# Low-cost solar water purifier for rural households

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*A simple, low-cost solar water purifier (SWP) for rural households, which does not require electricity or waste precious water has been developed. The SWP consists of four tubular solar water heaters attached to a manifold. Non-potable water is filled in the SWP after filtering with four-layered cotton cloth and heated in the stagnation mode by solar energy to make it potable. The cost of the SWP is around Rs 2500–3000 (~US$ 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. Details of the technology are provided in this article.*

**Keywords:** Coliforms, solar water purifier, tubular collectors, thermal degradation.

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)[1], each year diarrhoeal diseases claim the lives of approximately 760,000 young children throughout the world. There are many types of bacteria, viruses and protozoans responsible for diarrhoeal diseases with a range of persistence in water, infectious dose and health significance. Coliform bacteria, which are present in large quantities in human faeces, 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. These 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.

We have developed a unique and low-cost solar water purifier (SWP) for rural households, which does not require electricity or waste precious water.

The SWP consists of four tubular solar water heaters attached to a manifold (Figure 1). Non-potable water is filled in the 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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## Development of SWP and results

Tests done at Nimbkar Agricultural Research Institute (NARI) on the SWP for more than a year have shown that even on a completely cloudy and rainy day, water is heated to high enough temperatures to make it potable.

A similar system called solar disinfectant (SODIS) uses water stored in polyethylene terephthalate (PET) plastic bottles and exposed to sunlight[2]. The heat and UV radiation from the sun are supposed to make the water potable. However, there are concerns of bisphenol-A (BPA) from plastic bottles leaching into water at elevated temperatures and also ineffectiveness of the system under cloudy and rainy conditions, both of which have been confirmed in a recent study[3]. The SWP uses glass tubes and hence any contamination with plastics does not exist.

We have developed the SWP in two steps. In the first step a protocol has been developed for filtering unclean water through four-layered cotton cloth (mesh size less than 378 μm) and then heating it to 60°C for 15 min so that all the coliforms are inactivated. Tests done in our laboratories showed that such filtered water heated either to 60°C for 15 min or 45°C for 3 h inactivated all the coliforms. The initial count of coliforms was between

**Figure 1.** Four-tube solar water purifier.

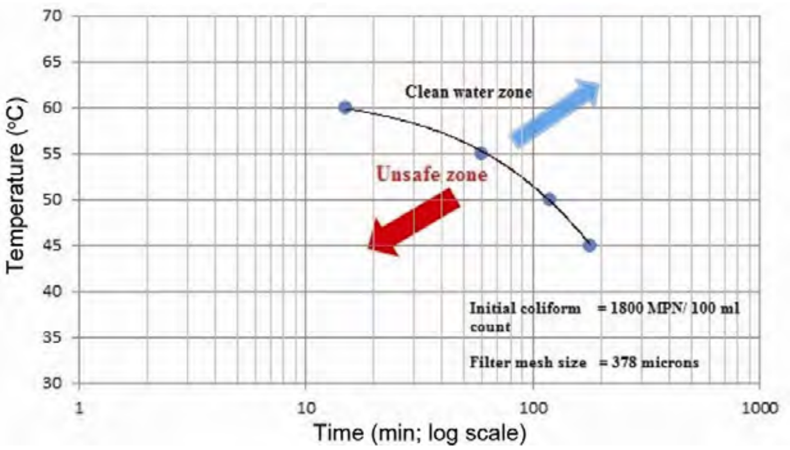


**Figure 2.** Temperature–time regime followed by solar water purifier.

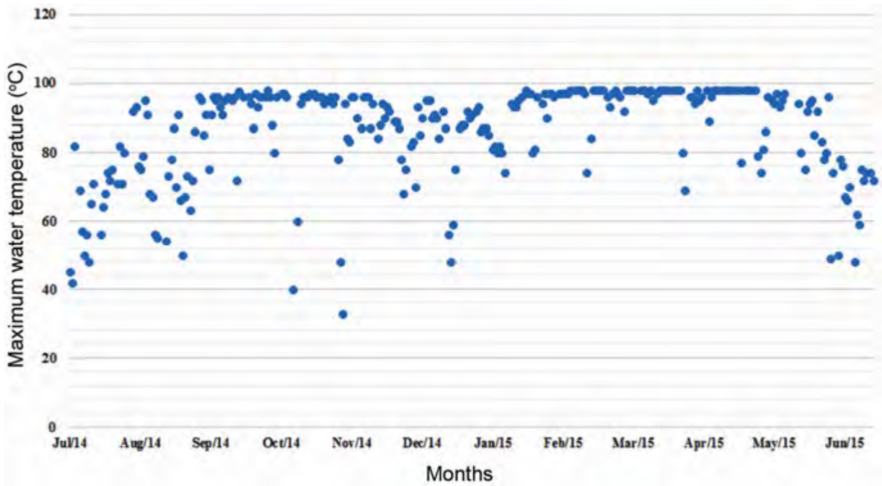


**Figure 3.** Graph of maximum water temperature versus month.

1800 and 2400. Thus, a temperature–time regime for treatment of filtered water was developed (Figure 2).

