

## **“SAFE WATER”**

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A paper on the “water management process” in the wilderness

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This paper is the collection of several posts on the NECLHG’ forum as result of an idea originally discussed with Keith concerning sharing among historical trekkers some knowledge of how to make water safe to drink while trekking for extended period of time. This paper has been simplified without omitting any essential information and hopefully, improved.

Having done a bit of survival in the army before (a whole different concept however) and later, as minimalist trekker, I believe that in a survival situation or in a long trek, water procurement could be second only to shelter or dealing with the exposure threat in broader terms.

Looking at survival statistics, **exposure** (to heat or cold) and as one of the indirect consequences of it, potential **severe dehydration** kills far more people than starvation in an unexpected survival situation.

If we are planning some long wood running stretch better we get our gear and our priorities straight just in case push come to shove and even if everything goes as planned.

Many people stranded in the wilderness or in general when planning a long trek, get over concerned about food supplies....well, that's the last of the concerns sort of speak, at least after water and shelter. Shelter and water are P1 and P2, sometime in different order, but still the first two.

Shelter intended in the broader term as defense against exposure.

We can go on (or survive) for a reasonable period of time without or with limited intake of food (believe it or not fasting for some time is good for our body), it is not pleasant to our senses but is not lethal; more of this perhaps in later papers; however we can't go very far if we suffer from the effects of exposure and dehydration (3-5 days top, a lot less for severe cases and not functioning very well).

Another consideration is that water is heavy (2.2 lbs/lit), if we plan to trek for a week, considering an optimal daily intake varying from of 2.5 to 3.5 lts (a small part of which comes from food metabolization) thinking of carrying all that water is out of question.

Most of the available canteens or hydration packs go from a quart to little less than a US gallon and they weigh like hell after a day trekking. It goes without saying that during

our trek the need of frequently replenishing our water supply will be one of the priorities and as a matter of fact, **part of the advance planning of the trek.**

We need to plan to be in proximity of a water supply at least once a day, two days top if we really are in dire straits and carefully manage the effects of exposure and level of activities the two main factors leading to dehydration, anything less than this equals to looking for serious troubles.

As part of the advance planning it is prudent to assume, as well, that not all the available water supplies are suitable for human consumption from the outset.

*“As a matter of information, if anyone of our Aussie friends finds himself trekking in Aboriginal desert areas, remember that the Aborigines used to mark water sources on nearby rocks by carving a symbol made of concentric circles (2 or more)”*

Both in winter and in summer exposure and dehydration are always lurking for the trekker. In the 18<sup>th</sup> century during the French and Indian war fought in the today United States, Cpt. Robert Rogers of the famous Rogers’ Rangers, in his book “Rules of Ranging Service” recommend that camp site is selected in proximity of a water supply or streams, there was a reason for that, maybe still not a scientific one, but he knew what he was doing and what his men needed.

As we go along in presenting this topic, I will get into more details on water purification and disinfection for now, as introduction, will suffice to say that as for the prevention of dehydration, the **water management process** begins with conserving the water we have in us.

Within the process of water management in the wild, which is: **procurement, disinfection (or purification) and conservation**; water conservation (which is not drinking less than required) implies minimizing, when possible, water losses which are through: **urination, respiration and perspiration.**

Since respiration and urination are unavoidable, perspiration is the only way of losing water that can be managed to a good extent by the same way we manage the exposure issue, that is, managing effectively our first line of defense against the elements, **our clothing.**

A second, but not less important, management tool is managing effectively our activities level.

In this topic we'll get into some modern scientific terminology and explanations (just the bare minimum) first; this is necessary to develop a good basic knowledge of the problem and with it **the capability to make informed judgment calls**; this basic knowledge becomes important when it comes to water management since it is not all black and white.

Before we get into the details of water conservation, it is worth asking upfront: how much water we need as daily intake? Answering this question is useful in planning our outing.

The rule is that there are no fixed rules. It is a matter of a bit of knowledge and sound judgment.

Water intake comes from drinking as well as eating, so both come into play in the equation. Second, eating and therefore digesting some food consumes water.

Third, the body's water consumption (including loss through perspiration and respiration), depends on other factors such as body mass, fitness level, age, gender, level of activity and environmental factors.

We have to make a judgment call in the planning stage to informatively guess how much water we would need daily and what to do to prevent, or minimize, losses.

First we plan to take it easy, the less we exert ourselves the less we sweat (and we become more energy efficient as well). As simple as that; this in turn involves in performing the many activities we are called upon to conduct in the wilderness, a bit of forward thinking, the availability and the proper use of the tools and techniques required to perform the tasks needed.

Second, we have to plan and manage our clothing in a manner consistent with the environment we will be dealing with.

**Let me make one thing very clear; sweating is our body's defense against hyperthermia (induced excessive body temperature), it is therefore necessary to regulate body's temperature through the cooling of our skin induced by the sweat evaporation (known as "evaporative cooling").** What we are talking here is unnecessary sweating coming from over-exertion or poor clothing management.

It goes without saying that trekking at 50+°C, requires sweating, it requires proper clothing as well, since not all the clothing material allows the proper evaporation of the sweat and the resulting cooling effect.

Yet, even in extreme situation, water management, the subject of our chapter, is a primary concern, the basic difference is how many techniques we have to put at work to battle the situation and how much time we have to fight and eventually win or lose the battle.

Another good saying is that the only good water is the one inside you, so do not conserve water by not drinking it, it won't make any good to dehydrate with a full canteen. If water is running out, plan to make water procurement your first priority and go for it aggressively. And start your trek fully hydrated.

So back again how much water daily?

As there is no fixed rule, we have to start somewhere. Let's use the US RDI (reference daily intake) as baseline and then we'll go from there. US RDI indicates 3.7 lts/day for human males older than 18 and 2.7 lts/day for human females older than 18. These include drinking water and water from food and from food metabolism as well.

Food on average contributes 0.5 to 1 lt per day; food metabolism contributes 0.25 to 0.4 lt per day; this considering a good and balanced diet.

Staying on the lower side, liquid intake in form of water could be reduced to roughly 3 lts for males and 2 lts for women if we are comfortably sitting at home.

Add to the above the level of activity, temperature, humidity, mother, father, etc. I would say that the above figure are a reasonable basic guideline if you can guarantee, at the same time, a very moderate level of physical activity and a balanced diet while trekking, e.g. two balanced meals a day including water rich food which is not always the case in my experience.

It becomes obvious that daily consumptions in extreme weather and during heavy activities can easily skyrocket to 10 liters or more.

Here a word of caution about proteins intake in hot weather is in order.

The metabolism of proteins utilizes body water. Proteins metabolism produces urea, a toxic compound that is excreted by the kidneys via urination, the more proteins (red meat for instance) you consume, the more water your body devotes to the production of urine to get rid of the urea.

On this subject we enter into the judgment area; on short term proteins intake in scarcity of water is detrimental to water conservation and helps the onset of dehydration; on long term, lack of proteins causes the body to self-procure the proteins needs by catabolizing muscular tissue, a very exotic term for the fact that your body eats itself from the inside.

Bottom line: if you eat a lot of meat, get plenty of water or alternatively, especially in hot weather, switch to a more carbohydrate based diet.

Alcoholic beverages consumption is strictly off-limit as it support the onset of dehydration big time by altering the functions of a gland (the posterior pituitary) responsible for the production of a hormone called ADH (Anti Diuretic Hormone). Diuretic is a fancy word for "piss", so we can call this hormone the "anti-piss" hormone. As the name says it, the purpose of this hormone is to regulate how much you piss (Diuresis) so that you hang on to your precious water supply unless strictly necessary. Alcohol wreck havoc with the production of ADH by diminishing it and promoting unnecessary pissing and water loss.

Consider that urine production is about 10 milliliter/hour per kg of body weight. One glass of beer or wine fools our body to produce about 120 ml of urine on top of the normal hourly production.

Drinking more water doesn't solve the problem while still under the influence of alcohol as you will end up hanging on to only one half to one third of the water you drink, the rest, will still go in urine.

Since we are dealing with a lot of latitude in determining our required daily water intake a rule of thumb to know if we drink enough water is in order.

A normally hydrated individual should urinate on average 4 times daily and the color of the urine should be pale yellow. Lower rate of urination and darker color indicates, with a very good approximation, that water intake is insufficient. Consider that medications might alter the color.

Most of us rely on thirst to hydrate which is being a bit late; it is also a fact that most of us get use to some degree of dehydration however this is by no mean a justification to not planning properly access to water sources during trekking.

Another aspect worth mentioning is that if we have to sweat, for whatever reason, profuse sweating can increase the need for electrolyte replacement. It is not guaranteed that whatever water source we find contains the required trace elements, sodium and others, to satisfy the body needs.

Dehydration might lead to serious electrolyte imbalance. So keeping some salt in the pack might prove useful not only for adding taste to the food.

*"Note also that in rescuing a seriously dehydrated person or more in general drinking too much water too quickly, can induce a conditions called hyponatremia which sometime can be fatal"*

Last but not least, if you are dehydrated, drink water. Forget about all other products, some of them are good but some have the bad habit, due to their ingredients, to cheat our body to think they are not drinks but food. As food, they get processed in the stomach and not in the first part of the intestine where water gets absorbed.

It should be clear, at this juncture, that it all comes down to proper preparation of our journey, sound self judgment and continuous personal monitoring during trekking.

After introducing the problem, next will start talking about water treatment.

The first step into the water treatment battle is to know the enemy. I like to make two broad classifications of the enemy as follows:

- **Natural enemies**, and
- **Industrial enemies**

Notwithstanding that everything eventually come from Mother Nature, the **natural enemies** are the small (very small) crawlies that have a life of their own. These fall into any one of the following categories:

**Protozoan,**

**Parasites,**

**Bacteria,**

**Viruses**

The **industrial enemies** are anything nasty we can think about from our studies of inorganic and inorganic chemistry. These are normally associated with one form or another of industrial pollution of soil and water supplies.

Let's talk about the crawlies first. In general the most benign effect of their presence is the well know diarrhea of various intensity all the way up to dysentery. Some of them can cause serious trouble over and above the s....t hitting the fan. Amongst other things, severe diarrhea contributes big time to potential severe dehydration if water supply is scarce.

With the crawlies we are concerned with **three (3) information** in order to effectively manage the water purification process: **their size, their reactivity to certain disinfecting substances or processes** and **where they come from** (the culprit for spreading them).

Where they are found is water but some of them can be found in soil and food as well through contamination often due to poor sanitation.

Considering that there are four general type of water disinfection processes available: **filtration\*, chemical, UV radiation and boiling** and that no one treatment, with the exception of boiling, is good for all the crawlies, it makes sense to look at size when it comes to filters and to look at their reactivity when it comes to chemicals and UV treatment (will spend few word on UV treatment as well).

