SAFE WATER INTERNATIONAL
Safe Water International is a tax-exempt organization for purposes of U.S. federal and California state taxes

5184Cambridge Lane, Carpinteria, California, 93013 USA
(805) 684-2911 FAX (805) 684-2911 e-mail: swi@cox.net
www.safewaterintl.org

BOLIVIA SOLAR WATER PASTEURIZER DEMONSTRATION

Background. The Safe Water International (SWI) Bolivia demonstration project seeks to test an inexpensive water treatment option for families that live in water scarcity areas. Typically, such areas have an abundance of sunlight, yet available water sources become increasingly polluted by agricultural, animal, and human wastes during the dry months of the year. The mission of SWI is to identify and demonstrate drinking water treatment systems which can effectively and economically serve households and neighborhoods in the poor rural regions of the world. SWI demonstrations are intended to display drinking water solutions that can be delivered to poor families via the marketplace.

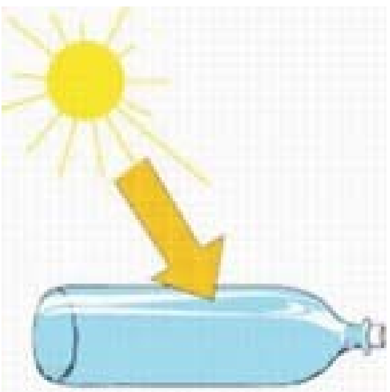
The dry season in SE Bolivia - October 2005

A new solar distillation unit, the SunRay30, has been developed by Safe Water Systems of Honolulu, HI. There is no organizational relationship between Safe Water Systems and SWI, but the two organizations have worked together for many years. The SunRay30 is designed to provide up to 7 ½ gallons of potable water per day using solar pasteurization and solar UV sterilization. A single batch of treated water produces nine to ten liters, or a little more than two gallons. On sunny days the unit is capable of producing three batches of potable water per day.

The retail price for the unit is expected to be about $125.00, a price beyond the reach of the rural poor. Because of its simplicity the unit, or some variation if it, could probably be produced and sold at a lower cost. The strong interest of SWI in this unit is based on the prospect of a cheaper price more within the reach of the rural poor.

Bolivia's Chaco Region. Because of its flat contours and abundance of sunlight, the so-called Chaco region of southeastern Bolivia provides an optimal location to test the effectiveness of solar drinking water applications and to learn the willingness of families to make regular use of them. With the financial assistance of the non-profit organization Global Water, the SunRay30 was placed in two homes and in a school in rural Bolivia in March 2006 to record acceptance and effectiveness over a prolonged period. In late June 2006, performance data was taken from one of the SunRay units and from SODIS water treatment bottles at the same location to understand the operating cycle of the SunRay30 and to compare its performance with the SODIS method of solar water treatment.

SODIS. In the early 1990s the Swiss Federal Institute for Environmental Science and Technology (EAWAG) developed and began promoting the SODIS method of exposing contaminated water to solar heat and UV radiation to remove pathogens and organic pollutants. As described by EAWAG, the SODIS method "improves the microbiological quality of drinking water, using solar UV-A radiation and temperature to inactivate pathogens causing diarrhoea." The combination of solar heat and solar UV rays are said by EAWAG to remove more than 99 percent of diarrhea-producing bacteria when there is sufficient sun and when the water to be treated is not excessively cloudy.



The SODIS method is the essence of simplicity. It requires only that a one liter or one quart clear plastic bottle of water be exposed to the sun for a prescribed period. To achieve optimal results, EAWAG suggests the following solar exposure:

ooo

The container needs to be exposed **to the sun** for **6 hours** if the sky is bright or up to 50% cloudy

The container needs to be exposed **to the sun** for **2 consecutive days** if the sky is 100% cloudy.

If a water temperature of at least **50°C** (122° F) is reached, an exposure time of **1 hour** is sufficient

Data Collecting Procedure. Four temperature readings were taken at various intervals during three days of data collection to compare the performance of the SunRay30 to the SODIS method of solar water sterilization:

(1) Outside temperature
(2) Temperature inside SunRay30
(3) Temperature of water inside a SunRay30 storage bottle
(4) Temperature of water inside a SODIS bottle

On the first day of data collection, June 27, 2006, the four readings were taken every fifteen minutes from 11:00 a.m. to 4:30 p.m. There was bright sun throughout the day, and the outside temperature reached 91° F in the early afternoon. The purpose of the frequent temperature readings on this first day was to understand the rate at which the two solar treatment methods achieved effective temperatures and to observe the rate at which water temperatures rose and fell.

