best for you.
- Drink before the hike, during the hike, and at the end of the day.
- A good policy: When you pull into camp, everyone stops, takes off their packs and drinks ½ liter of water before doing anything else. This is a nice transition and decompression from the trail to camp chores such as setting up tents, thinking about food, fire, stoves, etc.
- Hyponatremia. A lowering of sodium levels in the blood as a result of consuming *too much* water. "Any activity or situation that promotes heavy sweating can lead to water intoxication when water is consumed to replace lost fluids. Persons working in extreme heat and/or humidity for long periods must take care to drink and eat in ways that help to maintain electrolyte balance". (http://en.wikipedia.org/wiki/Water_intoxication). Probably this is extremely rare in scouting, but it is worth noting. Normal munching on trail snacks is the main way to combat this.

Are "sports drinks" necessary?

- Assuming the group is eating normal quantities of "normal food", there is no inherent need for sports drinks *per se*. But they don't hurt. Enough salts and sugars are generally replaced from trail snacks if consumed at regular intervals during a backpacking trip or hike. (Regular intervals = very frequent light snacking!) Bottom line: Use or don't use sports drinks or powders at your troop's prerogative.

Treating Upstate NY Water

What causes water to be "impure" or unsafe to drink?

- Biological contaminants (microbes, viruses, eggs or parasites), including *Giardia, Cryptosporidium*, etc.
- Where does it come from? Barnyard/pack animal runoff, dead animals upstream, normal wildlife activity (defecation, urination) in/around the water, or, most depressingly, *humans* urinating or defecating too close to the water source.
- Chemical contaminants (gas or diesel, oils, pesticides, etc.)
- What causes water to be less *desirable* to drink? Things like tannins, etc.

Is it necessary to treat back-country or "wild" water before drinking it?

- Yes! And, no. Artesian springs, for example are likely free of biological contamination. And…

Dr. Thomas Welch from Syracuse University has written in *Wilderness and Environmental Medicine* (15:235-237, 2004):

> "…we need to realize that, despite unsubstantiated anecdote to the contrary, there is no good epidemiologic evidence that North American wilderness waters are inherently unsafe for consumption. In bringing this concept forward at meetings of wilderness

educators, a common comment is for the need to ‘‘prove’’ that universal treatment of wilderness water is unnecessary. This creates a dilemma for evidence-based practitioners, because existing practice is apparently based upon absent or inappropriately interpreted data.

It might well be argued that it ‘‘couldn’t hurt,’’ even if universal water treatment were unnecessary. This attitude, unfortunately, overlooks a major issue in wilderness education and human nature. The public’s attention span for health advice is not limitless. **If our objective is to protect the backcountry user from enteric infection, then we should emphasize the overwhelming evidence showing that assiduous hand-washing or using alcohol- based hand cleansers is by far the most important strategy**. It must be impressed upon backpackers (just as it is impressed upon health care, food industry, and day-care workers) that **stopping hand-to-mouth spread is the key to preventing gastrointestinal infection.** Diluting this message with unfounded concerns about wilderness water quality or the relative merits of various water-treatment methods serves no useful purpose.”

Bottom line: On camping trips, we are *more likely* to spread more stomach flus, diarrhea, and other intentional maladies by *lack of hand washing and overall cleanline*s than by drinking bad water *per se*. So, first, *a scout should be clean.* Having said this, does Troop 4 treat all wild water on our hikes and campouts? Absolutely – health and safety is paramount! Therefore,

!! Assume all wild water needs purification before consumption !!

Obtaining water in New York hiking/camping areas

The most pleasant place to collect water is from a clear running stream. The worst place might be a puddle in a logging road with a dead squirrel in it or below an active wildlife run. There are many in-between. If needed, move a few strategic rocks to make a deeper area to access water without mud, debris, etc. I find a “dipping cup” (small plastic cup or Sierra cup) is handy to get water from small flows where a plastic bottle can’t fit. Sometimes, you need to dip water out and fill into a larger container such as a Nalgene, pot, or other reservoir.

Regardless of collection, how do you purify water, or how do you make backcountry water safe to consume? There are at least 5 main methods:

1. **Heat**
   - Bring water to a full boil. As soon as it boils, it is safe to drink (once cool). You DO NOT need to boil it for 3, 5, or 10 minutes as often stated. Just bring to a full boil and stop. Most diarrhea-causing organisms are killed instantly by boiling water. *Giardia* and *Amoeba* die after 2 or 3 minutes at only 140F. Viruses, bacteria and *Cryptosporidium* cysts are killed with a few minutes of 150F water. So, BY THE TIME IT BOILS IT IS SAFE! (see Table 2).
   - But what about high elevation? Adirondacks, Everest, etc.? Not a problem! For example, at 19,000 feet, the temperature of boiling water is 178F. Lower than 212F, but still easily high enough. Regardless of where you are: Just bring to a boil…no need to boil any longer.