*\*In the application of chemicals based, filtration and UV treatments, suspension particles or slimy organic stuff presence in the water influence the treatment outcome. In the presence of these suspensions in the water Filtration can be used as pre-treatment as well.*

It is also good to know the culprit, of human or animal origin, as the presence of anyone or both of them in the area might be an indicator of what is lurking in the pond and allow us to make a good judgment call on the most suitable treatment.

For reason of completeness and space will start with the **Protozoan**, subsequently will discuss about the other categories and their peculiarities.

The Protozoan of our concern (sometimes classified as single cell parasites) are:

**Giardia lamblia**

**Cryptosporidium parvum**

**Cyclospora cayetanensis**

**Entamoeba histolytica**

**Microsporidia**

Some of these protozoan are quite cunning, they have a double life form.

Inside a host (hopefully not us) they have a life as the everyday parasite. When excreted from a host, while waiting to find another accommodation, they take what is called “cyst” form. A cyst is a kind of cocoon that the crawly build around itself as protection (an “armored” crawly sort of speak).

Once the cyst is ingested by a new host the crawly gets rid of it and starts its life again in parasitic form. Quite smart isn't it for a single cell life form?

The cyst life stage makes the crawly a bit harder to kill with some treatment methods. It makes it also particularly resistant to heat and cold allowing its survival even for months while waiting for a new “accommodation”.

When it comes to information about the sizes we are concerned, when applicable to a particular parasite, with the cysts form life stage.

Upfront let us be clear that **boiling is the first and most secure method of water treatment for Protozoan type of crawlies**. It goes without saying that we need to make sure that we know how start a fire and that we have a container that can go on the fire to boil the water in your kit.

As a matter of fact boiling works for most of all the other as well, albeit one or two are heat resistant to a certain degree, but more of this later when we'll discuss about other crawlies.

There are hundreds of different indications about how long water should be boiled. The reality is that just reaching rolling boil temperature is sufficient; after all, pasteurization of foodstuff is obtained at temperatures lower than boiling, albeit at different holding times specific for each product.

The reason for rolling boiling is that, most of the time, we don't have a thermometer to check if this or that lower temperatures have been reached, so when water on the camp fire bubbles we know that, at sea level, we are at 100°C. Later, talking about virus, we will see that in some cases, it might be advisable to prolong the boiling to 2 to 3 minutes beyond the starting of the rolling boil.

Personally, if the water is full of organic matters (the greenish smelly slime that sometimes floats on the surface); I'd like to filter it before boiling.

The reason for that is an extra precaution, I do not want some of the "armored crawlies", the cysts, or others to hang inside or on the surface of the slime (as some tend to do) where full boiling temperature, being this in contact with outside air, might not be reached if boiling is very brief. It is a long shot in terms of precaution, but it might be worth the five minutes spent in filtering and I prefer it to longer boiling time as it conserves fuel (which in some areas such as the deserts, is not that abundant by definition).

How do I do this filtering? A sock or a bandana tied around the neck of the container before scooping water in. Anything with reasonably tightly woven fibers would do. As a matter of fact you can even do it with a tightly packed nest of green or dry grass as long as it catches the slime it is fine; more about organic slime and particles later on.

So far so good, but what if we cannot start a fire? Here the knowledge and judgment factors come into play. From now on, size and reactivity to chemicals or UV matters.

Let's bring back our Protozoans crawlies and analyze them a bit more in detail (as a reference 1 micron = 1/1000<sup>th</sup> of mm).

**Giardia Lamblia: 11-14 x 6-10 microns in cyst form**

**The most common water born protozoa.** Usually found where domestic or wild animals share water sources with human (also found in soil and food) which become infected through fecal contamination.

In Cyst form is very resistant to cold, heat and desiccation and can survive for months outside a host.

Because of its resistance in cyst form it has to be assumed to be omnipresent even in apparently crystal clear streams.

**Cryptosporidium: 4-5 microns dia. spherical in cyst form**

**The crawly is essentially ubiquitous** and the biggest concern as drinking water borne pathogen in industrialized countries nowadays.

**There is no established 100% effective chemical treatment** albeit most of the symptoms are generally self limiting in healthy individuals.

The cysts are highly environmental and disinfection chemicals resistant (chlorine & Iodine).

**Cyclospora: 7.5-10 microns dia. spherical in cyst form**

Mainly found in Tropical and Subtropical regions. Spread through fecal contamination of water as well food. Quite rare outside endemic regions is known to be resistant to chemical disinfectants (chlorine and iodine).

#### **Entamoeba: 10-20 microns in cyst form**

Primarily infecting humans and primates. Cysts exist in loose feces which are the primary cause of contamination of water, soil and food.

Cysts are heat and cold sensitive but thrive in moist environment.

#### **Microsporidia: 1-40 microns spores**

This crawly comes in a variety of species and spread through spores rather than cysts. Some of the species infect aquatic life (fish primarily) some terrestrial life (including insects like locusts, bees and silkworms).

Some 13 species of this crawly are known to infect humans. They are known to infect mostly human with some form of compromised immune system.

Spread by fecal matter and inhalation. Water species are sensitive to cold and dry climates, terrestrial species are more resistant to cold. **Exposure to sunlight kills the spores very quickly.**

Worth mentioning once more that **the size is given in order to counter check the efficacy of some filtration methods.**

It is comforting to know that the **Giardia cysts (6 microns)**, **Cyclospora cysts (7-7.5 microns)** and the **Cryptosporidium cysts (4-5 microns)**, while being the toughest crawlies are also two largest (speaking in crawlies relative terms).

This is particularly important for the Cryptosporidium (4-5 microns) and for the more rarely encountered in developed countries, Cyclospora, which are resistant to most of the common chemical treatment and, in absence of the possibility of boiling the water, can rely only on filtration for effective removal.

He I would like to make a bold statement about relying on filtration for water disinfection:

**“Filtration of water in the wilderness as unique method of water disinfection, utilizing makeshift filters, is a bet”\***

\*To provide some benchmark, a tightly woven piece of cloth or a microfiber type, has about 400 to 100 microns (0.4 to 0.1 mm) porosity, a coffee filter is in the range of 100 microns, fine sand particles' size ranges from 0.062 mm and 0.2 mm (62-200 microns), silt ranges from below 0.062 mm down to 0.004 mm (below 62-4 microns). Coal from the fire has extensive porosity, that's why it readily absorbs and retains some of the particles passing with the liquid however, the size of the pores cannot be determined. Bottom line, a silt filter would be the best bet, but still a bet; all other combinations do not do jack to stop crawlies.

In a true survival situation, if the alternative is death, we can take some risks and accept that by instance, Cryptosporidiosis (the disease brought by the Cryptosporidium) is bleak but in most healthy individuals, is self limiting and chose dysentery rather than death. After all, statistically, most of the unexpected survival situations resolve within a 72 hours period, statistically.....so even with some bad dysentery, we can hang on and wait for the cavalry.

However the purpose of trekking is not to become a survival statistic, so we must plan and think safely.

We can construct a by the book multilayer filter (gravel, sand and charred wood) and this will, hopefully, remove the Cryptosporidium and Cyclospora cysts, it won't!

It will remove organic slime and other particulates a step which is also essential for further treatment and hopefully some of the crawlies embedded in this suspension; however, I personally believe that hope is not good enough in the wilderness.

Graves and hospitals are full of hopeful wilderness trekkers.

Cryptosporidium is essentially ubiquitous, so the chance that is not going to lurk in our selected pond, is at the best, very slim.

The bottom line is, if you cannot boil it, you have to **reliably filter it**.

For **reliable filtration** I mean processing through a filter in which the pores' size (absolute pores' size) is small enough to guarantee, as per industry standards that "X" microns crawlies will not pass.

Again in selecting the type of filter we have several on the market produced by reliable companies specialized in this sector.

Keep in mind however the Cryptosporidium and if traveling, the Cyclospora sizes and take the lowest number of microns of minimum guaranteed "absolute" pores' size that can stop them. Other crawlies are a lot smaller than 4 microns; however they are not that resistant to alternative disinfection method.

As a matter of fact most of the filters on the market have absolute pores' size way smaller than 4 microns, however make a habit of checking the specs before purchasing.

I personally use a Sawyer® Point Zero Two\* and Point One portable filters.

*\*The Point Zero Two is also called “Viral Purifier” (a note is in order: The Point Zero Two DOES filter the totality of viruses which are the smaller in size of all crawlies but requires a bit of knowledge of the degrading factors that might affect its performance) and has an absolute pore size of 0.02 microns which is quite good for everything else that could be chemical resistant.*

The Point One (shown in the figure with its backwash syringe and the 1 liter flexible container) is also good, albeit with larger pores’ absolute size (0.1 microns), is very effective in filtering all of the crawlies, but viruses, which might be chemical resistant.

The Point Zero Two (looking the same as the Point One) is expensive (the 4 lts bladder model) sells at around 130 USD, however is guaranteed for a million USG with a very simple backwash care. On the long term is the cheapest filtration method. The Point One is cheaper, at about 40 USD, and guaranteed as well for a million USG with the same backwash care.



Both the above filters as many other on the market are light, easy to use and very contained in size.

As long as a filter stops the chemical resistant crawlies, we can effectively and safely complete the water treatment process with a high degree of safety.

With regard to the chemical resistant Protozoans, remember that the *Cryptosporidium* cyst (4 microns) is the “ubiquitous tough guy in the pond” so with the above filters as well as with the majority on the market we are on the safe side.

We have filtered our water, then what’s next?

Nothing if you are using a high performance filter (0.02 microns absolute porosity); if not we might be left with some leftover crawlies to deal with.

Here I have to briefly recall what I said early on about organic slime and suspension particles (will call them the “crap”). The crap doesn’t go along very well with some chemicals, with UV treatment as well as with filters with small pore sizes.

More specifically the organic crap reacts with some of the disinfecting chemicals and renders them less effective. With UV the crap makes the water tough to penetrate for the sun’s rays thus failing the purpose of the treatment.

As for filters the crap clog them, that’s all, they still work but the flow is greatly reduced.

So we have, in the process, to remove the crap upfront (before the “real” filtration or any other water disinfection process) and the suggested methods are the one I listed earlier in the paragraph (sock, bandana, etc.).

There are other methods for removing other smaller organic and inorganic particles which do not settle on the bottom of the container by gravity. Of particular interest, since it is also effective in removing (precipitating is more appropriate as it doesn't kill them) a large percentage of the Giardia lamblia cysts (or any other of the larger cysts lurking within the crap), is the FLOCCULATION.

