SODIS - Light Amplification
Using the Solar Jacket

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A Word of Caution
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Solar Water Disinfection (SODIS) is the easiest method I know for making naturally contaminated water safe to drink, using solar energy. Figure 1 shows the basic SODIS method. The procedure was developed by the Swiss Institute for Aquatic Science and Technology (EAWAG) and is endorsed by The World Health Organization (WHO), UNICEF, and the Red Cross as a way to treat household water in developing countries. The official website of EAWAG for SODIS is Sodis.ch. SODIS can be used as an alternative to water pasteurization (heating above 150° F), where pasteurization is not practical or economical. In SODIS clear plastic bottles made of PET (Polyethylene terephthalate) are filled with contaminated water and left exposed to direct sunlight for at least 6 hours. The heat of the sun plus ultraviolet (UV) radiation interact to kill harmful bacteria, virus and microbial cysts that cause diarrhea and other water borne illness. SODIS is NOT used to treat chemically contaminated water, seawater or brackish water. Also, SODIS is NOT a filter or purification system. EAWAG recommends filtering turbid water before applying SODIS. When only turbid water is available - I recommend boiling, chlorine treatment or solar *thermal* pasteurization methods like the Solar Kangaroo instead of SODIS.

Figure 1. Basic SODIS method = water bottle + 6 hours of sunlight.

SODIS works because UV radiation interferes with the metabolism and destroys the cell structures of bacteria. UV also reacts with oxygen in the water to create some oxygen free radicals and hydrogen peroxide that also aid in killing bacteria and virus. Finally, infrared radiation (IR) heat from the sun works with UV to help kill bacteria when temperatures rise to at least 120° F (50° C).

SODIS is used in over 30 counties by over 3 million people worldwide as a simple and inexpensive means of water treatment and storage for individuals and households. Countries where SODIS is used include Brazil, Kenya, India, Pakistan, and Indonesia. Generally, any location +/- 35° latitude from the equator is suitable for SODIS. In practice, 1.5 - 2 liter clear plastic bottles are filled with water. It is recommended to fill the bottles about halfway, shake the contents for about 20 seconds to oxygenate the water, then fill the bottles up to the neck of the bottle. Next, the bottle(s) are exposed to direct sunlight for 6-10 hours (all day). Ideally, the bottles are placed on a sloped sun-facing corrugated metal roof or panel. In addition to maximizing sunlight, the corrugated metal provides infrared heat and reflected UV radiation. Also, placing the bottle at an angle keeps water from remaining under the bottle cap where bacteria can hide and re-contaminate the water later (in storage). However, in actual use, bottles may simply be laid sideways on a flat ground or surface (c.f., Figure 2). Water remains under the bottle cap where bacteria can hide to re-contaminate water in storage. Where corrugated roofs or panels are not available, thatched or other non-metallic roofs are used. Many of these other surfaces may provide IR heat, but are poor UV reflectors.

Figure 2. Indonesian SODIS users (Source: SODIS Eawag)

The Solar Jacket

The Solar Jacket is a SODIS tool I invented to help collect, focus and amplify available sunlight including UV radiation. I developed the Solar Jacket in May, 2010. Figure 3 shows the amplified SODIS method I developed using the Solar Jacket. Below, I describe its development, application and construction.

Figure 3. Amplified SODIS method = water bottle + solar jacket + bottle stopper + 6 hours of sunlight

As I see it, there are three main components to the SODIS system: the sun, the surface where the bottle is placed, and the bottle. The sun is the sun; we can do nothing to change the sun. We just have to wait for mostly sunny skies to use SODIS and place our bottle(s) to maximize exposure. The surface where we place our bottle(s), should be 'shiny' so that the suns' UV and IR rays can be reflected back into the water. Also, the surface should be capable of absorbing and transferring IR heat. This is why corrugated metal roofs and panels are so good. Finally, In addition to being made from clear PET plastic or glass, I believe the bottle can be improved to focus and reflect sunlight thereby amplifying the available UV/IR radiation that impacts the water.

My humble contribution to the field of SODIS is the simple observation that I could greatly increase the sunlight/UV exposure of water in a bottle by adding up to four overlapping ~11 inch strips of white plastic or aluminum foil duct tape (1.89 inch) to the back of a clear SODIS bottle. I cover at least 1/3 but no more than 1/2 of the bottle with this reflective tape. Figure 4 shows a SODIS bottle wrapped 1/2 with white plastic duct tape. Next, I lay the bottle on a flat surface with the clear side centered and facing the sun. Doing this creates a small parabolic trough that focuses and reflects the sunlight back into the water - giving bacteria a double whammy! Figure 5 shows a side-by-side comparison of a bright and shiny taped SODIS bottle next to a basic SODIS bottle. Similarly, I have found that the same principle applies to water bags. One side of a SODIS water bag can be treated with white plastic or aluminum foil duct tape to make it more UV reflective. Bottles and bags shine so brightly - it hurts my eyes. Further, with sunny skies and air temperatures of at least 85° F (29° C), water in the bottle is heated to ~120° F (50° C) in about 5-6 hours.

Figure 5. Taped SODIS bottlle (left) compared to basic SODIS bottle (right).

(3)

Bottles treated with white plastic tape appear to reflect more bright diffuse light while aluminum is more like a mirror where you can see the sun reflected better. Aluminum has better parabolic properties and creates a warmer focal point in the center of the bottle. Aluminum foil tape is more rigid and easier to handle than white plastic duct tape. However, aluminum will begin to oxidize and discolor if exposed to water, so the surface needs to be kept clean and dry. Plastic is far more water resistant. I have a hard time choosing between the two, but plastic duct tape is ~50% less expensive than aluminum.