- Why all the above fuss about boiling it too long? Nothing, other than you are wasting resources, and this can be important if you are carrying the weight of the fuel (e.g. in a backpacking situation). There is nothing hurt by longer boiling, it is just not necessary…and probably tends to prolong the myth that water needs to be boiled "a lot" to make it safe.
- Boiling does not remove chemicals, nonvolatile organic molecules, etc.

2. Chemicals, generally the halogens (iodine, chlorine, chlorine dioxide)

Halogenation of water is a long-standing method, and generally very reliable against most biological hazards. Chlorine dioxide has an advantage in that it is effective against *Giardia* cysts (iodine and chlorine are not). The commercial products are robust, work well, are safe and reliable. Effectiveness is reduced by cloudy, dirty water with a high organic load. Thus, pre-filtering (neckerchief, bandana, shirt, etc.) is best for dirty and cloudy waters. Commercial products may come as tablets, liquid (a single liquid or 2 parts mixed together). Plain, simple Clorox bleach may also be used and is the cheapest agent available. With halogens, water is *NOT* available for immediate consumption…generally you must wait 30-60 minutes ("kill time") after treatment depending on temperature and type of water. Colder water requires a longer contact time (Table 4). Simple techniques to avoid contamination with "dirty" water (such as "bleeding the threads") are important to maintain safe water.

The products have distinct shelf lives, check the label carefully. For example, Potable Aqua recommends using within 1 year of opening. Chlorine and iodine are very lightweight vs. pumps or UV pens.

- Iodine. You can mask the iodine flavor with vitamin C, but *only* after waiting for the required kill time!
    - Tablets. Potable Aqua (tetraglycine hydroperiodide; 2 tablets/liter).
    - Solutions. Various recipes (see tables)
- Chlorine. Many think it tastes better than iodine.
    - Clorox bleach
        - Use 2-4 drops bleach per liter (yields 5 or 10 ppm, see Table 6), bleed threads and wait 30 minutes. Be sure it is regular, plain bleach without fragrances, soaps, etc. This is by far the simplest and cheapest treatment option available. The EPA recommends 8 drops bleach per gallon (2 drops per liter), let stand 30 min. Keep this one in mind when the zombie apocalypse starts. Clorox does lose effectiveness over time, so if this is in your emergency kit, develop a regular rotation of product.
    - Chlorine dioxide. Effective against *Cryprosporidium* (but, it takes 4 hours!)
        - Aqua-Mira. A 2-part liquid. Basic recipe is to use 7 drops each, wait 5 minutes (it turns yellow and smells of chlorine). After 5 minutes, add to 1 liter of water, then *wait 30 minutes* under normal temperatures and with clear water sources. Use higher doses if needed (dirty water, cold water) and wait longer. Aqua-Mira water tastes just like normal chlorinated tap water. About $15 for enough to treat about 30 gallons of water, comes to 12-15 cents per liter. This is the most cost effective of the chlorine dioxide products, but is less handy to use for larger groups unless you have a larger

water container and can treat 4-10 liters of water at one time) (inefficient to wait 5 min x 10 one-liter nalgenes!)
        - Katadyn Micropur Chlorine dioxide tablets (ca. $13/30 tablets; 1 tab/liter about 45 cents per liter). Philmont issues Micropur tablets as the main treatment option although crews are requested to have at least one alternative (pump, gravity filter, etc.). Very easy to use…add to a Nalgene of water and watch it fizz and break down. See information below. After a few minutes, bleed the threads and wait 30 min. Micropur water tastes just like chlorinated tap water.
        - Potable Aqua chlorine dioxide [ca. $13/30 liters])
    - MIOX "pen". Generates "chlorine oxidants" via a battery and salt solution. This product has gone off the market. Does the same as bleach, but much more $$$.

3. Ceramic filters or "pumps"

Water "pumps" have a direct filtration technology (based on a ceramic cartridge) that physically removes particulate and most biological contaminants (but, *not* viruses...they are too small). Filters with activated charcoal components can remove any chemical contaminants and generally improve the taste of the water. Not recommended in the winter, as freezing will ruin the equipment. Care in operation and maintenance is essential. For the MSR Mini-works EX (one popular model, 0.2 micron filtration) the fastest you'll get water is about 1 liter per 2 minutes of pumping (about 100-125 pumps/liter) which is really not bad. All pumps can clog depending on the water, however, and this dramatically lessens flow rate. So, for long trips (many days) be sure to get one that is "field cleanable" and *clearly understand how to do this safely (without contamination) before you head out.*

- Several brands are available, MSR, Katadyn, etc.
- Ca. $80-100 and about 1 lb. Replacement cartridges in the $40 range.
- The water can taste really great. Safe to drink immediately after pumping.