In industrial water treatment plant a substance called Alum is used. In the wilderness, baking powder or the white ash from the camp fire works fine as well.

Flocculation basically works on the principle that the substance introduced in the water, let's say white ashes, helps binding together the particles which are too light to settle by gravity alone making them all together heavier and allowing them to sink to the bottom of the container.

Simply drop one or two spoon of white ash in the water container, stir, let the water settle for a while till the majority of the particle sediment, together with the ash, settle on the bottom of the container. If the water is not enough clear, repeat the treatment after having moved the water into another container taking care of not stirring the bottom sediment too much.

After having removed (or substantially reduced it) the crap and filtered the water, next are chemical or UV treatments.

Starting with the chemical, we have to substances that are commonly used in various compositions: **chlorine based and iodine based**.

Chlorine based substances range from household bleach to more sophisticated compositions available in tablet form.

We can go into details of the various chlorine based disinfectant, however they are less effective than Iodine when in solution form and less stable (household bleach) in the sense that you cannot guarantee, in the long term, that X percentage chlorine solution will remain X percentage.

They tend to react with organic matters in the water losing in the process some of their effectiveness. The tablets address the issue of instability and are just fine however tablets tend to run out. What we need is a long term, reliable and portable disinfection method and Iodine gives us just that.

Iodine based products are many, there has been a lot of literature about toxicity of iodine, we'll talk about that as well a bit later.

In my opinion (corroborated by more medically knowledgeable persons) those individuals who need to be concerned about iodine are: **pregnant women** and **people with thyroid dysfunctions** (some people are known to be also allergic to iodine).



These individuals will need to switch to chlorine based disinfection methods and go for the tablets. Everybody else is quite safe with iodine in the quantities and concentrations needed for personal water disinfection.

Iodine comes in a variety of presentations: Iodine topical\* solution, Iodine-povidone

(Betadine®) and others.

*\*Topical means for external application*

They are all useful, some have few drawbacks, personally I use the commonly called **Iodine Crystals Saturated Water Solution**.

It is not sold commercially and needs to be prepared, but once prepared, it will last for very long time, the solution can be carried in a very small container, can be regenerated with the water just treated and it is easy to use.

It has, as any other method, few drawbacks but these are easily overcome.

The iodine solutions can only be stored in glass or plastic containers with Bakelite or plastic cap (I haven't tried cork but I guess it will work), no metal.

To make the solution we need:

1. 1 oz (30 ml) glass bottle, the same used for medications (about 20-30¢)
2. About 4-8 grams of Elemental Iodine crystals 99.99% ACS grade (about 45 USD @ 100 grams)

Throw the crystals in the bottle, fill it with clean water and shake it. After about one hour the solution is ready, meaning that the maximum amount of iodine crystal that could pass into solution in the water will have dissolved.

There will be some crystals left at the bottom of the bottle, leave them there, since the solution is saturated they will stay there for as long as needed (see figure).

The solution is poured, will see how, into the water to disinfect, the bottle is refilled with the newly disinfected water and a new solution is made with the remaining crystals.

When there will be no more crystals at the bottom of the bottle, add another 4-8grams of iodine crystals and keep going.

It doesn't matter if is exactly 4, 5, 6 or 8 grams, the crystals will go into solutions till it is saturated and then they will stop dissolving, it will work all by itself.

Most important is to ensure that there are always crystals at the bottom of the bottle, this is the proof that saturation has occurred and the system will last longer.

In general in order to be effective Iodine should reach a concentration per liter of water to be treated, ranging between 6 to 8 ppm (part per million) which is close to 6 to 8 mg/lit (milligrams per liter), albeit there is a temperature variable which will see later.

If it is stagnant water and kind of cloudy go for the higher dosage if it is gin clear water the lower figure will do the work. However as a ball park figure, anything above and including 6 mg/lit (or 6 ppm) will do the work and it won't taste that bad.

We have the bottle of solution and the liter of water to be treated, so how much we have to pour in? These are general indications that will result in solutions stronger than the suggested optimal, however it is a fact that remembering complex numbers is not for everyone, particularly in a survival situation, so use them and stay on the safe side.

If the water is very, very cloudy you can drop the entire content of the bottle (about 26-28 mg of solution, excluding the crystals) and live happily ever after. As a matter of fact you can always drop anything between ½ to the entire content based on water turbidity and keep going.

In plain terms it means that with one 1 oz bottle of solution, right away, you can treat anything from 2 to 1 liters of water depending on water conditions.

Reconstitute the solution with a little of the treated water, wait one hour for the solution to saturate and keep going.

I always go for the ½ or full content method. I like a little taste of iodine which some people call the "taste of safety". It is a little psychological boost knowing that iodine is there and makes the liquid you are drinking safe.

Remember **DO NOT DROP THE CRYSTALS IN THE WATER TO BE TREATED, LEAVE THEM IN THE BOTTLE.**

Let the water stand for 20-30 minute, after that cheers! You want to make double sure, let it stand for 1 hour, it is not necessary but if it makes you feel better, go for it.

\*make sure, in the event of using screw cap canteen or bottle, that the treated water spills through the thread of the cap by momentarily turning the canteen upside down with the cap partially unscrewed. This ensures that no crawlies will hide in the thread

For those who don't like the "taste of safety" (some might find it tasting like gag), **AFTER THE COMPLETION OF THE TREATMENT, AND NOT BEFORE**, it might be useful to bring along few tablets of Vitamin C, those of the effervescent kind with orange or lemon taste.

**AFTER THE TREATMENT** drop about 1/3 of one tablet (they are quite large in size and come in handy aluminum tubes) into the treated water, vitamin C kills the iodine taste (and its effectiveness, so use it AFTER iodine has done the killing not BEFORE) and makes the treated water more palatable.

Earlier we briefly mentioned the variables to consider while utilizing iodine for water disinfection, these are:

**Temperature:** Iodine is sensitive to cold temperature (which in general slows all chemical reactions), the colder it gets the slower it kills; we need therefore to increase the settling time once added to the water and here please bear with for a little reasoning.

As the water gets colder, the reaction slows down, so we need to give the indicated amount of iodine solution either more time to do its job or, if we don't have much time, we can stay with the same holding time but use larger amount of iodine solution (always remaining within the limits of ½ to full bottle range). The iodine solution utilization equation is:

**Effectiveness (at a given Temperature) = quantity x time**

We play on the two variables, quantity and time, that we have at our disposal.

In terms of safety one hour is the maximum resting time for temperatures down to 4-5°C to ensure that the iodine solution does its work.

I said that I prefer the ½ to full 1 oz. bottle solution, this is more than enough concentration of iodine in the treated water for a temperature range from scorching hot down to close to freezing (about 4-5 degree centigrade) and still holding the 20-30 minutes time.

The reason for my rough going when it comes to adding iodine solution is very simple.

**If I'm badly in need of water I might not be functioning properly, I just need to remember to drop in anything between ½ and the full content depending on how the water looks, and let it rest for 20-30 min.**

This is a lot easier if you are in a badly dehydrated state. Remember that in a survival or close to survival situation, the first things that get affected due to stress, urgency, exposure, etc. are your complex motor skills and with it the capability to do complex thinking. **You have to keep it simple and effective at the same time to have a fair chance.**

A word of caution when in proximity of freezing temperature, make sure you keep your tiny 1 oz bottle from freezing it will break if filled to the top and make sure that the water you treat is not in the pre-freezing state, that won't work very well, it must be liquid. You can always carry the iodine solution into a pocket to keep it warm and preventing it from freezing.

**PLEASE READ CAREFULLY THE FOLLOWING PARAGRAPHS AS THEY CONTAIN IMPORTANT CLARIFICATIONS.**

The following paragraph deal with the subject of iodine toxicity. I didn't invent the content it comes from medical publications.

You can find several claims that iodine used for water disinfection is dangerously toxic. Every bottle of iodine solution bears the familiar skull and bones.

Goodman & Gilman' "Textbook of Pharmacology" goes to the extent of saying that: "*the belief that iodine is highly toxic is a popular fallacy.*" The reality is that iodine is only weekly poisonous.

The lethal dose is 2-3 grams; however survival has been documented after ingestion of up to 10 grams. Iodine in such large quantities is a potent gastrointestinal irritant and causes immediate vomiting which eliminates most of the ingested iodine\*.

*\*The immediate treatment for iodine poisoning is the administration of starchy food.*

Consider that the daily dose of potassium iodide administered to asthmatic as expectorant is 1.2-8.0 grams, equivalent to 0.9 to 6.0 grams of iodine. We are talking about grams!

Consumption of up to 8 mg/l (ppm) in solution by healthy individuals with normal thyroid functionality would not cause problems. **Individuals with thyroid problems and pregnant women, as stated earlier, should not utilize iodine for water disinfection.**

So unless you plan to party at iodine, in a normal survival situation, where the intake is limited in time, iodine mild toxicity shouldn't be a concern.

To add more in dispelling the myth, between 1915 and 1936 out of 327 individuals that attempted suicide by ingesting iodine and arrived alive at the Boston City Hospital, no death were reported; and that was in a period when the medical science was not as advance as it is today on many fronts.

The accidental intake of one or two small crystals (try to avoid it as vomiting consumes water) while pouring the solution, it should not be a problem as well.

Here I must make a clarification. We have talked about 26-28 mg of concentrated solution. These values are by far higher than the 8 mg/liter mentioned, these however

refer to the **SATURATED IODINE SOLUTION' QUANTITY** and **NOT TO THE PURE IODINE QUANTITY**.

This is a due clarification for those that might doubt that the suggested way to kill the bugs is by killing the host (in this case the survivalist). The question is how much is then the full 1 oz bottle of saturated iodine solution in terms of absolute iodine content in our 1 liter of water to be treated?

Iodine is moderately soluble in water; our little 1oz bottle contains 29.6 ml, solution concentration is dependent on temperature (the higher the temperature the more crystals dissolves into solution, at 80°C about 2.6 times enters into solution than at 20°C), however as a guideline iodine enters into solution in water in the amount of 0.029 grams each 100 cc or ml at 20°C.

**29.6 ml (our 1oz little bottle) equals 29.6 cc, which is roughly 1/3rd of 100cc, so at 20°C we will have 1/3rd of 0.029 grams dissolved, which is approximated up to 0.01 grams or 10 milligrams.**

So throwing the full bottle of solution (26-27 mg), **EXCLUDING THE CRYSTALS**, into one liter of water, at 20°C, will create a 10 mg/lit or ppm solution (same thing), throwing half bottle will create a 5 mg/lit or ppm solution (we have seen that anything above 6 ppm is good). You can jiggle a bit around but ½ or full is not much thinking.

