- Dr. Bob's Philmont Hints, C - [2021 Edition]

Water Sterilization/Purification Primer (A "Conversational" Guide for Advisors and Crew Chiefs)

There are dozens of authoritative sources on how to purify or sterilize water in the backcountry. Punch "water purification" into Google if you have a free month. However, as the old aphorism goes, there are a hundred ways to skin a cat, and whichever one you pick, you will still end up with a skinned cat. But the quality and speed of the job will differ based on the technique you chose. It basically boils down to what exactly are you trying to conquer, and how much time, money, and effort you are willing to put into it. You have five basic problems - debris, bacteria, viruses, cysts, and pollution. That order is also the order of difficulty in their removal or neutralization - debris is (usually) trivial, bacteria moderately difficult, viruses and cysts tougher, and pollution from moderately challenging to all but impossible.

You have various techniques to address these problems, from primitive (boiling vigorously for 10 minutes) to more modern (solar distillation and oxidizing chemicals) to space age (filters, purifiers, reverse osmosis (RO) systems, and ultraviolet (UV) irradiation). Boiling, chemical treatment, and UV irradiation are *sterilizing* techniques, while filters, purifiers, and RO systems are *purifying* techniques (solar distillation is also a purifying technique, but in a separate and unique category).

Boiling will kill virtually everything (excepting some really hardy microorganisms that most of us will never encounter), and will also get rid of organic pollutants with any appreciable vapor pressure. However, it does nothing for debris or most pollutants, takes a lot of fuel and time, requires a cooling off period to be able to drink, and usually results in really flat tasting water (however, the latter can be remedied by pouring the water between containers a couple of times, allowing it to become re-aerated).

Solar Distillation is the old survival technique of sealing a piece of plastic over a damp or muddy hole and allowing sunlight to distill water vapor out of the soil, which will then condense on the plastic. A strategically placed cup in the hole (i.e., below a small stone placed on top of the plastic) will collect the falling droplets. When done properly the water is pure. However, this is of little use for a group in a standard camping environment – it is very slow – and so is listed here merely for completeness.

Oxidizing Chemicals include iodine, hypochlorite, chloramine-T, and chlorine dioxide, among others. Polar Pure is iodine, Bleach is sodium hypochlorite, and Micro-Pur is chlorine dioxide. Most water purification tablets (like Potable Aqua) produce a solution of chorine or iodine when dissolved in water. Any of these oxidizers will, when used properly, kill nearly any bacteria in a reasonable amount of time. Most will also kill viruses and cysts, but *can* take a looooooong time to do so. Some will react with certain types of pollutants, and turn them into other types of pollutants - which may or may not be an improvement on the original set (it's a crapshoot). They do nothing for debris, and are only poorly effective for some cysts and most pollutants. Philmont currently uses Micro-Pur tablets.

Note that the sale of Polar Pure and other iodine-based purification solutions are increasingly restricted, due to the use of iodine in illicit methamphetamine production. Iodine is also problematic for anyone with a thyroid condition, and will cause their metabolism to go haywire - for this reason it is prudent to ask if anyone in your Crew has such a condition if you intend to use it (shellfish allergies suggest a possible thyroid condition, so that's the second question to ask if everyone says "No" to the first).

Critically Important Information - All oxidizing reagents are "instantly" deactivated by Vitamin C and certain other additives in drink mixes and some foods; for this reason, you must wait the full recommended time for the water to be purified before adding anything to the water, or before using it to

prepare any meal items. **Many Crews make this mistake!** Also for this reason, if you allow flavored drink mixes in your canteens or water jugs, you have to be very careful to rinse residual drink mix out of them before refilling them with impure water and attempting to purify it - even a little residual drink mix can deactivate your oxidizing agent. In which case you still have a host of microorganisms now happily multiplying in a warm broth of sugar water – this is *not* a good thing! This is the salient reason why my Crews NEVER have drink mix in any of their canteens (and neither should yours).

Filters easily remove debris, but clogging is problematic, which can be a disastrous drawback in some settings (endless silty or muddy water). In the latter cases, pre-filtering the water through fine cloth or a coffee filter, or allowing the sediment to settle in a large pot before filtering, can help. Back-contamination can (and probably will) occur for the untrained or foolishly careless - but at least can be corrected when it does occur, as long as the fact that it <u>has</u> occurred is <u>recognized</u> (unfortunately, it rarely is). Filters do nothing for most pollutant chemicals, but *may* remove some macromolecular pollutants. Depending on the filter quality (see next paragraph), they can remove from most to all bacteria, from most to all cysts, and from some to nearly all viruses.

As noted in the previous paragraph, probably the biggest issue with filters is the quality of the actual filter - that is, the size of the "holes" on a molecular level. Think of screening as an analogy. A cheap filter is chain link fence, a decent filter is chicken wire, a good filter is window screen, and a great filter is ultrafine mosquito netting. The smaller the holes, the better the filtration. Conversely, however, the smaller the holes, the more difficult it is to force water through them, and the easier they will clog. This is not a perfect correlation, however, because some filters compensate by having more filtering surface area (i.e., a bigger filter). So a top-of-the-line filter has really small holes and a large surface area. Of course, the higher the quality, the higher the price. As was noted above, it is possible to extend filter life by "pre-filtering" the intake through a fine cloth or a coffee filter, to reduce clogging. Clogging is also (partially) alleviated by back-flushing, but that is also another potential problem area for contamination.