4. Hollow fiber membrane filtration/gravity based filters, in line "straws" etc.

- Newer introduction to the market: Platypus, MSR, Sawyer, Katydyn, etc. This is an adaptation of waste water treatment technologies, reverse osmosis, etc. Essentially, just 3-4 feet of gravity provides enough force to pull water through the filtration membrane, leaving contaminants behind. Clear water is the result. Simple and easy! It is important clearly understand the use and maintenance of these products. My experience is that these are great technologies.
- The Platypus unit ("Gravity Works") makes 4 liters of water in just a few minutes without pumping. There is an optional in-line carbon filter to improve taste and help reduce chemical contamination. I have modified mine to include an in-line fuel filter to further reduce solids getting to the main filter. There are other similar products on the market.
- Great for larger groups, crews, etc. Much faster and easier than pumping.
- $90-100 for the apparatus, replacement filters ca. $50
- Filters last for 1000+ liters of water. So, about 5 cents/liter.
- Sawyer and others offer a number of in-line "straws" or "squeeze filters" that seem very good on a smaller scale (I do not own one, however). The idea is that dirty water can go in the water bottle or bladder, and the filter is used in-line, so water if filtered as you drink.

Also, as a squeeze-expulsion system…fill a flexible container and squeeze out clean water.

5. Ultraviolet light

- Becoming more popular, good for individuals and small groups and when small quantities of water are needed.
- Fast, easy, effective against organisms, cysts, eggs, viruses
- Much less effective in cloudy and dirty water
- Treats 1 liter in 90 seconds. *Water is safe to drink immediately*.
- Be careful to not contaminate threads on bottles with dirty water. Treated water has no residual "sanitizing potential", so avoiding thread contamination is important. Some have pre-filters that attach to Nalgene bottles that help keep the bottle threads from being contaminated with the dirty water.
- Consider replacement batteries, weight of the equipment (about 1 lb.), etc. A need for batteries for an essential technology when backpacking raises a red flag for me, thus I would not rely on this as the sole treatment method.
- Ca. $70-90. SteriPen and similar brands.
- Some reviews complain of difficult of inconsistent operation. I would definitely say this is a technology that takes more finesse and thought than working a pump, hanging a gravity filter or dropping a chlorine pill into a bottle of water, and as such should be considered an "advanced" technique…and perhaps not the best choice for a multi-day trek with 8-12 people. I have traveled with my Steripen to China, Turkey, Costa Rica and France and it has performed excellently.

Tables below from: Backer, H. 2002. Water disinfestation for international and wilderness travelers. Clinical Infectious Diseases 34:355-364.

Table 2. Temperature and time required for heat inactivation of microorganisms.

Organism	Lethal temperature and time	Reference
Giardia species	55°C[a] for 5 min	[26]
	50°C for 10 min (95% inactivation)	[27]
	60°C for 10 min (98% inactivation)	
	70°C for 10 min (100% inactivation)	
Cryptosporidium species	64°C within 2 min	[28]
	72°C heated up over 1 min	
E. coli, and *Salmonella*, *Shigella*, and *Campylobacter* species	65°C[b] for 3 min	[29]
Vibrio cholerae	60°C for 10 min	[30]
	100°C for 10 s	
E. coli	60°C for 5 min	[31]
	70°C for 1 min	
Enteric viruses	56°C–60°C for 20–40 min	[32, 33]
	<1 min at ≥70°C[c]	[34]
Hepatitis A virus	98°C for 1 min	[35]
	85°C for 1 min	[11]

NOTE. *E. coli*, *Escherichia coli*.

[a] 131°F.
[b] 149°F.
[c] ≥158°F.

Table 3. Susceptibility of microorganisms to filtration, by size.

Organism	Approximate size, μm	Maximum recommended filter rating, μm
Virus	0.03	NA*
Escherichia coli	0.5 × 3–8	0.2–0.4
Campylobacter species	0.2–0.4 × 1.5–3.5	0.2–0.4
Vibrio cholerae	0.5 × 1.5–3.0	0.2–0.4
Cryptosporidium oocyst	2–6	1
Giardia cyst	6–10 × 8–15	3–5
Entamoeba histolytica cyst	5–30	3–5
Nematode egg	30–40 × 50–80	20
Schistosome cercariae	50 × 100	Coffee filter or fine cloth
Dracunculus larvae	20 × 500	Coffee filter or fine cloth

* Not applicable to most portable filters, only reverse-osmosis membranes exclude viruses by virtue of pore size.