Just remember: full bottle of solution per liter = 10 ppm at 20°C (one quart is not as much as one liter but it doesn't make a dramatic difference).

**Is 10 mg/lit (ppm) above the 8 ppm mentioned by the doctors earlier in this paper?**  
**Yes but don't worry too much, it won't affect you for limited intake periods.**

**If it makes you feel better, consider that while pouring the solution and being careful not to throw the crystals in, a little solution will remain in the bottle this also reduces minimally the dosage.**

At lower temperatures the "full bottle" throw will ensure that the solution is still effective, albeit the concentration in the solution might be lower than at higher temperatures and the iodine will work at slower pace, while we can still maintain the 20-30 min. holding time albeit, if you feel, you might increase it to 45 min. to 1 hour and be in peace with yourself.

Here as usual we have to make some judgment considering the potential for crawlies load. As a suggestion, when you make the solution in cold weather try to let it settle inside a pocket or anywhere warm, more iodine will dissolve and once dissolved, even if it is cold it will remain into solution.

In conclusion we can see that, at 0.029 grams of crystals dissolved in a full 1oz bottle shot, our 7-8 grams of crystals, can last for up to 276 solutions (8 grams at 20°C), in the worst case scenario 276 solutions can treat 276 liters (full bottle throw) or double the quantity at half bottle throw. Not bad as sustainable method.

It is always preferable to have a water container capable of withstanding fire in the pack. However when it comes to filtration, flocculation and/or iodine treatment or as a matter of fact any other treatment that we will explore other than boiling, I prefer to utilize a transparent container such as a Nalgene® large neck bottle (see figure).

These bottles are tough as hell and come in various colors, transparent is the way to go.

It allows us to visually check the progress of the treatment (the iodine induce coloring and/or the progress of the flocculation). I find it comforting being able to see what I am doing and psychology is a major part of the survival equation.



In emergency even a spent common PET water bottle will do. Will see later why PET.

To complete the Iodine discussion, if anyone wants to know more about how to deal with other iodine based mixtures (such as iodine tincture, Betadine®, etc.) which are also used for disinfection, please let me know and I will publish some information about those as well.

The reason I omitted them at this stage, rightly or wrongly, is that I prefer a method that is of immediate use without the need of much thinking for the reasons I stated above.

The additional information on other iodine compounds, if requested, will be provided and could prove useful in the event (that would never happen.....) that we are caught unprepared and we need to improvise a treatment using, for example, the car first aid kit or any first aid kit where iodine based disinfectants are normally at home.

Let's now talk about Chlorine. It is worth, for those who cannot use iodine, to know the subject in detail.

I'm not trying to get over technical but when it comes to survival situations, having as little doubts as possible on what you are doing is a major psychological boost.

Chlorine based products come in different forms, liquid and tablet, the most common liquid form is the old good household bleach which is a solution of anywhere between 5.25 to 6% of Sodium Hypochlorite and water (the familiar Clorox®)\*.

*\*I find amusing that at the supermarket, we buy Clorox® for washing the dishes and we buy other “products”, Milton® for instance, for disinfection of food and baby stuff, at a higher price! They are exactly the same thing, Sodium Hypochlorite and water, with little differences in concentration of the first (Milton® has a slightly less concentration). You can disinfect food with Clorox® just by accounting for the extra concentration by adding additional water (read the label of contents).*

**Bleach (of the unscented, uncolored, not powdered and with no cleaning additive type)** can be used for disinfection; however it is impractical for wilderness mainly because the solution is not very stable and on the long term, the percentage of Sodium Hypochlorite dissolved changes. This weakens the concentration making difficult to achieve an efficient disinfection with the indicated dosage.

On short term, it is efficient as household or emergency disinfectant for those crawlies that are not chlorine resistant.

The prior mentioned organic matter (the slime\*) has also a part in reducing considerably the efficacy of this disinfectant so rough “sock” pre-filtering is in place to eliminate any slimy substance present in the water to be treated.

*\*For those into chemistry, the organic slime (not lifeless suspension particles like mud or the like), causes the chlorine to react with the omnipresent (in any organic matter) ammonia and amino acids to create what are called chloramines, a byproduct that release chlorine slowly and inconsistently (so the known holding time and dosage are becoming unreliable parameters).*

We recall that some of the Protozoans are chlorine resistant as well, at normal concentrations, so pre-filtering with a state of the art filter is mandatory.

The dosage is 5 drops of bleach for 1 liter of water to be treated with a standing time of 30 minutes.

Again, in my opinion, this is fine at home, but a bit too theoretical for a wilderness situation. After all who carries a dropper in his pack?

I had to use bleach for emergency disinfection and after the recommended 5 drops (I had to figure how much 5 drops were) and 30 minutes standing time, the water didn’t have a light smell of chlorine, that gave me a headache, as well a little chill on my back, was it is safe or not to drink?

I ended up adding a half spoon of my cooking kit (the size of the spoon is little less of the common table spoon) full of bleach and the water, after 30 minutes it smelled a bit like a public swimming pool but it all went fine including my bowel functions, so please draw your own conclusions.

**As I said earlier, an immediate, no brain method, to gauge your disinfection results is in place in the wilderness.**

However in the interest of safety let me re-state that in that occasion, I couldn’t filter the water albeit it was gin clear, so basically I GOT LUCKY. Due to some unexpected

circumstances, I had to push my luck a bit further since the alternative was no water at all at close to 45°C outside temperature with 90% humidity.

Again chlorine reactions are temperature sensitive, if the temperature is anywhere above 15-16°C the 30 minutes holding time is fine, for lower temperatures increase the holding time from 45 minutes to one hour.

On the market there are other products which are chlorine based and here I'm not doing marketing but for those who cannot use iodine this is what is available.

The following two chlorine based products are the one I tested and used:

1. Chlorine Dioxide (trade names: Potable Aqua®, Katadyne Micropur®, Aquamira Water Purifier Tablets®)
2. Sodium dichloro-s-triazinetrione [SDST] (distributed in US by HQ COMPANY brand name Chlor-Floc®)

They both come in tablet form in handy water proof sealed wrapping. Each tablet once opened, must be used fairly quickly and cannot be packed again. They have a pretty long shelf life, albeit by law the manufacturer has to indicate an expiry date. I have used expired tablets which were properly stored.

Of the two, Chlorine Dioxide is the chemical of my choice.

These tablets are, in chemical terms, a small masterpiece of laboratory work or as some defines them, a highly engineered chemical delivery system. I call them a "micro-lab".

Chlorine dioxide is a substance that is highly unstable (that means explosive), so processing and transportation of large quantities has been out of question. It must be produced right on the spot where it is used and that's what these tablets do.

Each tablet includes chlorine and an activator which upon immersion, combine and produce chlorine dioxide, all in a 3 mm. diameter pill, quite amazing isn't it?

Each tablet is good for one (1) liter of water.

**If you are using a transparent container this should be kept away from direct sunlight during the holding time.**

Chlorine dioxide, as per manufacturer indications, is good for killing Protozoan, Parasites, Bacteria and Viruses. However there are different holding times and still the issue of temperature sensitivity as for all chemical reactions.

Follow the producer recommendations which are clearly printed on the pack and on the tablets wrapping (albeit I need glasses to read them); as reference I list the various holding time of the Aquamira Water Purifier Tablets® which I keep as a backup.

1. **Clear water at 20°C:**

Bacteria & Viruses = minimum 15 minutes

Protozoa (Giardia & Cryptosporidium) = minimum 30 minutes

2. **Murky water at 4°C (worse case scenario):**

Bacteria & Viruses = minimum 15 minutes

Protozoa (Giardia & Cryptosporidium) = minimum 4 hours

Personally I like to roughly pre-filter the water with the method mentioned before (sock, etc.), the less organic slime there is, the better, even with chlorine dioxide.

In addition to, shake the container well to ensure that the tablet dissolves entirely (here a transparent container helps) and don't forget to wash the thread as indicated earlier to kill any bug that might be hiding there.

Four hours is a long time when you are thirsty but in absence of alternative is better than nothing. It goes without saying that some forward planning is required.

However tablets are of immediate use (although they run out), so we can treat, having a suitable container, more than one liter of water at a time as opposed to iodine saturated solution where the 1 oz bottle is good for anything between 1 and 3 liters but can be reconstituted in one hour time. All systems have the pros and cons.

To the best of my knowledge (I might be wrong), chlorine dioxide tablets, is the only chlorine based simple to use, portable treatment that kills our dreaded, ubiquitous Cryptosporidium (there are others but not as handy and easy to use). So they are highly recommended for those who **cannot use iodine, cannot reliably filter the water and cannot start a fire**....the lack of this latter skill is enough to suggest of not venturing too far from civilization.

**SDST.** This product' brand name is Chlor-Floc®, as the name says has the double effect of flocculating and disinfecting the water to be treated.

One 600 mgr tablet is good for 1 liter of water. It is also temperature sensitive so the manufacturer gives a mix of different holding time at various temperature (at 25°C, 7 minutes up to 15 minutes at 10°C and 5°C) as well as increased quantities (2 tablets instead of one per liter) at very low temperatures (5°C).

On the instruction for use on the "killing list", there is mention of: Giardia Lamblia cysts, bacteria, viruses and other harmful micro-organisms. There is NO MENTION of Cryptosporidium so we have to assume that it is not effective in removing the ubiquitous bug.

This product has an additional flocculation property, thus during the treatment, sediments will form on the bottom of the container. These can be removed by straining the treated water with the usual sock, bandana or the like.

A last note on liquid chlorine based disinfectants. Aquamira produces the Aquamira Water Treatment Drops® a two products treatment system which requires some pre-mixing before utilization. I don't find this suitable for wilderness use for the same reason stated above (complex motor skill deterioration), however if you like it you can use it.

There are other liquid products as well as purifiers that utilize electric current generated by batteries to do the work, by all mean try them, however if they take too much of assembling (by the Murphy' Law they will break when needed most), reading or thinking, you know the rationale. This pretty much closes the chlorine subject.

Next we will discuss about UV (ultra violet) treatment, including the SODIS (Solar Water Disinfection) method (this is where PET bottles come handy), and the various options we have.

### **UV or ULTRAVIOLET LIGHT**

UV or Ultra Violet light is extremely effective for water disinfection and other disinfection applications.

However on the market there is only one product that has some of the features that would make it suitable, albeit not ideal, for wilderness applications, bearing in mind that a malfunction might leave you in very dire straits.

The product is called SteriPEN® (see picture), it is an electrically supplied device powered by rechargeable batteries. By the very fact that it has to emit UV light it has a lamp which is well protected against accidental damages. Despite being a hardcore minimalist, I have to admit that it is a handy gadget for quick fix.

