1,000 Bottles of Water on the Roof, by James C.

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It is predicted that 76 million people will die from water related diseases by the year 2020. This statistic may be a drastic underestimation if the collapse occurs before the end of the decade.
Imagine that you just used up your last pocket micro-filter, and although you have access to fresh water, you have no way to purify it. You think about starting a fire to cleanse your mucky pond water or reclaimed rainwater, but looters have sacked several outposts that you trade with in the area, and you fear smoke from a fire may draw unwanted attention to your retreat. Your family is in need of water, what do you do? Well, you may have a supply of water stored in containers from last week in your cache, but if you did not read this article you would not know that the water you stored is now only moderately cleaner than the barrel, river or lake that it came from.

It is known by virtually everyone in the United States that if you boil your water it is safe for consumption. The *Clasen 2008: Microbiological Effectiveness and Cost of Disinfecting Water by Boiling in Semi-urban India*, exposes this well-known fact to be true, but also discovers the downfall associated with boiling water occurs in its storage after boiling.

Clasen verifies in the field by observing pasteurization habits performed by locals, not scientists in a laboratory, that 99.9% of dangerous materials were removed from water with high fecal matter content in India. The fact that boiling water in a third world country where water quality is beyond horrible should make everyone feel a little safer about using pasteurization as a primary means of water purification, but the study further tests water which had been stored after boiling. The research published discovers that less than 60% of the stored water met the World Health Organizations standards for quality drinking water. How can this be?

The study reveals that a very high percentage of households where drinking water is first boiled that re-contamination occurs during storage and results in the consumption of polluted water. Unlike chemical treatment there is no residual treatment of the water after the water is boiled and placed in a container for storage, so bacteria re-growth is possible even with the slightest contamination. It is important to note that boiling water is by far the preferred method for treating water because when done properly it kills

100% of the pathogens. Clasen's research highlights the importance of practicing proper water boiling habits and the need for a secondary system to provide an extra measure of safety to ensure that your drinking water is safe.

Secondary Systems of Treatment

I am a fan of learning skills that are not reliant on an open loop supply chain. I have spent the last year practicing my gardening skills, learning how to harvest fruit and vegetables, as well as seed harvesting and storage. This is a closed loop system and is infinitely viable. Much of the material that I have read on water purification focuses on technology or low-tech systems that rely on the availability of machined products. The problem with anything mechanical or technical is that eventually it will break or simply wear out, and then you are faced with the question, *now what?* I like to take a bottom up approach to all of my preparations. If someone says you should have a steady supply of salt and sugar, the first question I ask is *how do I make my own salt and sugar?*

In the short term many people will be able to use chlorine, hydrogen peroxide or other forms of chemical treatment as a secondary form of water purification after pasteurization to reduce re-contamination during storage. Even if you are lucky enough to have a 'Big Berkey' I would recommend treating any water that is stored, no matter what the primary system of purification is. But what happens when you run out of chlorine or hydrogen peroxide? If you live close to the coast, then salt production can easily enable an endless supply of chlorine, but unfortunately the production of hydrogen peroxide is by far more complicated and dangerous, *so what do I do if I am not a mad scientist?*

There is another system of water treatment that exists within a closed loop regardless of your location because it makes use of the sun's powerful UV rays. Although the SODIS method can be used as a primary means of purification, it does not offer a 99.9% treatment capability like pasteurization. The advantage of SODIS (solar disinfecting) is that the water treated is easily stored in the same containers that are used to purify the water, which eliminates the risk of re-contamination. If you plan on using, consuming or cooking with the boiled water immediately then you are relatively safe and a secondary system is not needed. The purpose of this article is to highlight the dangers associated with water storage and provide readers with a closed loop system that ensures that the water stored after TEOTWAWKI is just as safe as water that is consumed after being boiled.

SODIS

In 2009 my architecture firm began designing a portable disaster relief housing unit that could easily be deployed in response to 'Hurricane Katrina'-type natural disasters. I began researching sustainable technologies that could be implemented in the design to give disaster survivors food, energy and fresh water in a closed loop system. Photovoltaics, natural ventilation, and the ability to grow food on the roof of the structure were all ideas that were incorporated in the design, but water purification technologies either required too much space, complicated mechanical equipment or would eventually require maintenance, and consumed large amounts of energy. After all we had to work with a 10' x 40' footprint for easy transportation.

As my research intensified, I began studying water purification techniques used in third world countries. There is one method of water purification that is infinite and accessible to all, the sun. The SODIS (*solar water disinfection*) method does not require any mechanical devices, electrical power or chemicals. All that is required is a plastic/glass bottle and some sunshine. There are tidbits of information and misinformation regarding SODIS all around the web. I have collected all of this information in hopes of compiling a definitive guide on the process.

How does SODIS work?

UV light destroys the cell structures of bacteria by interfering directly with the metabolism of the bacteria. The UV light additionally reacts with the oxygen dissolved in the water and produces oxygen free radicals and hydrogen peroxides that are believed to also damage pathogens, preventing reproduction. The solar radiation heats the water and if the temperature rises above 122 degrees Fahrenheit then the disinfection process occurs three times faster. The SODIS method has been proven to destroy diarrhea-causing organisms in polluted drinking water and laboratory experiments have shown that extremely high levels of E. coli populations 100,000 (1-3,000 is a natural maximum) per 100ml of water can be made harmless.