Table 4. Recommended contact time for specified halogen concentration, according to water temperature.

Halogen concentration	Contact time, min		
	At 5°C	At 15°C	At 25°C
2 ppm	240	180	60
4 ppm	180	60	45
8 ppm	60	30	15

NOTE. Contact times are extended from the usual recommendations to account for (1) uncertainty about the presence of residual halogen and (2) the time required to kill *Giardia* cysts in very cold water.

Table 5. Halogen disinfection data from 11 studies.

Halogen type, organism	Concentration, mg/L[a]	Time, min	Temperature, °C	Disinfection constant, Ct	Reference
Chlorine					
Escherichia coli	0.1	0.16	5	0.016	[46]
Campylobacter species	0.3	0.5	25	0.15	[51]
20 enteric viruses	0.5	60	2	30	[52]
Hepatitis A virus	0.5	5	5	2.5[b]	[53]
Entamoeba histolytica cysts	3.5	10	25	35	[54]
Giardia cyst	2.5	60	5	150	[55]
Cryptosporidium oocyst	10	720	20	1440	[56]
Schistosome cercariae	1.0	30	28	30	[57]
Iodine					
E. coli	1.3	1	2–5	1.3	[23]
E. histolytica cyst	3.5	10	25	35	[54]
	6.0	5	25	30	[54]
Poliovirus 1	1.25	39	25	49	[58]
Coxsackie virus	0.5	30	5	15	[58]
Giardia cyst	4	15	30	60[c]	[59]
	4	120	5	480[c]	[59]

NOTE. Most experiments use a 2–3-log (99%–99.9%) reduction as the end point.

[a] Residual concentration of active chlorine disinfectant compounds.

[b] End point of 4-log reduction.

[c] A 100% rate of killing organisms, viability tested only at 15, 30, 45, 60, and 120 min.

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MAKING WATER DRINKING WATER

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MICROPUR MP 1

Emergency Drinking Water Tablets

- New Micropur MP1 tablets replace Iodine as the safest choice for disinfecting water
- The only tablet or liquid effective against viruses, bacteria, Giardia and Cryptosporidium
- Easy to use tablets require no mixing (just add 1 tablet to a liter of water) and have no unpleasant taste.

UNDERSTANDING MICROPUR MP1

To protect consumers, Katadyn and the EPA require that packaging claims for Micropur MP1 communicate how the product performs in the most challenging water conditions (water that is very cold and dirty). While MP1 is effective against bacteria and viruses in 15 minutes, it requires 4 hours for cryptosporidium in cold, dirty water. Therefore labeling requirements include a 4 hour wait time for maximum consumer protection (see chart below for details).

CONTACT TIME

	EPA Water #1 (clear, 20° C)	EPA Water #2 (dirty, 4° C)
Bacteria	15 Minutes	15 Minutes
Virus	15 Minutes	15 Minutes
Cysts	30 Minutes	4 Hours

Note: Note that product instructions have a 4 hour contact time.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

For Control of Bacteria, Viruses and Cysts: Use Micropur MP1 Water Purifier Tablets to kill bacteria, viruses and cysts *(Crypto and Giardia)* in water.

To use: Remove the tablet from its foil packaging with knife or scissors and quickly insert into 1 quart (1 liter) of contaminated water. Allow to react for 4 hours in an area away from sunlight to generate a use solution of 4 ppm chlorine dioxide. The treated water is now ready for drinking.

STORAGE AND DISPOSAL

Store in a cool, dry area away from sunlight and heat and in an area inaccessible to children. Place empty foil pouch in trash.

[redacted]

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FIRST AID

If In Eyes: Hold eye open and rinse slow and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes. Then continue rinsing the eye. Call a poison control center or doctor for treatment advice.

If Swallowed: Call a poison control center or doctor immediately for treatment advice. Have a person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

If on Skin or Clothing: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

Have the product label with you when calling a poison control center or doctor, or when going for treatment.

Note to Physician: Probable mucosal damage may contraindicate the use of gastric lavage.

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

DANGER. Corrosive. Causes irreversible eye damage and skin burns. Harmful if absorbed through the skin. Harmful if swallowed. Do not get in eyes, on skin or on clothing. Wear protective eyewear (goggles, face shield or safety glasses, protective clothing and rubber gloves). Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash before reuse.

ENVIRONMENTAL HAZARDS

This product is toxic to fish and other aquatic organisms.

PHYSICAL/CHEMICAL HAZARDS

Keep away from combustible, organic or other readily oxidizable materials.