The pen comes with one set of spare rechargeable batteries, a neoprene belt pouch and



a plastic container which incorporate solar photovoltaic cells to be able to recharge the depleted batteries using the sun. It can takes up to 3-4 days to reach a complete charge. It has also a standard charger that can be plugged into the electricity supply.

The pen is completely water proof and comes with a rubber anti-shock liner; the lamp unit is also protected by a transparent plastic tube and an additional removable plastic protection.

It is easy to use and it can sterilize up to a liter of water in as little as one minute

and half, albeit the water container must have a large enough mouth to be able to submerge the lamp element completely as well as allowing some steering of the liquid. It can be used to disinfect as little as one glass of water in a matter of seconds. Remember turbidity and light don't get along very well.

One set of batteries is enough for several treatments and will last enough to guarantee that the depleted batteries could be recharged with the slower solar power option.

These are all the features. Having said that, it is more suitable for occasional traveler and campers, however for those who like gadgets or cannot use other disinfection methods; this is a very efficient device that might have a place in anyone gear as back-up.

### **SODIS (Solar Water Disinfection)**

This system is quite intriguing. Personally I haven't tried it yet in the field but I have taken some time to familiarize myself with it just to be able, if push comes to shove, to use it. As the old saying goes in war ammunitions are never too many.

The extent of the effectiveness of the SODIS system has been the subject of extensive field testing in various developing countries and its efficacy and limitations, have been documented by thorough microbiological laboratory testing. Data available clearly identify the extent and limitations of the method in neutralizing water borne pathogens.

The application of this system requires a bit of study, however the advantage is that the information available allow us to make very informed decisions should we require putting it at work for water disinfection.

I would judge the system reasonably efficient within its limitations, and certainly better than direct drinking of untreated water after a make shift filtration in a survival situation.

SODIS was developed by the Swiss Federal Institute for Environmental Sciences and Technology (EAWAG) in cooperation with EAWAG' Department of Water Sanitation in Developing Countries (SANDEC). I encourage the readers to visit EAWAG website and familiarize with the information contained about the SODIS.

EAWAG is Swiss Government's none profit organizations an aspect that rules out marketing related overrating of the system efficiency, an unethical aspect that plague even the survival industry even though human lives are potentially at stake.

The SODIS method is surprisingly simple, it utilizes spent transparent PET bottles (the majority of the current water and soda bottles) and the sunlight.

The whole process boils down to three easy steps:

1. Filling spent transparent PET water or soda bottles  $\frac{3}{4}$  of their capacity (most of them are 1.5 liters capacity) with the water to be treated and capping them,
2. Shaking the bottle for 20-30 seconds in order to increase the water oxygenation,
3. Leaving the bottles laying down on a clear reflective surface exposed to the sun light for a certain amount of time; 6 to 8 hours minimum in sunny weather, in poor weather up to 2 full days might be required.

That's all there is to it.

The “variables” and “limitations” of the method are several, we will look at them.

The principles on which the method is based are scientifically sound; this implies that the limitations of the methods are equally well defined. Let's look at the principles first.

What does sunlight do? Water borne pathogens (the crawlies), albeit not all of them, are susceptible to two effects of the sunlight:

1. Some of the crawlies are vulnerable to the UV-A\* radiations
2. Some of the crawlies are vulnerable to heat which is the effect of solar infrared radiations

*\*UV-A is one of the bands of Ultra Violet light. Lights, visible or not to the human eye, are divided in categories on the basis of their wavelength (imagine the sea waves and the distance between the tops of two consecutive waves). Ultra Violet light, not visible to human, is subdivided into several subcategories of wavelength of which the “A” category is the one with the longer span. UV light stands in between the visible light to human eye and the X-Ray light.*

Briefly, UV-A reacts with the oxygen dissolved in the water producing what are called oxygen free radicals and hydrogen peroxides. These two products kill the microorganisms. UV-A also interferes with the reproduction cycle of bacteria by damaging their DNA.

Infrared radiations, by heating the water, accelerate the above processes at temperatures at or above 50°C.

SODIS achieve a substantial reduction of the crawlies in the water but not the complete elimination (this has been corroborated by extensive laboratory tests which are still ongoing due to the complexity of the various crawlies reactions to the UV-A under a variety of environmental conditions).

However seen from the angle of providing reasonable water sanitation in large scale, the method is a simple, almost no cost alternative for the developing countries where mortality due water borne pathogens infections claims the life of thousands of people, amongst them, children which have reduced immune system efficiency\*.

*\*I call this the “mine field” probability game, if you have to walk through a mine field your chances of survival are much better if the density is 5 mines per square kilometer than if you have 300 of them. People in some developing countries have no other option but to walk the mine field and in some survival circumstances, we might have to as well.*

Let’s see how SODIS, under optimal conditions, performs. While we are going to talk about other crawlies later (Parasites, Bacteria and Viruses) we are going to mention them in illustrating the “crawlies killing” results of the SODIS system.

It is worth mentioning that according to international health standards, the accepted indicator for water quality is the presence of the so called Escherichia Coli (E. Coli), a bacteria thriving in presence of fecal contamination of water supplies typical of developing countries (but not only) and responsible for a good portion of the health problems experienced by the population.

SODIS application has resulted in the following results (UV-A induced reduction or inactivation):

**Bacteria:**

E. Coli (Gastro-Enteritis) 3-4 log reduction\*

Vibrio Cholera (Cholera) 3-4 log reduction

Salmonella (Typhoid) 3-4 log reduction

Shigella (Dysentery) 3-4 log reduction

**Viruses:**

Rotavirus (Diarrhea, Dysentery) 3-4 log reduction

Polio Virus (Polio) inactivation results not known\*\*

Hepatitis Virus (Hepatitis) reduction present but not quantified\*\*

**Protozoa:**

Giardia L. (Giardiasis) 3-4 log reduction of the infectivity of the cysts

Cryptosporidium (cryptosporidiosis) 3-4 log reduction of the infectivity of the cysts

*\*Log (which stands for the mathematical logarithm) 3-4 is a conventional way of indicating the % of reduction of microorganisms in microbiology. For reference here are the % values related to various Log indication:*

*0.5 log = 68.4 % reduction/inactivation*

*1 log = 90%*

*2 log = 99%*

*3 log = 99.9%*

*4 log = 99.99%*

*5 log = 99.999%*

*6 Log = 99.9999% and so on*

**So 3-4 log reduction or inactivation indicates that between 99.9% and 99.99% of the crawlies have been either killed or disabled. That’s pretty good on paper, however we**

**must consider that mathematic doesn't always translate in absolute safety on the ground.**

The log reduction unit of measurement doesn't show a variable that is **the number of crawlies in the water (the "load")**.

Looking at the ubiquitous and tough "Crypto" (a friendly nickname of the Cryptosporidium) to pick one; suppose we have a log 3 reduction performance, the end result changes if we have 1,000,000 cysts or 1,000 cysts in our water.

At 1,000,000 cysts a log 3 (99.9%) result means we are left with 1,000 Crypto roaming around.

At 1,000 cysts a log 3 result means we are left with 1 Crypto roaming around.

So beware of the laboratory results, there is no way we can measure the Crypto or any other crawly number into the water and some of them don't need to be too many to cause problems.

However having cautioned the readers against mathematic and statistics, I want to emphasize that, **if nothing else is available the method is the best you can get with the little as possible.**

Considering that most of us are vaccinated against Hepatitis and Polio and that, in the wilderness, the crawlies load (quantity) in the available water sources can be reasonably lower than in some villages in the middle of some developing countries by virtue of the lower population density (human and animals like cows, dogs, cats, etc. In the village everyone does everything, including defecating, in close proximity of water sources), **SODIS is a good bet if push comes to shove.**

Let's look now at the parameters for applying this method.

**Intensity of solar radiation:** the SODIS is most efficiently applied in regions comprised between latitudes 15°N and 35°N (South as well) due to the lower precipitations and therefore higher average solar radiation yearly (more than 3,000 hours/year of sunshine).

The second region in terms of effectiveness is the one comprised between latitudes 15°N and 15°S, the equatorial region. Humidity and rain reduced the yearly radiation considerably however through scattered clouds about 2,500 hours/year of sunshine can be achieved).

**Seasonal and daily variation of solar radiations:** the seasonal variation is responsible for the climate in the region; regions near the equator experience the least amount of variation throughout the year, northern latitudes experience more.

In very sunny days, 6-8 hours complete the treatment, provided other variables are respected (condition of the bottle and cloudiness of the water), in presence of a

complete overcast sky (but no rain), 48 hours is likely the most appropriate time as the dose of solar radiations is reduced by 1/3rd .

Scattered clouds sky cover, still is sufficient for the treatment to be effective with a time in between those indicated above.

During rainy days the method is not effective **however, if it rains, we can collect rain water and drink it.**

**Temperature:** if the water temperature reaches 50°C or above, the treatment efficacy is considerably improved. In the wilderness we don't always have a thermometer, but we can help the temperature increase by construction a reflective surface on which to lay the bottles. A piece of discarded undulated metal sheet cover, the roof of the car, anything shiny and metallic will do.

I carry always about a yard of aluminum foil, the one used for food wrapping, carefully folded, into my pack; it serves many purposed, in this case it makes for an excellent reflective surface if arranged in a V shape under the bottle. Carrying a space blanket is also a good idea.

**Water turbidity:** if the water is turbid SODIS won't work very well (radiations can't go through effectively). Filter it or decant it with the known systems mentioned early on (I didn't include flocculation since if we have ashes we should have had fire and we should have thought about water before).

The minimum turbidity level for the treatment to work should be below 30 NTU (Nephelometric Turbidity Units).

Since not everyone can measure NTU's outside a laboratory a little trick is in order.

If you have a compass, place the compass under the 3/4 filled bottle with the bottle standing on it in the shade. Look through the bottle opening and if you can see the compass' needle with reasonable clarity the water turbidity should be around 30 NTU or less. For those who need glasses and wouldn't see the compass even looking through a bottle of gin, wear them.

**Conditions of the PET bottle:** the bottle should not be scratched or aged to the extent that their surface becomes almost none transparent. This will hamper the passing through of the radiations.

Another good thing about PET is that above 65°C starts to deform visibly. If the bottle starts to assume funny shapes or starts to feel flimsy at the touch, it is a good indication that the temperature of the water and bottle has reached a level that makes the whole contraption work well. It will not melt, so don't worry.

**Depth of the water to be treated:** 10 cm water level in the bottle is as much as we can go. Allow for this when filling the bottle (remember that the bottle must be laid down when exposed to the sun, not left standing).

**Water Oxygenation:** remember to shake the bottle for 20-30 seconds to increase oxygenation. DO NOT shake it during the treatment.