The UV rays can kill germs such as viruses, bacteria and parasites in as little as six hours of exposure to the sun

Bacteria are highly sensitive to UV-A radiation (wavelength 320-400nm) and are quickly killed by sunlight. This is the principal concern when storing water.
The viruses are slightly more resistant, but are also killed within the recommended 6

hours.
Parasites are less sensitive to sunlight. While giardia cysts are rendered inactive within 6 hours, cryptosporidium cysts must be exposed to direct sunlight for at least 10 hours before they are neutralized. Amoebas do not die until the water temperature has been warmer than 50°C for over an hour.

The Process

First, you must be sure to use clean PET bottles, see the next section on *bottles* for more information. Fill the bottles with water and close the cap. Bottles should only be filled three-quarters of the way full and be shaken vigorously for 20-30 seconds with the cap on to increase the oxygen content of the water. After oxygenating the water, fill the bottle completely and recap. If you can read black printing on a white paper through the bottle, then the turbidity is low enough that the UV rays from the sun will be able to purify the water. For water with high turbidity use smaller diameter containers so that the sun can fully penetrate the water. If the water is very cloudy then it must be filtered before using the SODIS method, and in general I recommend always filtering water first even if you plan on boiling. The filled bottles need to be exposed to direct sunlight for at least six hours or two days under very cloudy conditions. Solar reflectors or metal roofs are preferred because they increase the amount of sunlight that infiltrates the bottle. After the water has been purified it can be stored in the plastic or glass bottles that they were sterilized in until it is time to drink or use the water. The risk of contamination is greatly minimized if the water is stored in the bottles used for solar disinfection.
Re-growth of bacteria may occur if the water is stored in the dark. Recent studies have shown that simply adding ten parts per million of hydrogen peroxide is effective in preventing the re-growth of wild Salmonella. In addition table salt is an effective agent for reducing the turbidity.

Type of Bottles:

All bottles are *not* created equal. Thin-walled polyethylene terephthalate, labeled PET or PETE in the US can safely be used for SODIS. These are the water bottles that are marked with a "1" recycling symbol on the bottle.
Nearly all soda bottles, including 2 liter bottles which are great for daily use can be used for SODIS. Care should be taken to minimize scratches and wearing of bottles as this reduces the efficiency of SODIS, because it prevents UV rays from passing through the plastic. Typically plastic bottles need to be replaced every 6-12 months, although if greater care is taken or glass is used then the life-cycle of the bottles is greatly increased. Glass bottles can be used and will last forever under proper care, but you must be sure

that they are free of UV-blocking additives.

Additional Filtering

If additional filtering is required there are a number of means that can greatly increase the quality of drinking water. The following is a great source on SODIS and secondary means of water filtration: http://fundacionsodis.org/site/index.php/simple-solutions/safe-water-tutorial/filtering

Due to the abundance of sand in my region, I am biased towards the sand filter, which conveniently is the lowest tech filter of the bunch.

The PotaVida indicator: Practice Makes Perfect

The PotaVida indicator, is not required, but is a great tool to have as you hone your SODIS skills. The indicator is designed to tell you when the water has reached a safe level of drinkability by measuring the water's exposure to solar irradiation. The PotaVida indicator is not needed for each bottle, it simply measures sun exposure and calculates based on the actual conditions when your water is purified. Get to know how long it takes on a cloudy day in February in your region for a water bottle to be exposed to enough solar radiation to be purified. Keep a journal and log the temperature, day, and the conditions of the sky. This information may save your life one day. It is important to note that this is a learning device that helps you perfect your SODIS skills. The PotaVida indicator runs on solar power, lasts for five years and the price is less than $10 per indicator.

Do Chemicals Leach from the PET bottles?

The leached organic compounds amount to less than 10% of the safe amount for drinking water as defined by the World Health Organization, and studies have shown that no other chemicals are leached into the water during the SODIS process.

If you are using glass bottles then there is no risk of any leaching.

What mistakes do new users make most often?

Use only clear bottles, do not use green or brown bottles because these bottles absorb UV-A light.

Do not use bottles that hold more than 3 liters or are greater than 4" in diameter.

Do not place bottles vertically, they must be laid horizontally. This increases the area exposed to the sunlight and reduces the effective depth of the water the light has to penetrate.

Keep the treated water in the same container, remember that we are trying to prevent re-contamination.
Do not store treated water in dark places, this encourages growth of bacteria. If limited algae growth occurs, the water is still drinkable. Algae are not harmful.
Check the turbidity, pre-filter or better yet, pasteurize your water before using SODIS.

What does SODIS *not* remove?
SODIS does not remove any toxic chemicals that may already be in the water, which makes it ideal for rainwater sterilization.

Closing Water is by far the most important resource and although there may be some skeptics that dismiss SODIS, it is always wise to be aware of multiple ways to purify water off the grid, and to know the pros and cons associated with each. I strongly encourage everyone to question their strategies for water purification and to become familiar with SODIS and the Readers should also familiarize themselves with the *Guidelines for Drinking-Water Quality, third edition*, incorporating first and second addenda, which is available as a free PDF.