Low-cost solar water purifier for rural households[1]

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Safe drinking water is the basic need of human beings. Microbial contamination of drinking water is a major health hazard. According to World Health Organization (WHO) each year diarrheal diseases claim the lives of approximately 760,000 young children throughout the world. There are many types of bacteria, viruses and protozoans responsible for diarrheal diseases with a range of persistence in water, infectious dose and health significance. Coliform bacteria which are present in large quantities in human feces are good indicator organisms for the presence of pathogenic bacteria and are relatively easy to determine by simple methods. For drinking water, WHO recommends that total coliforms must not be detectable in any 100-ml sample.

Researchers world over are developing or have developed low cost water treatment devices for rural households. They include filters, reverse osmosis (RO) and ultraviolet (UV) based water purifiers, among others. However these devices suffer from problems like filter clogging and their periodic replacement, wastage of water (in case of RO) and unavailability of electricity in rural areas for both RO and UV-based systems.

Nimbkar Agricultural Research Institute (NARI), an NGO working in rural Maharashtra has developed a unique and low cost solar water purifier (SWP) for rural households which does not require electricity or waste precious water.

SWP consists of four tubular solar water heaters attached to a manifold (Fig. 1). Non-potable water is filled in SWP after filtering with four-layered cotton cloth and heated in the stagnation mode by solar energy to make it potable.

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Fig 1. Four tube SWP

Tests done by NARI on this SWP for more than one year have shown that even on a completely cloudy and rainy day, water is heated to high enough temperatures to make it potable (Fig.3).

A similar system called SODIS uses water stored in PET plastic bottles and exposed to sunlight. The heat and UV radiation of the sun is supposed to make the water potable. However there are concerns of plastic from bottles leaching into water at elevated temperatures and also this system does not work under cloudy and rainy conditions. SWP uses glass tubes and hence any contamination with plastics does not exist.

NARI developed SWP in two steps. In the first step it developed a protocol for filtering unclean water through four-layered cotton sari cloth (mesh size less than 378 microns) and then heating it to 60°C for 15 minutes so that all the coliforms are inactivated. Tests done by NARI in its labs showed that such filtered water heated either to 60°C for 15 minutes or 45°C for 3 hours inactivated all the coliforms. The initial count of coliforms was between 1800 to 2400. Thus a temperature-time regime for treatment of filtered water was developed (Fig. 2).

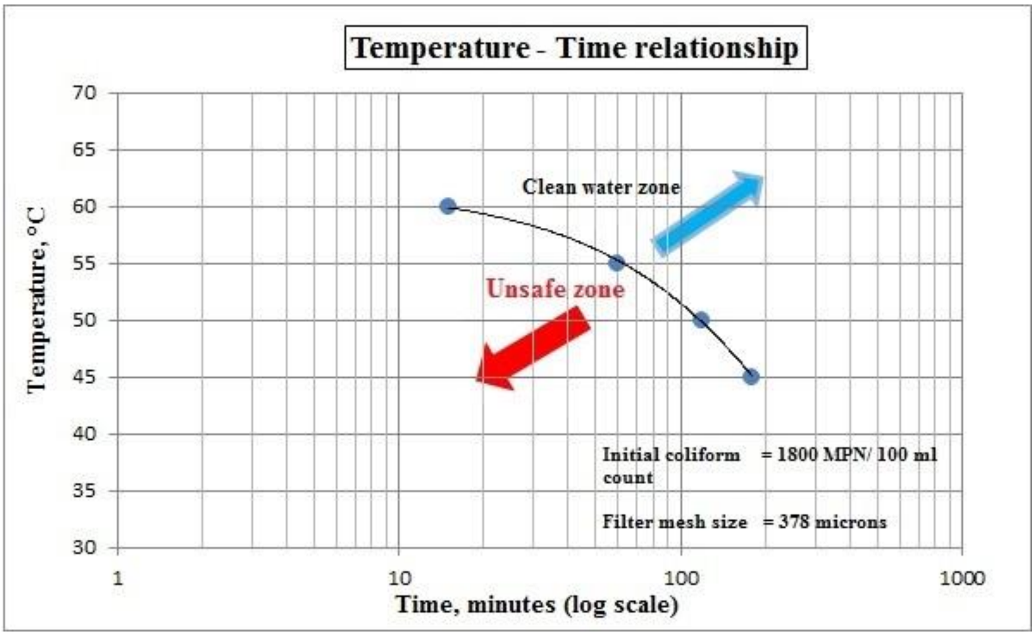

Fig 2.

The bacterial colony count was done in the Institute's microbiology lab according to well-known International protocols for such testing. NARI published a paper on this in Current Science in 2013. Since sari cloth is washed daily and hence this ensured that fitter clogging will not take place.

Once the protocol was developed, the next step was to develop an economic method of heating the filtered water in an environmentally friendly manner. Generally in rural areas wood is used for heating bath-water. This produces smoke pollution, is costly and time consuming in terms of wood collection. Hence a better method was to use solar energy and to see whether this temperature-time regime could be obtained in a simple solar device. The filtered water was therefore heated using the tubular solar collectors in the SWP. Thus every morning the water was put in the SWP; solar energy heated the water to the desired temperature and the potable water was taken out next morning from the unit.