What about other materials such as PVC or Glass?

PVC can be used, however both PVC and PET bottles contains a certain amount of additives amongst them UV stabilizers which increase the stability of the material and protect the content from oxidizing and UV radiation.

PET bottle have been found to have much less of this UV unfriendly matters.

As far as glass is concerned, the capability of UV radiations to pass through glass is determined by the amount of Iron Oxide used in the manufacturing process.

To provide a benchmark consider that a 2mm window glass allows close to zero UV radiations to pass. Pyrex glass used for cooking pans allows more UV to pass, however I do not normally carry a Pyrex pot in the wilderness, my wife won't allow me.....

I beg our readers pardon for the apparent theoretical mark of this chapter, however the understanding to the variable of this little know method of water treatment is important for the correct application.

As I said earlier, it is not 100% effective, however it is a reasonable bet, if it is a sunny day and nothing else is available and sometimes, survival, comes down to a series of informed bets which, in a way or another, buy us time and the more time we buy the more chances we have to make it out.

Finally we came to the other three families if crawlies which we briefly mention early on.

In talking about these little nasty creatures we run the risk of making this chapter an incomplete microbiology treaty, we don't want that and we don't need that.

In my humble opinion, the discussion should be limited to the essential information that might prove useful in the wilderness and in a survival situation. These are:

1. Areas of distribution (this allow us to gauge the chances of encountering them),
2. Infection route (animals, humans, etc.),
3. Size and/or appearance (recognition),
4. Reactivity to specific treatments

All of the listed crawlies are water borne; some of them do not thrive exclusively in water but in soil and food as well through cross contamination.

I'm not going to dwell into complicated description of what these little and not so little buggers do to us; this might discourage few people from venturing outside their own houses. However let me make clear that some of them are not exclusive prerogative of some distant wild countries in some undeveloped continents. Proper water (and food) sanitation begins at home.

Let's start with the **Parasites**. We have, earlier, mentioned that Protozoan are sometimes referred to as single cell parasites, the following are, instead, multiple cells parasites (full fledge animals).

**Schistosoma (commonly referred as blood-flukes or bilharzias):**

A flatworm of about 10 to 20 mm in size at the adult stage of its life. This crawly is number two on the WHO' most wanted list second only to malaria.

In order to reproduce it need to find an intermediate host which normally are fresh water snails of the Bulinus, Oncomelania, Biomphalaria and Neotricula Aperta species (I encourage to look at pictures of these snails to be able to identify them).

The presence of fresh water snails of the species above is a good indicator that this parasite could be present.

There are many different types of this parasite, seven of them are known to infect humans and they are spread through a variety of regions including: West Africa, Tropical Africa, South East Asia, Asia, Middle East, Caribbean, China, Indonesia, Philippines, South America and Taiwan.

This parasite normally enters a host through the skin in larval form, ingestion per se doesn't lead to infection, however while procuring potentially untreated water, care must be taken in the event of need for immersion of the hands as well as contact with other parts of the body.

Ingestion of untreated water might cause the parasite to enter though lips or the oral cavity.

**The larvae are known to take about 20-30 minutes to perforate the skin, in an emergency, if larvae presence is suspected, the briefly immersed part of the body can be vigorously dried with a towel**, this is not a substitute for proper prevention and it has to be considered an emergency measure in the event of accidental, limited immersion.

Boiling or aggressive filtration resolve the problem of larvae eventually present in the water.

Iodine or chlorine effectiveness is not enough documented to ensure safety at the dosage available for wilderness disinfection.

**Dracunculus Medinensis:**

The largest parasite (a worm) of all, reaching up to 800 mm in length (mature females). Typical of Africa and India. Infection is through ingestion of water in which a species of small crustaceans called Copepods\* (which are omnipresent in either sea or fresh water in developed and developing countries) are present which are infected with the parasite' larvae.

*\*To the defense of the Copepods, it has to be mentioned that they are useful and are utilized in many applications including: food for certain sea water aquarium fishes and as active combat agent against the proliferation of certain type of mosquitoes. To this end they are introduced in water reservoir where they aggressively attack the mosquitoes' larvae. Experiments to this end are ongoing in the south of the US and in Thailand. Copepods are also present in some public mains water supply of major cities (S. Francisco, New York City and others) where the water is not filtered.*

Upon ingestion the Copepod dies and releases the so called Stage 3 larva that goes about and does its own business of developing into male or female worms.

The good news is that basic filtration of suspected water utilizing a tightly woven cloth is enough to stop the Copepods which are from 1-2 mm up to 10 mm in size (and can be visually detected perhaps utilizing the Fresnel lens we have as a mean of starting fire and with it, the risk of infection.

Iodine or chlorine efficacy in disinfection is not well documented.

**Taenia:**

The Taenia is a tapeworm and there are over 100 types of it. It is distributed all over the world.

Infection is through the ingestion of the eggs (found in contaminated water) or of pregnant female worms found in the feces of humans (through cross contamination due to poor sanitation), cattle and pigs. It infects other species of felines, rodents and ruminants.

Contamination can be through water (fecal contamination with the eggs) or poorly cooked/raw meat.

The species Taenia Saginata and Solium (beef and pork worms) infect humans, pigs and cattle and can only reproduce in human hosts.

The eggs size varies between 30-40 microns so if boiling is not an option, aggressive filtration should be considered.

The parasites' eggs are NOT sensitive to chlorine or iodine disinfection.

**Fasciolopsis:**

A flat worm (called giant intestinal fluke) that can reach 75mm x 25mm in dimension at adult stage. Three species are known of which the "Buski" specie causes symptoms.

Endemic in the following regions: China, Taiwan, South-East Asia, Indonesia, Malaysia, Thailand and India.

Infection is through fecal contamination of water. Eggs are released in water and find an intermediate host which is normally water snails of the species *Segmentina* and *Hippeutis* (I encourage to have a look at how these snails look).

Into the snail the eggs go through a series of mutations till they become cysts which are released in the water by the host. These cysts can be ingested or **attach themselves to aquatic plants like Bamboo, Water Chestnuts, Lotus, Water Caltrop and other edible aquatic plants.**

Boiling or aggressive filtration are the only effective methods of killing the cysts both in the water and on the plants.

#### **Hymenolepis nana:**

Known also as “Dwarf Tapeworm”. Its size is about 40mm x 1mm in adult form, eggs are 30-50 microns in diameter.

It is typical of temperate areas (latitudes 23.5°N & S to the Arctic/Antarctic circles). This is the most common worm infecting humans, especially children.

Infection is mostly by fecal contamination of water (and food) with the eggs, although fleas and some grain beetles are known to be potential hosts. Flea bites are not known to transmit the parasite, accidental ingestion is required.

Boiling or aggressive filtration are the only effective methods of killing the eggs in the water.

#### **Echinococcus granulosus:**

Known also as “Hyper Tape Worm” or “Hydatid Worm”. Its size is 2mm to 7mm at adult life stage.

Spread through fecal contamination of water and food by canids (dogs, dingo, and wolves).

Animals that serve as intermediate host are herbivores like sheep, deer, moose, wallabies, free roaming cows and kangaroo which are at risk of eating grass contaminated with canids’ feces containing eggs. Human can be also host through canids’ feces cross contamination of water or food.

In the host the eggs hatch and form larvae which in turn, forms large size cysts that can grow the size of a softball or larger. These larger cysts contain smaller balloon’ shaped cysts (in some species is not the case) filled with a large number of juvenile worms.

Although it is not related to water, since this crawly is not that far from us, I'd like to indicate that these cysts are located mainly in the **LIVER, BRAIN and LUNGS of the host.**

**THEREFORE IN THE EVENT WE PLAN TO EAT SOME CANGAROO, WOLLABY or ANY OTHER GRAZING GAME' ENTRAILS, ESPECIALLY THE LIVER, I recommend we inspect it for the presence of these large size cysts which are visually detectable** (they might be smaller but still detectable to human eye), these cysts as said above, are full of juvenile worms, for the less faint hearted breaking the cysts, is the final proof that it is what we are looking for.

In this regard it is a good practice to thin fillet game meat (muscles as well as entrails) before cooking it and look for anything that doesn't look right; **THIN FILLETING** ensure thorough cooking even in presence of moderate heat sources, and before eating, cut it through to see if it cooked inside.

Boiling or, with regard to food, thorough cooking, is the only reliable method of disinfection. Aggressive filtration is also a substitute method for eggs removal.

#### **Ascaris lumbricoides:**

This is the largest and most common parasitic worm in human. Size is 2-4mm diameter by 150-300 mm in length (adult male), females are smaller. It has a worldwide distribution.

Eggs are 45-75 microns by 35-50 microns (oblong shape); unfertilized eggs are larger.

Eggs have a fatty outer layer that makes them very resistant to acids and alkalis, desiccation and low temperatures. Eggs can survive in the soil for years.

Infection is through fecal (human and canids) contamination with eggs of water or food.

Agricultural areas where fertilization utilizes human feces content are at risk.

Boiling and aggressive filtration is the preferred treatment. Iodine resistance is thought to be high, therefore iodine treatment is not recommended.

Chlorine bleaches **DOES NOT KILL THE CREWLY** but removes the sticky outer layer of the eggs thus facilitating removal from food.

I believe the lesson is clear, **when it comes to parasites, "BOIL IT"**, filtration is also an option, however on long term trekking, filters might become less effective due to clogging, **and so boiling is the first and most sustainable method in my humble opinion.**

Does it look a bit of a "drastic" conclusion? Be patient and bear with me for few lines more.

Due to the widespread nature of some of these parasites (Ascaris) in what we can call the modern wilderness (developed countries farming areas mostly) I have read quite a few of the infinite microbiology papers available on the subject of parasites in an effort to determine with a certain degree of certainty, if a milder heat treatment (lower temperatures than full rolling boil) is effective (SODIS for instance).

The most complete document I have found is a 2004 paper of the WHO (World Health Organization) which indicates the results of various experiments (by different researchers) over a period of 64 years comprised between 1923 and 1987. The experiments were trying to define at what temperature the Ascaris' eggs would eventually die.

Without going into the details of all and each readings I'll give very few flashes of the most recent results (later years) of different researches (21 in total):

1. **Temperature: 55°C**  
**Time: 6.5 min.**  
**Results: eggs developed**
2. **Temp: 50°C**  
**Time: 10 min.**  
**Results: eggs dead**
3. **Temp: 55°C**  
**Time: 19.5 min.**  
**Results: eggs hatching**

How does it look in terms of clear cut?