The bacterial colony count was determined in the microbiology lab, according to well-known international protocols for such testing[4]. Since the cotton cloth is washed daily, this ensures that filter clogging will not take place.

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 is to use solar energy and note 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. Every morning water was put in the SWP; solar energy heated the water to the desired temperature and potable water was taken out the next morning from the unit.

The main criterion in designing the SWP was that under completely cloudy conditions, the diffused solar radiation should be able to raise the water temperature above 45°C and maintain it for more than 3 h. Thus the collectors have to be efficient. Tubular vacuum-based solar collectors (tube dimensions 47 mm ID and 1.8 m long; volume of each tube ~ 3 litre) were found to be the most suitable. The tubes were fitted in a specially developed stainless-steel manifold so that total volume of the four tube collector system was approximately 15 litre.

Data on this system have 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 h to make it potable.

Figure 3 shows the yearly data of maximum water temperature reached in the SWP during 2014–15. Figure 4 shows the relation between solar radiation and maximum water temperature. Though this relationship is primarily valid for Phaltan weather conditions[5], as a first step it can be used in designing the SWP in most places in India.

The cost of the SWP is around Rs 2500–3000 (~US$ 40–50) and is so simple that any small rural

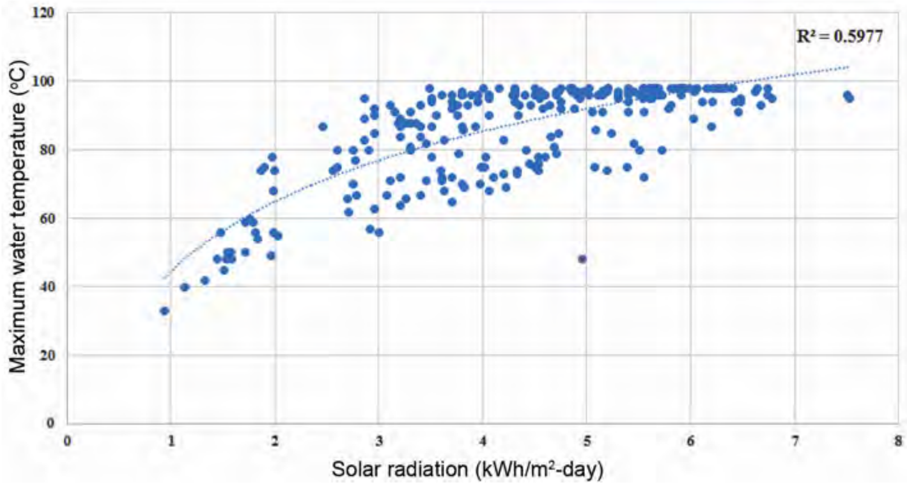


**Figure 4.** Maximum water temperature versus solar radiation.

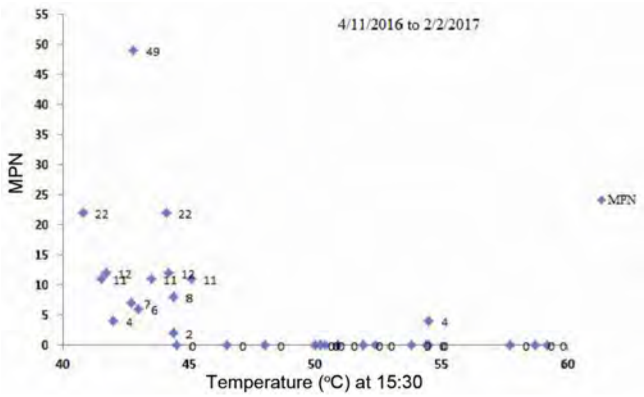


**Figure 5.** Most probable number (MPN) count as a function of temperature.

workshop can fabricate it. In large-scale production, it is envisaged that the cost can come down to Rs 1500.

The SWP can be an excellent system for providing clean drinking water in disaster-affected areas. Besides, it can also be used in conjunction with rainwater harvesting to provide safe and potable water. However, it should be pointed out that this system does not remove or reduce total dissolved solids like arsenic or other salts. For that some form of RO or desalination system is needed.

Since the last one year, two such systems in our campus are producing around 30 litre of potable water daily for all staff members. The actual data on one of these systems is shown in Figure 5, where the most probable number of coliforms is plotted against temperature of water in the tubular collector. The temperature was taken at 3 : 30 pm (local time) and was maintained for at least 3 h in the tubular collector.

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

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