Finally, there are also "passive" (gravity feed) filters, similar to the ceramic type filters for household water pitchers, that have been adapted to use in camping environments. They work, but are slow.

Purifiers come in two types, which I will refer to as "standard" and "absorbent" for lack of any better terms. A "standard" purifier has a filter followed by a cartridge that contains an oxidizer, usually iodine (some other chemical may also be used, depending on the brand and model). So it first filters the water, and then chemically treats it (i.e., it combines both systems). The same comments made above on filter quality pertain to the filters in standard purifiers. So, a standard purifier will either filter or chemically kill nearly all microorganisms, but still doesn't do much for pollutants other than what was noted above under chemicals and filters.

This is where an "absorbent" purifier comes in. These have an activated charcoal or other absorbent-based cartridge. These absorb most pollutants. Top-of-the-line purifiers have a filter, a chemical cartridge, and an absorbent cartridge, in sequence. Yes, expensive.

Reverse osmosis (RO) based systems use a different type of filter (i.e., an osmotic membrane). They are so effective that they can be used to produce pure water from sewage, or (with different filters) from seawater. There are portable models, most of which are designed/intended to purify tap water in areas where the municipal water is suspect. There are also "camping" models, primarily intended for use in saltwater environments. They are rather pricey, and their replacement filters are also expensive.

Most filters and purifiers involve a pumping device to force water through the filter(s) and (if present)

the purifying and absorbent cartridge(s). These devices are subject to mechanical failure, so you need backup filters/purifiers, or a backup system such as tablets.

The **Steripen** is a "naked" ultraviolet (UV) lamp, powered by 4 AA batteries. When used properly, it kills every living thing, and I do mean everything. However, it has no filtering or purifying ability, and the water has to be reasonably clear in order for it to work properly (debris can "shade" organisms in the water, so this is important). The Steripen is the fastest sterilization technique, taking 90 seconds for a 1 liter canteen. However, it cannot be used for quantities larger than 1 liter at a time - this is because radiation intensity decreases as a $1/r^2$ function, where r is the distance from the source, so you have to use relatively small containers (like 1 liter canteens). "Ultimate Lithium" batteries are recommended, and will sterilize approximately 130 liters of water (standard alkaline batteries will only sterilize about 25 liters). For this reason, when using 4 or fewer Steripens, the Crew will need to bring extra "Ultimate Lithium" AA batteries (4 per Steripen) as backups. As of 2007, Philmont Trading Posts (including at Basecamp) did NOT stock Lithium or Ultimate Lithium batteries. As a recommendation, a full Crew (12 trekkers) would need 6 Steripens; you could get away with 4, but that would be pushing your luck.

Critically Important Information - "Threading" (back-washing the threads of canteens and other water containers) is **required** whenever (A) the container was used to collect impure water; and (B) a sterilizing technique was used. This is because the water in the threads remains untreated - and this is the first thing your mouth will touch! To "thread" a container, wait til the sterilization process is complete, then turn the container upside down, loosen the cap, and force (squeeze) some of the sterilized water through the threads. If a Steripen was used, rinse the cap out with sterilized water twice before screwing it back on to thread the canteen.

You will note that (except for the Steripen) I have not discussed the attributes and/or failings of any brand names or models - nor will I. This field is changing (and improving) rapidly, and what was state-of-the-art 10 years ago is yesterday's news today. There are at least 100 different water filters on the market - and probably more than 200. Two general statements can be made: First, bring the system you need to suit the area where you'll be using it; don't spend a fortune to appease paranoia. This is North America, not Bolivia, Cambodia, or Rwanda. While there are some problem locales, most aren't all that bad (if they were, half of us would be chronically ill or dead). Second, like with most things, you get what you pay for. Fortunately, in most areas of North America, and specifically at Philmont, even standard (i.e., reasonably priced) filters are usually adequate.

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Capacity for Philmont? - A Philmont Crew can go through a LOT of water, between 1½ and 3 gallons a day per person (remember, it's a desert environment). That is a significant water purification challenge. Oxidizing chemicals remain popular because they can purify large quantities with minimal effort (and in fact, that's what my Crews still use). "Individual"-scale filters and purifiers do not produce large quantities quickly, and take a significant amount of manual effort. I have seen several Philmont Crews where every member had his own filter or purifier. That's certainly faster but it's also excessive - a full size Crew could use 4 filters, purifiers, or Steripens as a compromise between speed and weight. In case of failures, Crews using a minimal number of filters, purifiers, or Steripens should also carry a backup system of one of the oxidizing chemicals, e.g., Micro-Pur tablets, enough to cover 2 days (i.e., enough time to get to a commissary or at least to a staff camp to pick up additional tablets).

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