Well to me a little puzzling. Without questioning the much more competent microbiologists and considering the possibility that not all the eggs where from the same sub specie, I can only state that this crawly (all were Ascaris eggs), whatever sub specie we encounter (surely we cannot determine this in the wilderness), is a bit funny and unpredictable when it comes to dying or thriving. **So better be safe and go for the sure kill.**

Continuing with the **Bacteria & Viruses**, I believe it is not necessary to provide a description of all of them.

We will list them by name (only those that might be ingested with untreated water) and if applicable we will group them by size (filtration) and reactivity to either chlorine or iodine treatments, or both.

Boiling is generally effective with all of them (those causing potential infection through water ingestion).

*\*Some bacteria are “thermophile” (e.g. they like and thrive in hot water environment) some in temperatures exceeding water boiling point. We can see them in some hot water springs; they create, sometime, a bright coloration of the rocks. But these are of no concern to us.*

Some of the names are very familiar to us, some a little less know. What is important to know is that they almost omnipresent.

It has to be said that there are many sub-species of a single type of these crawlies. Bacteria, especially, could be good (we use them in many industrial processes, food production and even in medicine for some experimental cancer treatment) and some, those we are concerned with, less amenable.

Concerning the viruses, bear in mind that when it comes to claim of this or that filter to remove them, you must be in the position of reading and understanding the product specifications and do not take anything for granted when it comes to stated tests or standards.

One of the common mentioned standards for filters is the US EPA (Environmental Protection Agency), many manufacturers uses EPA standard for their own testing.

**EPA doesn't test, approve or endorse mechanical filters (those where no chemicals are used and that rely exclusively on mechanical removal of the micro organisms), it merely assigns registration numbers.**

**During EPA regulated “laboratory” testing, the pass requirements are as follows:**

- 1. 3 log reduction for cysts**
- 2. 4 log reduction for viruses (99.99%)**
- 3. 5-6 log reduction for bacteria (99.999 – 99.9999%)**

To be called a “microbiological water purifier” a device must eliminate all of water borne disease causing micro organism from the water.

We have seen when talking about the SODIS method, that the “load” (the amount) of micro organisms in the water might vary considerably thus changing the end result of a given log filtration performance in terms of left over crawlies.

In highly contaminated water where contamination by sewage is suspected, filtration only with anything but a microbiological water purifier is a bet, if not accompanied by additional heat or chemical treatment.

So be aware of a claim that says that all the viruses have been eliminated according to EPA standards. It has some latitude for uncertainty.

Having read few microbiology articles in which viruses' average size or range of sizes have been mentioned, I have noticed that rarely they coincide. Here are few examples:

**0.004 – 0.06 microns (a textbook)**

**0.03 microns average size (a microbiology paper)**

**0.02 – 0.09 microns (a microbiology paper)**

**0.004 – 0.1 microns (a microbiology article on the web)**

Since when it comes to human life I don't really like approximations I have listed all the sizes I have found for each specific virus in an effort to cut the chase.

This gives me a pretty good feeling of the worst case scenario in the event I have to go for filtration albeit as much as I can search, the data will always have some latitude for the reasons stated above.

I benchmark these sizes with 0.1 microns filter (Sawyer Point One®) as not everyone can afford to spend 150 dollars on a piece of equipment for a Point Zero Two® device.

Let's see the bacteria and viruses listing:

**Bacteria (dimensions in microns in parenthesis)**

1. Clostridium Botulimum\* (0.6 x 3 – 7)
2. Campylobacter Jenuni (0.5 x 2.0 approx.)
3. Vibrio (including V. Cholerae)\* (0.5 x 1.5 – 3.0)
4. Escherichia Coli (0.5 x 3 – 8 microns)
5. Shigella (1.5 x 3.0 microns)
6. Salmonella\*\* (0.5 x 2.0 microns)
7. Legionella (0.5 – 1.0 x 1.0 – 3.0 microns)
8. Leptospira (0.2 – 0.3 x 6.0 – 30.0 microns)

*\*Several subspecies exist, including the one responsible for Tetanus.*

*\*\*Several subspecies exist causing more than one disease.*

Some of these bacteria are highly infective (very small number required to start doing damages), heat resistant (will see to what extent), acid resistant and thrive in absence of oxygen.

Given the smaller size of the diameter (we don't know if the bug comes though standing or laying) we can see that a 0.1 micron ABSOLUTE POROSITY FILTER should do the work.

Let's look at chemicals. As stated earlier, Chlorine treatment is subject to a lot of variables including temperature, concentration, time and PH.

To cover all the variables would require considerable time and would go beyond the scope of this paper as well as the objective of providing an easy, immediate way of water disinfection in the wilderness.

As stated before I would not recommend chlorine solutions (bleach) in the wilderness, but rather chlorine dioxide in tablets when it comes to bacteria.

Iodine is effective at killing bacteria at the concentrations and holding times indicated earlier and therefore recommended in the wilderness. As a matter of fact lower concentrations are sufficient to eliminate a variety of bacteria, however in the wilderness we have to go rough and simple. Boiling is 100% effective.

#### Viruses (dimensions in parenthesis):

1. Adenovirus\* (0.06/0.07 – 0.09 microns)
2. Astrovirus (0.028 – 0.03 microns)
3. Calicivirus (0.03 – 0.04 microns)
4. Parvovirus (0.03 microns)
5. Coronavirus (0.08 – 0.016 microns)
6. Hepatitis Virus (0.042 – 0.047 microns)
7. Poliovirus (0.03 microns)
8. Polyomavirus (JC and BK strains) (0.04 – 0.05 microns)

*\*Present in more than one sub specie*

As we can see benchmarking against filters with absolute pore size of 0.1 microns, it is obvious that they won't do the job.

A 0.02 microns absolute pore size on paper will perform quite well.

If the filter is tested under EPA standards some viruses' presence is tolerated, this means that the indicated sizes sometime have a degree of latitude in the measurement (after all, albeit very tiny, within a species, each one might not be a copy of the other).

It also indicates that **borderline performance (0.02 micron filter to catch a 0.03 microns virus)** might be affected by any degrading in filter performance in terms of enlargement of pores' size due to prolonged utilization over time.

**If you want to go for an expensive filter, by all mean feel free to go; I recommend, when it comes to "border line performance" to familiarize yourself THOROUGHLY with the factors that might cause DEGRADATION OF SUCH PERFORMANCES (lack of regular backwashing, pore enlargement, mechanical factor due to the filter construction, anything you can think about), always with the objective in mind of being able to make informed judgment calls. When it comes to borderline performance I use double treatment (filtration + iodine). Of course boiling clears all of the above.**

*\*Some testing indicated that Hepatitis virus gets inactivated at temperatures above 98°C in 2 minutes (so keep rolling boil up and going for a while) so it appears quite heat resistant when it comes to*

**alternative methods of heat disinfections like SODIS. Other papers indicated a much lower temperature for complete killing. As usual we have to cut the chase and go for a sure kill. BOIL IT FOR TWO TO THREE MINUTES.**

Iodine treatment in the concentration indicated in the saturated solution description and at the prescribed holding times, is an effective virus killer. If you want to be 200% sure, especially at lower temperatures, throw in the entire content of the 1oz bottle (EXCLUDING THE CRYSTALLS) and wait for one full hour.

That's pretty much all about bacteria and viruses. Next we will look at industrial pollutant and a bit about carbon filters principles.

When it comes to industrial pollutants, drawing from my professional background in the petrochemical and later on mining industry, I can reasonably state that the number of nasty substances that mankind have produced is considerable.

These pollutants have no life and you can't kill what has no life (sounds Lapalissian\* isn't it), they can only be, if ever, neutralized chemically, stopped or removed utilizing both mechanical filtration and/or mixed mechanical/chemical filtration.

*\*Monsieur Jacques De La Palisse (or La Palise) was a French nobleman and a soldier of the 16th century which, after his death at the battle of Pavia (15 February 1525), in the 18th century became, thanks to Bernard de la Monnoye, a character of the French comic literature in the publication "Song of La Palise". From this song became the French term Lapalissade which means "an utterly obvious truth". Famous amongst the quartets of the song is the statement which says that M. De La Palisse, "two day before his death, he was still quite alive". A little literature breaks.*

Here is where carbon filtration might come into play (somebody said.....), but will discuss it a bit later on.

Industrial pollutants come into two categories as far as we are concerned:

**a) Those used in some industrial production of what we use every day in our lives (minerals, precious stones, plastic, chlorine, detergent, leather, paints, disinfectants, etc., you name them)**

**b) Those used in agriculture (inorganic fertilizers, pesticides\* and livestock disinfectants)**

*\*Pesticides are now called by some multinationals "life science products" the same as, in some countries, the garbage guy (with all due respect for honest workers) is now called "environmental operator". For the former is all about making the name more palatable to shareholders, after all who wants to invest in pesticide shares with all these "greens" making noise, life science sounds much better.....*

category "a" above is an endless list of chemicals and mixtures; some of them quite harmless (some biodegradable, although the practical extent of this definition needs to

be carefully examined especially when you throw in the environment tons of products), some of them deadly.

My suggestions are a series of preventive measures as follows:

**Never procure water in proximity of very old mines or very old petrochemical complexes or refineries. Even if these sites look quite all right (clean) and the chaps who runs them swear to God almighty that they are environmentally friendly, if the plant or complex has been around as far as we can remember, avoid it.**

The reason for this bold statement is that I have been in many of them, some as old as 1959-1960. Now it is true that relatively recent environmental legislations have put a serious patch on industrial pollution and that process units backdating the early '60's are no more in operation; however if the site has been around for more than 15-20 years, it is likely that it suffers from the old good days effects of industrial pollution, when anything went and everything was legal, including dumping (willingly or not) all sort of crap underground and forget it. Technologies for the treatment of industrial wastes were not that advanced and treatment of industrial waste doesn't make money. Years of dumping crap into the soil, in some areas adjacent to these complexes, have created irreversible pollution. Same apply to mines.

Adjacent mean within the range of up to 10 km from the site; this doesn't count much for soil contamination as much as for aquifer wells contamination. Water can go long way underground and if any stream or lake is within range it is likely that some crap makes its way into that as well.

A good indications that something might be going on in the area (for those who want to spend the time researching) is the depth at which urban water wells have been drilled over time and the type of terrain/soil surrounding these industrial sites.

If you can get any data about these aspects you can make some informed judgment calls.

**-If wells have been drilled increasingly deep there are only two reasons: water has been depleting or lower layers of soil have shown contamination by one chemical or another,**

**-If the contamination is there, rocky or clay soil tends to channel the water somewhere usually down slope. Sandy soil absorb it, to a certain extent,**

**-If you have a stream or lake or pond, located at lower level than the surrounding area and the two of the above "if" are applicable, maybe some crap has found its way into these.**

As usual I like to give a good pragmatic way of determining if anything of the above is present, here it is.