The main criterion in designing the solar water heater was that under completely cloudy conditions the diffused solar radiation should be able to raise the water temperature above 45°C for more the 3 hours. Thus the collectors had to be very efficient. Tubular vacuum-based solar collectors (tube dimensions; 47 mm ID and 1.8m long; volume of each tube ~ 3 liters) fitted the bill. The tubes were fitted in a stainless steel manifold so that the total volume for 4 tube collector system is ~ 15 liters.

Data on this system has shown that only for three days in the whole year water temperature was below 45°C and on some of the cloudiest days when it was raining the tubular solar collectors heated the water to 45°C for 3 hours to make it potable.

Fig. 3 shows the yearly data of maximum water temperature reached in the system during 2014-15 and Fig. 4 shows a correlationship of solar radiation and maximum water temperature. Though this relationship is primarily valid for Phaltan weather conditions but as a first step can be used in designing the SWP in most places in India.

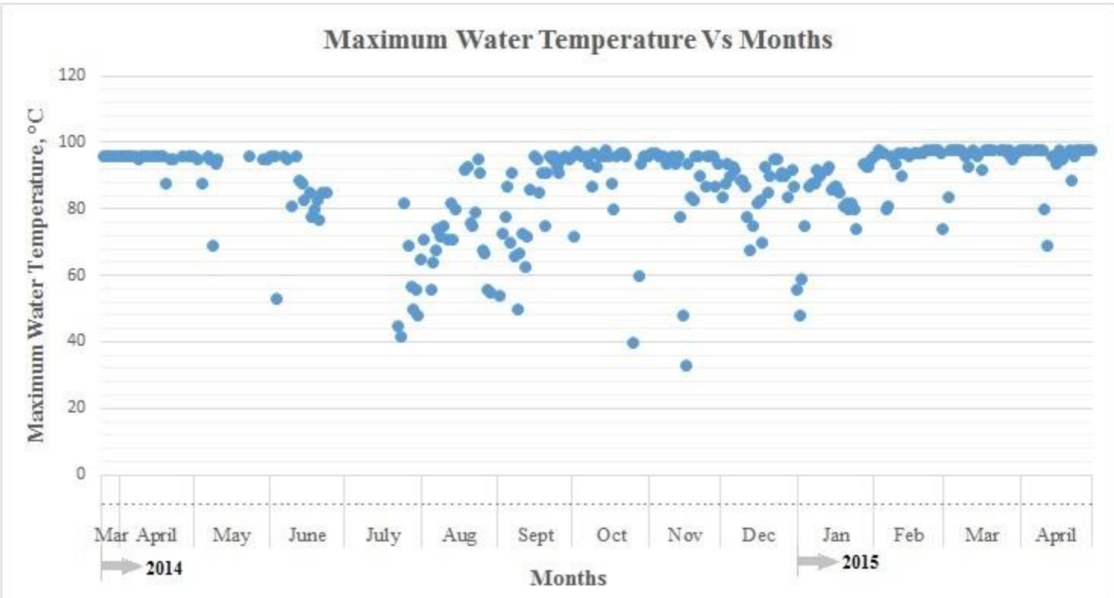

Fig 3. Graph of maximum water temperature vs. months

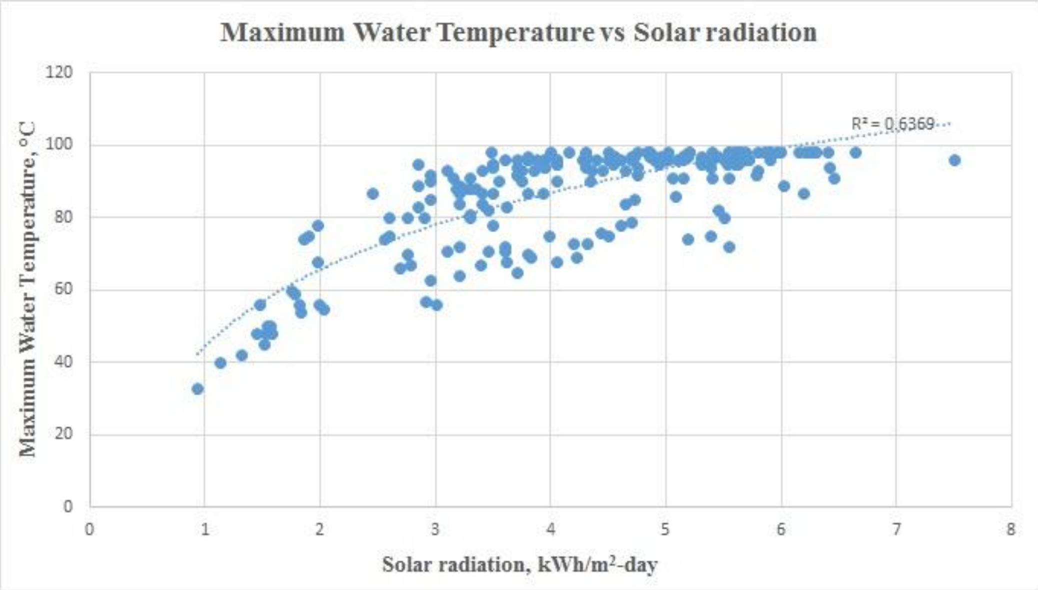

Fig 4. Maximum water temperature vs. solar radiation relationship

The cost of the SWP is around Rs. 2500 – 3000/- (~$40 - 50) and is so simple that any small rural workshop can fabricate it. In large scale production it is envisaged that the cost can come down to Rs. 1500/-. Thus a reasonably low cost and simple water purifier for rural households has been developed. The manual of SWP is available here. In addition, a YouTube video of the working unit is here.