The second day of data collection was intermittently cloudy with a high temperature of 78° F at noon. These conditions offered comparative readings at less than optimal solar conditions, and the readings were taken every half-hour.

The final two days of readings were completely cloudy with a maximum temperature of 78° F. Because of the sunless conditions, the SODIS and SunRay water bottles were given an additional day of solar exposure – also a sunless day. Temperature readings were only taken on the first of the two cloudless days.

Water Testing Results. The source water used each day was taken from the same spigot fed by a local well system. The Hach PathoScreen testing method was used to determine the presence of fecal bacteria. It uses a chemical medium to detect hydrogen sulfide-producing bacteria associated with the presence of fecal contamination. While the test does not indicate the volumes of bacteria present, it gives clear indication of the presence or absence of the indicator bacteria. The tests produced consistently positive readings for the source water used in the two solar devices, indicating the presence of hydrogen sulfide-producing bacteria.

The treated water from the SunRay30 and the SODIS method produced identical results on day one and day two of testing. On both days, the SODIS water tested positive for the presence of fecal bacteria, and the SunRay30 did not. Day one had been cloudless and sunny, while the second test day had intermittent clouds and was more than ten degrees cooler than the day before.

The water tests performed after the final two sunless days of solar exposure showed the the water in both the SODIS and SunRay containers to be free of hydrogen sulfide producing bacteria. This water had been left outdoors for two successive sunless days, as suggested by the SODIS guidelines mentioned above.

Comparative Performance. The data charts below show that water in the SunRay30 reached much higher temperatures much more quickly than did the SODIS water. The first day of data collection is particularly instructive, since readings were taken every fifteen minutes in hot, cloudless conditions. The water inside the SunRay30 quickly became twenty degrees hotter than the SODIS water, and after a few hours, there was a fifty degree temperature difference between the two.

There are varying reports on what temperatures must be reached for effective solar pasteurization. In combination they suggest water must reach a temperature of at least 120 degrees to begin the pasteurization process. The above mentioned guidance from the Swiss agency, EAWAG, suggests a water temperature of 122° F for one hour for effective treatment. Safe Water Systems advises that a temperature of 145° F be reached for effective pasteurization.

A second consideration for solar water treatment is the effect of solar UV radiation which is said to deactivate rather than destroy disease causing pathogens. Because the SODIS method does not reach the water temperatures needed to fully pasteurize drinking water except at extremely high outside temperatures, the effect of accompanying UV radiation is counted on to complete the disinfection process. The final water tests taken for this trial seem to bear out that the contention that the combination of solar heat and solar UV can be effective. The SODIS water left exposed to two cloudless days tested free of hydrogen sulfide producing bacteria.

Initial Conclusions. The initial data described here cannot be considered conclusive in any fashion, yet there are clear observations to be drawn. It is obvious that the type of enclosure used by the SunRay30, which resembles a solar oven, can bring treated water to much higher temperatures far more quickly than can the SODIS method. The few days of data collection and water testing that have occurred so far reflect the advantages of the higher heat efficiencies of the SunRay on both sunny and intermittently cloudy days, since the SunRay water tested cleaner than the SODIS water on both days. Of course, far more exhaustive testing is needed to validate these results over the long term.

The only fair conclusion to be drawn at this point is the pronounced heat advantage created by the type of enclosure used by the SunRay30. Conversations with Safe Water Systems, the developer of the SunRay30, indicate that the materials in the SunRay are not holding up to long-term exposure to hot sun. The ability of materials to withstand consistent high temperatures is certainly relevant to the practicality of a device like the SunRay30.

Further, the SunRay is limited in its capacity in that it treats 10 one-liter bottles at a time. The SODIS method is constrained only by the amount of space available for laying out one liter bottles in the sun. With sufficient space, any number of bottles could be treated at the same time, and presumably these bottles can be obtained at no cost.