**A good indication of potential water contamination with industrial pollutant is the health of the fishes in the pond**, if they don't look quite right and lively it is either an animal parasite (which normally causes some form of ulcerations) or some industrial crap have found its way into the pond.

**Above all FROGS (water, arboreal or ground dwelling) and SNAILS are also a very good indicator of industrial pollution level**, they breathe in these substances through their skin and they disappear.

Where there are frogs I feel quite comfortable that soil, grass and water are alright as far as industrial pollutants are concerned (remember that some species of snails are host for some bugs, but this is another subject).

*\*In Italy, where I come from, we live on a lake, when I was a child, back in the 60's, frog and snails hunting was quite common (they both make a good meal. Snails or escargot, for the more refined, are now quite expensive at top French gourmet cuisine restaurant), now they are all gone.....*

That's all I can say with reasonable amount of certainty about industrial pollutants prevention.

Category "b", the substances used in agriculture, is a bit more challenging.

We have seen how "organic" fertilization with waste water or animal/human feces can create bugs contamination. However not always crops are fertilized with some organic matter.

A lot of time industrial fertilizers are "inorganic" and use substance such as: Ammonia as feed stock for Urea and Anhydrous Ammonium Nitrate and together with phosphates, to produce compound fertilizer.

The principal effects, in large scale farming, is the presence in the soil of nitrates or/and heavy metals (zinc, cadmium, lead, arsenic, chromium and nickel) where steel industry waste is used as fertilizer due to the presence of zinc which is good for plants. Of course lead, zinc and mercury are the nastiest of all.

These (metals, ammonia and nitrates) can find their way into water the same as industrial pollutants, which indeed they are.

**Fish conditions are a good gauge to the presence of these pollutants especially metals which in the short terms do not kill the fishes rapidly, but slowly and subtly disable them (lead and mercury) by creating deformities, discolorations, erratic behavior (swimming on the side), pale eyes and gills coloration.**

Nitrogen rich chemical compounds are also responsible for a process called "eutrophication" which is the lack of oxygen in water. This is responsible for algae bloom and the development of bacteria, which thrive in zero or close to zero oxygen,

which sometime gives a funny coloration of the water. Although this is happening in larger scale into the oceans, fresh water is also affected.

**Again fishes are good indicators of the lack of oxygen in the water.**

**While this might be due to natural lack of water replenishment (drying up after rainy seasons) or poor oxygenation due to lack of movement, fishes living in these conditions are used to scooping air at the surface, occasionally, but they maintain almost intact their mobility and other functions if you bother them they swing down very quickly.**

**However when you see fishes scooping air at the surface big time, not looking very perky and at the wrong time of the year, it is likely that something is wrong with the water and if the causes appears to be natural, like a major algae bloom, it is likely that behind that there's something like nitrates.**

Pesticides and disinfectants are two families of their own, I'm not going to dwell into the details of what they do in the long term, however it is a fact that they are no good. Disinfectants are basically a good thing, the problem becomes when they are used in industrial quantities such as in the livestock industries.

**Anything that goes for fertilizers, in terms of precautions or prevention, is good for pesticides as well as for disinfectants, although the former are intentionally meant to kill this or that bugs so they might be basically more poisonous in lower quantities than fertilizers.**

That's pretty much it about these substances, the real problem is that, when they are present there is not much we can do other than applying some form of filtration and hope for the best (an approach which I don't feel very comfy with). Chemical or heat treatments do not work most of the times.

We can dwell in exploring many chemicals that have lower boiling point than water and therefore might be eliminated by boiling, it is a good indication if you know all of them and if you can suspect them in the water. This is a long, very long, shot and it won't work in the wilderness. Moreover when it comes to metals, is a no go or if it comes to cyanide (used in the gold mining industry) how effectively you can treat a poison?

**Bottom line, stay away from the area I have been indicating if ever possible. Generally heavy polluted areas, these days, are known to almost everyone, but still, pollutants might end up way far from the source for the reasons stated above.**

Here we come to the one of the filtration method that at least on paper, should be able, to some extent, to eliminate or reduce industrial pollutants. The Carbon filter, probably one of the least understood type of filter.

There are several types and sizes of carbon filters and not all of them are portable and suitable for trekking, as a matter of fact almost all of them do not fit into this category. They are almost exclusively used in household applications.

However knowing the principles and the features will help in case you need to improvise, albeit I'd like to stress it, IT'S A LONG SHOT AND I WOULD NOT USE IT. All of them use charcoal, the one we are familiar with.

The charcoal can be produced with bituminous material (derived from oil refining), wood or coconut shells. For some reasons coconut shells make the best one and filters based on these charcoal are generally more expensive.

The reason charcoal is effective as base ingredient for filters is by virtue of its porosity that in turn, makes the available contact area (surface) huge when compared to the volume. Carbon is an excellent ABSORBENT, likely the best known to man for thousands of years.

**One pound of charcoal can have a contact surface of up to 120-125 acres (about ½ square kilometer),** this together with the intricate porosity makes it a very good candidate for filtration, sizes of the pores available in different carbon filters ranges from 50 microns down to 0.5 microns.

“Activated” is the magic word, the carbon is slightly electro-positive charged this characteristic makes the negative ions in the molecules of the contaminants attracted to the carbon; a bit like a magnet. The carbon come in activated granule or densely compacted blocks, blocks generally yield a better performance.

The key to the filter performance, in addition to activation, are VOLUME of carbon and CONTACT TIME (which implies also low flow rate as it yields more contact time). So keep these two in mind, just in case.

The filter works by two ways: ABSORPTION and CATALYTIC REDUCTION (positive attractive negatives as explained before). It is a fact that we cannot activate our charcoal in the wilderness or at home. The only way we can make it work is by ABSORPTION, leveraging on VOLUME and CONTACT TIME (the longer the better).

However before anyone thinks of using charcoal as primary filtration or even as pre-filtering method, bear with me and read the following lines taken from a treaty on industrial pollutants filtration.

***“Activated carbon filters remove/reduce many volatile organic chemicals (VOC), pesticides and herbicides, as well as chlorine, benzene, Trihalomethane (THM) compounds, radon, solvents and hundreds of other man-made chemicals found in tap water.***

***Carbon filters are NOT generally successful at removing dissolved inorganic contaminants or metals such as minerals/salts (hardness or scale-causing contaminants), antimony, arsenic, asbestos, barium, beryllium, cadmium, chromium, copper, fluoride, mercury, nickel, nitrates/nitrites, selenium, sulfate,***

*thallium, and certain radio nuclides (uranium particles and the like).*

*Granular Activated Carbon does not remove sediment / particulate material very well, so they are often preceded by a sediment filter.*

*Sediment pre-filters also prolong the activate carbon cartridge life by eliminating gross contaminants that would otherwise clog the activated carbon thereby reducing the surface area available for absorption. Carbon block filters are generally better then GAC filters at removing sediment.”*

As stated before filter clogging produces a what is called “channeling” that is, the water takes the path of less resistance and basically pass through almost totally untreated. In listing what carbon does and doesn’t we are always talking about ACTIVATED CARBON.

In addition to, when it comes to pure filtration (e.g. pore sizes), the industrially produced carbon is kind of pre-engineered as to guarantee the pore size being this 50 or 0.5 microns. There is no way we can do that in the wilderness.

We are left with ABSORPTION only; this is why, if we get diarrhea in the wild and at home, we ingest charcoal pills or charcoal powder with water to utilize the absorption properties and reduce the amount of water flowing through (not healing or preventing dehydration). We might get lucky, from time to time, that with the water some microorganism causing the diarrhea get absorbed with it and expelled, but this is not 100% proven and it is a palliative.

Personally I find field made charcoal filters a waste of time, but that’s me and I’m open to debate on this. We cannot activate the charcoal thus making it almost useless for trapping some industrial pollutants (we might get lucky and some will stick to it, but that’s not enough, at least for me). We cannot compress it that much to be able to have a porosity that stops metal particles and microorganisms.

We can however rely on its porosity and absorption properties to do part of the work, part of the work, a small one, but again it is an intergalactic shot, farther than the moon.

**The reality is that when it comes to industrial pollutants, pesticide or fertilizers, there is very little we can do in the wilderness, we have to stay away from them, contact prevention through judgment and observation of the surroundings is, in my humble opinion, the solution.**

We have come to the end of our Safe Water trek. I thank our readers for their patience.

I have tried to share what I know about the subject and my personal experience, the fact that I’m here writing and (touch wood) that I have never ended up into a hospital following my treks and, worth mentioning, my work travels in some less than amenable countries, is a little tribute to the fact that most of it is reasonably sound, albeit common sense always have to come into play when it come to the application of academic knowledge.

A thank to Keith that has given me this opportunity to provide this little contribution to safe trekking.

In conclusion, a humble word of advice, read the chapter, digest first the principles and after the numbers (the least number of them). In a true survival situation we are called to make infinite judgment calls, knowing the principles, will help you making those calls if the situation departs from the boundaries of the laboratory results' basis which produced the numbers.

If you need numbers, memorize the least number of them, it is likely that in an emergency you won't remember more than a couple.

We have seen that we need at least to have filtration (a rough one) and boiling capabilities. **This means we need a reliable way to make fire in dry and wet conditions (master three ways of doing fire, you'll never run out of options) and know how to make it with closed eyes (sort of speak).** We need a container that can go on fire, there is little point in starting a fire having the water to be treated stored in a plastic can, but this is common sense.....

If no fire we need filtration (a good one) and a chemical treatment or SODIS as last option.

Know all of them. It will increase your flexibility in emergency and your chances to make it out. But remember, if in doubt and if you can make a fire, your first option remains: **BOIL IT\***.

**\*INTERESTING END NOTE:**

After many recommendations of having a water container that can go on a fire, one handy thing to know, if push comes to shove, is that water can be boiled in a PET bottle as well.

Sound strange but it is entirely a feasible proposition provided that:

- a. The water is filled to the top in such a way that there is no air between the cap and the bottle content, and
- b. The bottle so filled is placed on hot coals with the cap not resting directly over the hot coals or any residual flame (caps are generally not made of PET),

Having done all of the above we will notice that, as the water heats up, micro bubbles will start to form in ever increasing number to the point that, as the temperature reaches the boiling point, an air space will form inside the bottle where the bubbling effect of boiling can be clearly seen.

With the necessary precautions, remove the bottle from the hot coals, beware it will be hot, and leave it for a while to cool down. Exercise a bit of caution when opening it, **there will be some pressure.**

This method, if properly used, allows the utilization of the PET bottle for several treatments if not indefinitely. I recommend trying this at home to perfect the technique it is a handy thing to remember and a lot of fun to show, safely, to our friends.