Moreover, by cutting a 2 liter soda bottle in half, lengthwise, and applying eight strips of white or aluminum duct tape, I can make two reusable Solar Jackets which fit on any other 2 liter SODIS bottle of the same dimension. Applying the tape this way allows us to use the more shiny and bright side of the tape instead of the less shiny adhesive side. The jacket has a durable reflective surface on the inside and a hard plastic shell on the outside to protect it from surface friction. I also find that it is easier to maintain a few reusable jackets than dozens of taped bottles. This is a savings over treating every bottle with tape. Furthermore, I can think of no better use for a discarded plastic soda/water bottle. About 85% of used plastic bottles are discarded and end up in landfills. This includes millions of bottles, annually. The production of SODIS bottles and Solar Jackets from recycled PET bottles will help ease both our safe water crisis and plastic pollution problem. Figure 6 shows a comparison of jacketed aluminum and white plastic SODIS bottles (left) with a basic SODIS bottle (right).

Figure 6. Comparison of jacketed aluminum and white plastic SODIS bottles (left) with a basic SODIS bottle (right).

Another advantage of this method is that the surface where we place our bottles becomes less relevant. Our main concern becomes exposure to sunlight. I have found that bottles laid flat on the ground get the best exposure when positioned East to West. Bottles on a roof or other sloped surface should be facing South (if north of the equator) or North (if south of the equator). Using our Solar Jacket, we can increase the water temperature by placing our bottles on dark (black) surfaces like asphalt, old concrete slabs or dark soil. In some parts of the world, pasteurization temperatures could be reached. At this time, I am not

advocating that sunlight exposure time can be cut using this method, but the time spent will be far more productive in killing harmful bacteria and virus.

Another recommendation is that when bottles must be laid flat, we can avoid bacteria hiding under the bottle cap by replacing the cap with a recycled wine cork or soda bottle stopper. A cork or stopper pushes most of the water out from the neck and into the main body of the bottle. The goal is to spare bacteria no quarter, no safe haven. Below, I show how to make a simple yet effective SODIS bottle stopper.

Finally, if we place jacketed or taped bottles on an uneven surface, the bottles may roll around and block the sunlight. We can prevent this by placing multiple bottles together or placing small pebbles or twigs to the underside of troublesome bottles/jackets. I have also taped a couple of small pebbles to the underside of jackets for stability.

Steps for Making a Solar Jacket

Materials (brands in parenthesis)

All these materials may be purchased in the USA at most large hardware stores and supermarkets. I found everything between Loews, Home Depot and any food market that sells soda in 2 liter bottles. Everything you need is shown in Figure 7.

A clear PET plastic 2 liter bottle (recycled soda bottle).

Aluminum Foil Tape (Shurtape at Loews or Nashua 322 Aluminum Foil Tape, 1.89" at Home Depot hardware)

OR

White plastic duct tape (Shurtape white duct tape 1.88" at Loews hardware).

Wine cork (recycled)

.104"x 2 1/16" screw eye (at Loews hardware).

Tools (for cutting)

Razor knife, sheet metal sheers, and scissor

Figure 7. Materials and tools used in making a SODIS Solar Jacket.

Step 1: Cut the bottle in half

You will be making two Solar Jackets from one 2 liter bottle. The bottle can be in poor condition, including a discarded SODIS bottle. We are interested in its' frame not its' appearance or ability to hold water. Remove the cap and any plastic rings about the neck.

Begin cutting the bottle at the opening using your sheet metal sheers. Try to line up with any existing seams, and if possible, sheer the bottle in half in one continuous cut. You should end up with two equal half sections as shown in Figure 8.

Figure 8. Two equal half bottle sections.

Step 2: Apply the reflective tape.

Apply four ~11 inch white plastic or aluminum reflective duct tape strips to the inside of each half-bottle section - one strip at a time. Avoid taping the neck and base parts. After you finish applying the tape, cut the neck and base parts of the half sections away. The finished Solar Jackets are shown in Figure 9.

Figure 9. Completed Solar Jackets - aluminum foil tape (left) and white plastic duct tape (right)
(1)

Step 3: Make a bottle stopper (optional)

Figure 10 shows how we make an inexpensive and effective SODIS bottle stopper with a recycled wine cork and a .104 x 2 1/16 inch metal screw eye. The cork may be natural or synthetic. The screw eye can be installed manually without tools. A small dab of glue may be used on the threads of the screw for better security. Inserting the screw eye makes the cork fit nice and snug into our bottle and provides a convenient handle to pull the cork out later. I've held filled bottles upside-down and shaken them, without incident, using these simple, handmade bottle stoppers. Later after disinfection, we may carefully replace the stopper with a clean bottle cap for storage.

Figure 10. Simple cork and screw eye SODIS bottle stopper

In Conclusion

The Solar Jacket is a simple do-it-yourself tool for water disinfection using solar energy. It is based upon the proven and reliable SODIS method that was developed by EWAG and is endorsed by the The World Health Organization (WHO), UNICEF, and the Red Cross. I have shown how we may amplify the germ killing power of SODIS in about ten minutes and at a cost of ~50 cents with the Solar Jacket. Figures 3 and 6 show the significant sunlight amplification that is possible using a Solar Jacket. A snug, secure bottle stopper instead of a cap gives fewer places for germs to hide. Further, with a few minutes instruction, the Solar Jacket can be hand-made by any able-bodied person. Given the materials and simple tools, one household in a developing country can make all the jackets they need in about an hour. It may also be a good idea to encourage household cottage industries to produce and sell Solar Jackets to other people in communities where they live. The Solar Jacket and stopper will help provide both safe drinking water and an extra income for enterprising people in developing countries. Finally, the Solar Jacket may allow the application of SODIS well beyond the current +/- 35° latitude from the equator. Many more lives may be saved worldwide.

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