Next Steps. The data collection reported here is one part of the SWI demonstration that is expected to continue through 2007. Customer convenience and satisfaction are both important factors, and customer surveys will be taken on the next field visit in late 2006. As inspections of the SunRay30 units continue, attention will be paid to the impact of the temperature conditions in SE Bolivia and to the materials used in the unit. Conversations will continue with the developer to seek design modifications that might improve the unit.

Because of its relative compactness, its potential for economical manufacture, and its apparent effectiveness in producing potable drinking water, the SunRay30 is a very attractive household water treatment prospect at this stage. Obviously, the SunRay30 must be able to serve the test of time to merit widespread use.

SUNRAY DATA CHART

Unit #: 1 Date: 6/27/06

Location: Macherati, Bolivia Alojamiento Doña Nancy

I. Temperature Readings

Time	Outside Temp	SODIS H_20	SunRay Temp	SunRay H_20 Temp	Notes
11:00am	75 (F)	75 (F)	80 (F)	75 (F)	1st Sun 10:50 am; no clouds. Direct sun throughout test
11:15	75	80	115	89	
11:30	78	80	125	98	
11:45	84	84	125	105	
12:00	88	88	130	113	
12:15	90	89	135	120	
12:30	88	91	140	125	
12:45	88	92	140	132	
1:00	90	95	140	138	
1:15	88	97	145	141	
1:30	88	97	145	143	
1:45	89	99	145	147	
2:00	91	99	145	149	
2:15	86	101	147	150	
2:30	82	101	147	152	
2:45	84	101	145	152	
3:00	77	101	140	152	
3:15	75	101	137	152	
3:30	72	101	135	150	
4:30	74	99	124	141	

II. HS Bacteria Test

Date	Input Water Pos/Neg	SODIS Bottle Pos/Neg	SunRay30 H_20 Pos/Neg	
6/27/06	POS	POS	NEG	Per Hach PathoScreen Field Test Kit; results read 6/28/06 Taste of SunRay water good

SUNRAY DATA CHART

Unit #: 1 Date: 6/28/06

Location: Macherati, Bolivia Alojamiento Doña Nancy

I. Temperature Readings

Time	Outside Temp	SODIS H_20	SunRay Temp	SunRay H_20 Temp	Notes
11:00	74	75	112	86	Cloudy; intermittent sun
11:30	77	77	112	91	Cloudy; intermittent sun
12:00	78	79	114	98	Cloudy; intermittent sun
12:30	75	80	115	102	Cloudy; intermittent sun
1:00	75	81	115	105	No sun, complete cloud cover
1:30	74	81	115	106	No sun, complete cloud cover
2:00	75	81	115	109	No sun, complete cloud cover
2:30	73	80	110	109	No sun, complete cloud cover
3:00	70	79	105	107	No sun, complete cloud cover
3:30	69	77	103	105	No sun, complete cloud cover
4:00	68	75	100	104	No sun, complete cloud cover

II. HS Bacteria Test

Date	Input Water Pos/Neg	SODIS Bottle Pos/Neg	SunRay30 H_20 Pos/Neg	
6/28/06	POS	POS (slight)	NEG	Per Hach PathoScreen Field Test Kit; results read 6/28/06 Taste of SunRay water good

SUNRAY DATA CHART

Unit #: 1 Date: 6/29-30/06

Location: Macherati, Bolivia Alojamiento Doña Nancy

I. Temperature Readings

Time	Outside Temp	SODIS H_20	SunRay Temp	SunRay H_20 Temp	Notes
6/29/06					
11:00	76	71	95	77	No sun, complete cloud cover
11:30	78	72	97	80	complete cloud cover
12:00	73	73	100	86	complete cloud cover
12:30	72	74	100	89	complete cloud cover
1:00	70	75	100	91	complete cloud cover
1:30	70	76	100	93	complete cloud cover
2:00	71	76	102	96	complete cloud cover
2:30	69	76	101	96	complete cloud cover
3:00					
3:30					
4:00					
6/30/06					SunRay30 and SODIS water bottles given second day of exposure due to absence of sun.

II. HS Bacteria Test

Date	Input Water Pos/Neg	SODIS Bottle Pos/Neg	SunRay30 H_20 Pos/Neg	
7/01/06	POS	NEG	NEG	Per Hach PathoScreen Field Test Kit; results read 7/1/06 Both SODIS and SunRay30 showed no signs of e-coli presence after two days of solar exposure.