Solar water boiler for providing safe drinking water

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Background

The world is currently experiencing a humanitarian crisis that is largely unrecognised in western high income countries. Currently, more that 1 billion people do not have access to safe drinking water within reasonable walking distance of their homes. This factor combined with poor sanitation and inadequate hygiene is causing about 1.8 million deaths each year throughout the world (World Health Organization, 2007). For each death, many more become seriously ill, particularly children who bear much of the burden of diarrhoeal and other water-related diseases throughout the world.

The management of small community or household water supplies remains problematic in many parts of the world because of the difficulty of disinfecting drinking water using locally available resources. In many regions it may not be possible to obtain enough firewood to boil water because of the effects of deforestation and land degradation, and it is often difficult to obtain chlorination agents for water disinfection in these regions. Although a number of techniques have been developed for the solar pasteurization of drinking water, the application of these techniques may be hindered by the availability of thermometers or other devices for measuring when water temperature reaches levels where pathogen die-off will occur. In the absence of water temperature measurements, boiling is the only unequivocal way of ensuring of drinking water safety.

The following notes describe the construction of a solar water boiler made with recycled wastes and other readily available materials that is able to disinfect small amounts of drinking water for household use. Depending on the local availability of materials, the unit described can be constructed within a few hours for a material cost of about $US 2 - $US 5.

Construction

The water boiler assembly consists of a parabolic reflector made from cardboard and aluminium foil, and an insulated bottle for heating and storing drinking water. The size of both the parabolic reflector and the insulated bottle were constrained by the nature of raw materials available for the project. As a consequence, the unit described below only boils 300 mL of drinking water at a time. However this inconvenience is offset by the increased simplicity of construction and use of this assembly by comparison with many conventional parabolic cookers. It was found to be simpler to construct a number of smaller units to boil water rather than trying to boil a larger volume of water in one larger parabolic solar cooker.

Construction of the parabolic reflector

The construction of the cardboard parabolic reflector was adapted from a method outlined by Gregory Kunkel at web site http://www.bio.umass.edu/biology/kunkel/gjk/parabola/cardboard.htm, which in turn was based on a design given by Alex McEachern and Paul Boon in the journal *Scientific American* in 1973. The reflector is constructed with 12 cardboard segments, each of which is made in the following way:

1. Draw an isosceles triangle with a height of 33.56 cm and a base of 17.37 cm on a sheet of cardboard cut from a cardboard box. Eight rows are marked on this triangle at distances from the apex shown in Figure 1. The reflector is easier to construct if the rows are aligned parallel with corrugations in the cardboard.
2. Mark a point 1.72 cm inwards from each corner along the base of the triangle.
3. Similarly mark points 1.28 cm inwards from each edge of the triangle on row No 8, 0.92 cm from the edges on row 7 and so on for all rows using dimensions shown in Figure 1.
4. Connect these points with lines as shown in Figure 1 and cut along these lines to remove the outer part of the triangular shape.
5. Glue a piece of aluminium foil on the reverse side of each segment and trim to size.

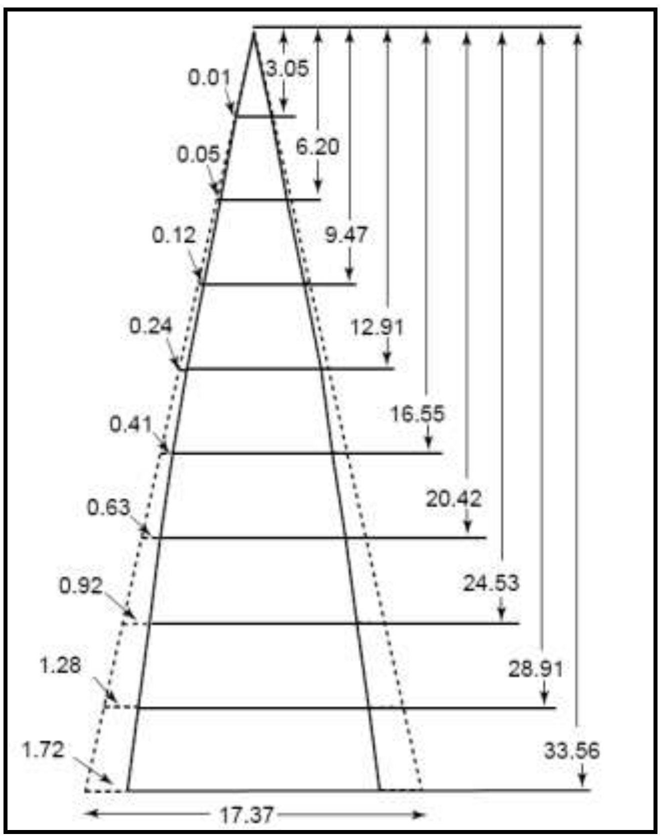

Figure 1. Dimensions (in cm) of the cardboard segments for making the parabolic solar reflector

The segments were carefully glued to each other ensuring that the lines drawn on each segment were well aligned. I used hot glue, but segments could also be secured by punching holes along the edge of each segment and binding them together with loops of string or wire. The assembled parabolic reflector has a diameter of about 57 cm and a focal length of about 12 cm.

The water bottle holder was made by cutting the top off a clear, straight-sided 1.5 L plastic bottle and gluing its base to the centre of the parabolic reflector. Figure 2 shows the completed parabolic reflector and the insulated water bottle.

Figure 2. View of the completed parabolic reflector and insulated water bottle.

Construction of the insulated bottle

The insulated bottle was constructed using a 300mL black powder-coated aluminium spray bottle, and a wide-necked 500 mL clear plastic bottle (I found that ice-tea beverage bottles to have the ideal size and shape). The aluminium spray bottle was the only component of the solar water boiler assembly that was not made using recycled materials. The bottles were purchased for a unit cost of about $US 2, although it may be possible to purchase these for a lower price if they could be obtained without the spray-top.

The spray-top was removed from the aluminium bottle, and a collar of epoxy-resin putty was placed around the neck of the bottle. The base of the clear plastic bottle was carefully cut-off and the aluminium bottle was inserted ensuring that the epoxy resin putty formed an air-tight seal around the inside of the neck of the clear plastic bottle. The base was refitted to the clear plastic bottle ensuring that there was an air-gap to the base of the aluminium bottle. The base of the clear plastic bottle was glued in place with waterproof glue ensuring that there was an air-tight seal.

A large cork was used to make a lid to the insulated bottle assembly.

Testing the solar water boiler

The solar water boiler was tested on a clear day during the winter months in the southern hemisphere (July at latitude 32^{o}S). Under these conditions, it took 45 minutes to raise the temperature of water in the insulated bottle from 15^{o}C to boiling point. Boiling point could be detected by the appearance of small water bubbles and steam around the lid of the bottle. The estimated heating power of the boiler was about 40 watt. Assuming that insolation at the time was about 1000 watt m^{-2}, this equates to an energy conversion efficiency of about 31%.

Figure 3 shows the solar water boiler in use.

Figure 3. View of the solar water boiler assembly in use

References

World Health Organization, 2007. Combating waterborne disease at the household level. Publication available at web site http://www.who.int/household_water/advocacy/combating_disease.pdf.