We also feel that SWP can be an excellent system for providing clean drinking water in disaster affected areas. Besides it can also be used in conjunction with rain water harvesting to provide safe and potable water. However it should be pointed out that this system **does not remove or reduce total dissolved solids (TDS) like Arsenic or other salts.** For that some form of Reverse Osmosis or desalination system is needed.

Since last one year two such systems at NARI are producing around 30 liters of potable water daily for all its staff members. Fig. 5 shows the data of most probable number (MPN) of water from one of the units. A graph of temperature of water (at 3:30 pm local time) has been plotted against MPN. Around 3:30 pm the temperature of water in the tubes reaches a maximum and remains nearly constant for 3-4 hours.

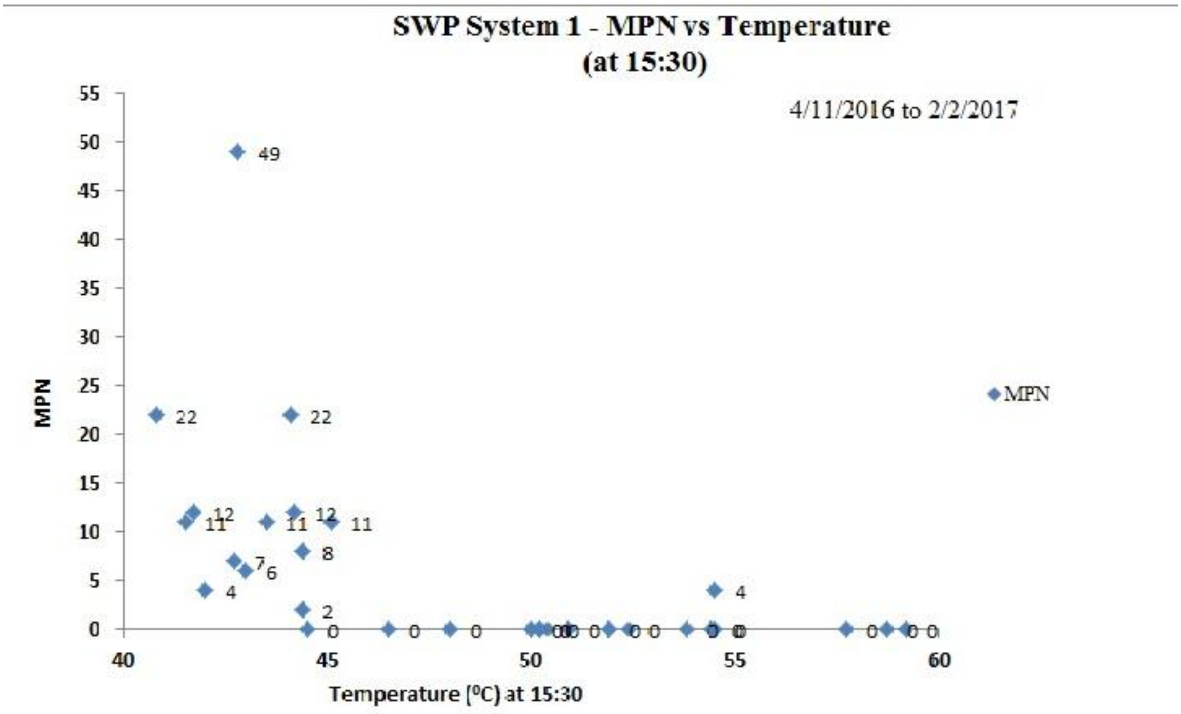

Fig.5 MPN vs. temperature of water in solar tubes

NARI is now looking for funds to scale up this technology for village level application so that 30,000-40,000 liters of water can be made potable daily for its residents. ***NARI has made available this technology free of cost for single household applications.***

We also feel that the hot water after sterilization, which is at temperatures around 80°C, can be used to **make ice via an absorption- type refrigeration system**. This ice, supplied in properly insulated ice boxes, can provide low cost refrigerators for unelectrified rural huts. Experiments are underway to develop an efficient absorption cooling system for SWP.

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News stories on this article appeared in various news lines like Business Standard, Moneylife, Newsgram, Huffington Post, among others. In addition Better India carried a special story on it.