

## What would be a Sustainable Water Pasteurization Indicator (WAPI) Producing Method for Developing Countries?

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### **ABSTRACT**

For over twenty years, the solar panel based water pasteurization method has established its solid reputation and evidence for providing safe drinking water for people in developing countries. Despite of this resounding success, one fundamental shortcoming has been that this seemingly simple technology still has not been truly adopted by those developing countries to a level that they can reproduce necessary components for this method and spread this technology to their neighbors or succeed it into the next generation. To this day, most of components are produced by industrialized countries and supplied to developing countries. For a true success of solar water pasteurization, it is essential that this technology will be eventually adopted and sustained by developing countries.

This paper reports the attempts made by a group of students and faculty of Mechanical Engineering (ME) at California State University, Sacramento (CSUS) to design sustainable manufacturing processes for Water Pasteurization Indicator (WAPI) in developing countries. In 2004, the first WAPI maker was developed. It has a pair of electrically heated aluminum plate mounted on jaws of a vice. Ends of five polycarbonate tubes are clamped and sealed by these heated plates to make WAPIs. The device is simple to build with a total material/parts cost of less than 150 dollars. This production method was introduced to people in Kenya and Tanzania from 2004 to 2006 when the Biological Science team of CSUS visited there and promoted solar water pasteurization with several thousands of WAPIs produced in this manner. In 2011, the second WAPI maker was produced. It was similar to the first maker but it used more commonly available components such as an automobile jack rather than a vice. The design of this device was distributed in Afghanistan when a group of Trust in Education (TIE) visited there in 2012.

More efforts and studies will be necessary to obtain data for sustainably producing WAPIs in developing countries. What kinds of raw materials and parts are available in each specific region of developing countries? What are manufacturing capabilities at a small town in developing countries? What should be a price of WAPI for which people can afford? Can a business of producing WAPI be established in a developing country? If so, what should be the

supply chain system to distribute WAPIs even to rural communities? These may be a few of many questions which need to be answered. The author of this paper hopes to explore various ways of developing sustainable WAPI production methods through the network of expertise available at this conference. The author is also interested in exploring any opportunities for sustainable technologies other than WAPIs.

**Keywords:** Appropriate Technology (AT), sustainable production, solar water pasteurization, Water Pasteurization Indicator (WAPI)

## INTRODUCTION

According to the data published by UNESCO [9] in 2013, 783 million out of 7.16 billion people in the world do not have access to safe drinking water for their daily living. For over twenty years, the solar panel-based water pasteurization method has established its solid reputation and evidence for providing safe drinking water to people in developing countries. Most of the solar water pasteurization kits have been made in industrialized nations such as the USA, and distributed through the network of volunteers to developing countries. There is no doubt that this effort has not only improved the quality of living for a countless number of people but saved the lives of many people including children. It is essential that these solar pasteurization kits continue to be distributed to people in developing countries.

In addition to this current effort, however, it is also critical to consider developing ways to make this solar water pasteurization method sustainable in developing countries. In many cases, products or methods provided from industrialized countries to developing countries don't match with life styles, technologies, economics circumstances, political situations, and geography that exist in developing countries [2,4]. Things provided by developed countries may help people of developing countries temporarily but may not last for a long time. For example, 30% to 50% of water infrastructure systems built in developing countries failed to function in less than 5 years after they were constructed [10].

There have been some movements to develop appropriate technologies (AT) in developing countries. University of Colorado, Boulder, has an extensive program focused on AT for both education and research [7]. Pennsylvania State University too has conducted a number of AT projects [4]. However, significantly more efforts will be needed to make technologies more sustainable in developing countries. It is too difficult to develop a generalized method for AT [4]. AT needs to be developed one case at a time taking into consideration the socioenvironmental factors unique to each focused region in developing countries.

To this day, most of the components for solar water pasteurization are produced by industrialized countries and supplied to developing countries. For a true success of solar water pasteurization, it is essential that this technology be adopted and sustained by developing countries. In this paper, the sustainable production and distribution of Water Pasteurization Indicator (WAPI) is considered. WAPI was invented by Fred Barrett and Dale Andreatta [1].

Since then, it has been a critical component of the solar water pasteurization kit distributed by Solar Cookers International (SCI). In the next section, WAPI manufacturing methods developed at the California State University, Sacramento (CSUS) are described. Then issues related with sustainable production of WAPIs will be discussed.

## WAPI MAKERS DEVELOPED

WAPI shown in Fig. 1 is a very simple but effective device to check if water is pasteurized. A group of scientists and students led by Robert Metcalf at CSUS Biological Science Department has worked with SCI to provide solar water pasteurization devices to developing countries for over a decade [6]. A group of students and faculty of CSUS Mechanical Engineering (ME) Department participated in this project by developing manufacturing methods for WAPIs.

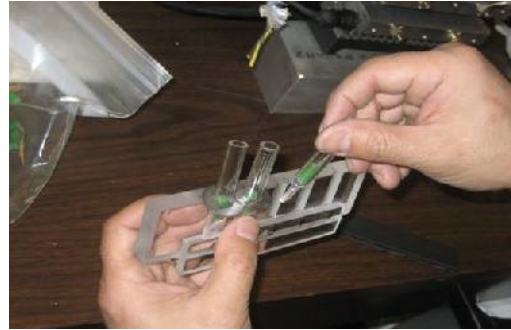
When this engineering project was started in 2004, there were two focused countries, Kenya and Tanzania. It is understood that the WAPI manufacturing methods introduced in this section probably need redesigning to be truly adopted by those countries. However, those methods are presented here as they may be considered as the first step to develop a sustainable WAPI manufacturing method. The ME group first studied about life style, technology, and other socioenvironmental factors in these countries based on published articles and interviews from Robert Metcalf. The first WAPI maker developed by the ME group is shown in Fig. 2. It uses a pair of aluminum plates heated by electrical resistance wires. Those aluminum plates are mounted on the jaws of a vice. Ends of polycarbonate tubes are clamped by the heated aluminum plates to make WAPIs. Fig. 3 shows a mold for making wax pieces of WAPIs. The total cost for materials and parts of this WAPI maker is less than 150 US dollars. It is possible to produce a set of 5 WAPIs in about two minutes by a trained worker. This manufacturing method was briefly introduced to the local government officials in those countries. However, there is no known report indicating that this manufacturing method has been adopted in these countries.



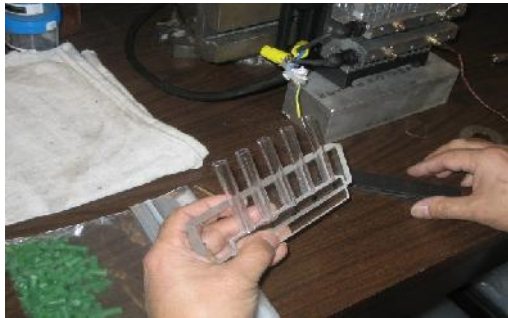
Fig. 1 Water Pasteurization Indicator (WAPI). Before heating water, wax at the top of the tube (Left). After water being pasteurized, wax at the bottom of the tube (Right) [8]



A



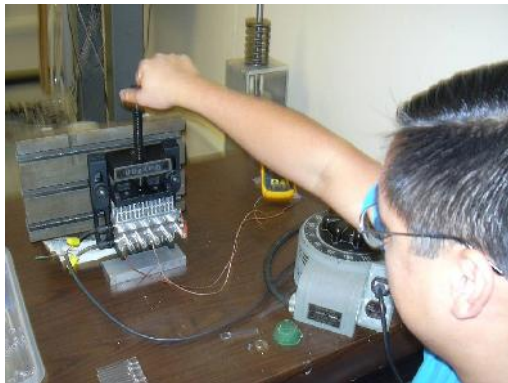
D



B



E



C



F

Fig. 2 WAPI manufacturing. A: WAPI maker overview. B: Setting up five polycarbonate tubes to a guide fixture. C: Clamping and sealing one end of polycarbonate tubes. D: Inserting wax pieces into the tubes, placing a washer outside of each tube, and setting up all five tubes using the guide fixture. E: Clamping and sealing the other end of polycarbonate tubes. F: Completed WAPI pieces [3]



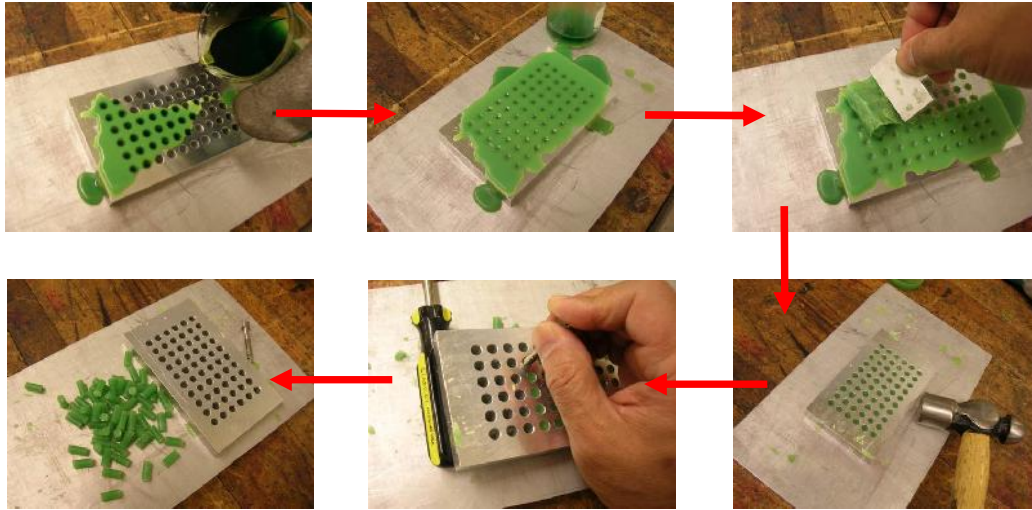


Fig. 3 Making wax pieces using a mold [3]

Fig. 4 shows a new WAPI maker designed and built by Victor Rodrigues of the CSUS ME group in 2011. Instead of a vice, an automobile jack was used, assuming that it is readily available from unused or scrapped automobiles. Compared to the first WAPI maker, the clamping operation become much easier with a higher mechanical advantage of the automotive jack compared to that of the vice. The design of this device was introduced to people in Afghanistan by volunteers of the NPO Trusts in Education (<http://www.trusteducation.org/>). However, they reported that people there did not show very strong interest in the solar water pasteurization.

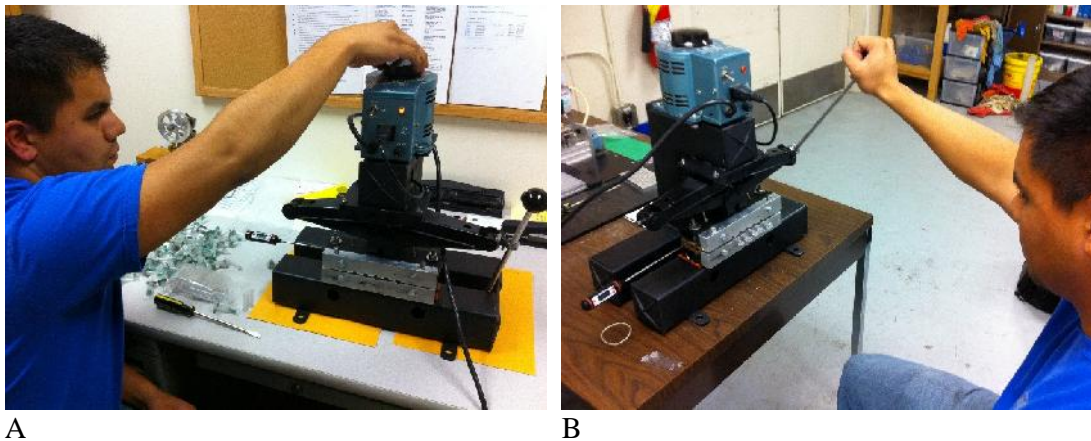


Fig.4 A new WAPI maker

## **MAKING TECHNOLOGIES SUSTAINABLE IN DEVELOPING COUNTRIES**

In this section, the author would like to present issues for sustainably producing WAPI and other products in developing countries. It is a desire of the author to develop a network with people of a variety of backgrounds to discuss and challenge these issues.

1. There are a variety of situations that are dependent on different regions of developing countries. Hence, an AT including a WAPI production technique needs to be individually developed, by focusing on one region at a time.
2. The current effort of supplying completed solar water pasteurization kits to developing countries is still essential as sustainable WAPI production will not occur overnight.
3. At a given focused region of a developing country:
  - a) What materials are available to produce WAPI?
  - b) What level of manufacturing capability is available? For example, would it be possible for a small-town shop to produce a WAPI maker such as the one introduced in the previous section?
  - c) Is a solar water pasteurization kit affordable?
  - d) How easy or challenging is it to make people understand the importance of solar water pasteurization and accept a new way of life?
  - e) Are there any social or custom barriers to accept the solar water pasteurization technology?
  - f) Before considering a 100% sustainability, would it be possible to implement partially sustainable solutions? For example, a WAPI maker such as the one introduced in the last section may be provided to a small town shop. Furthermore, workers will need to be trained to use and maintain it to produce WAPIs locally. This situation is “more” sustainable than people being provided with a completed solar water pasteurization kit. Such a local shop may eventually develop skills to build its own WAPI makers to make WAPI production truly sustainable.
  - g) Is there any local manufacturer or company interested in producing WAPIs for business to sell WAPIS to local people?
  - h) What kinds of regulations about patenting and licensing exist?
  - i) If any level of sustainable activity is generated, how support approach should be modified to encourage further sustainability activities? For example, when a partial sustainable activity, as explained in 3 f) is observed, it would be more appropriate to provide technical support of training the shop and encourage sustainable WAPI production than providing completed WAPIs to the region.
  - j) How should a supply chain system be designed? For example, what are the critical constituents to distribute WAPIs produced at a small shop to people in rural villages? In addition, should a flow of imported WAPIs into such a region be restricted to encourage sustainable WAPI production?
4. Regardless of different situations in various regions among developing countries, any partially sustainable or sustainable case generated at one region could provide some key ideas to start sustainable activities in other regions.

5. Ultimately, it would be a goal to see a sustainable activity at each region based on supply and demand. However, especially at the beginning, finding such a business solution may not be easy. Other motivational factors such as volunteering spirit, cultural exchange, and scholarly work will be important. It will be an exciting inter-cultural experience for participants from both, industrialized and developing countries to challenge for sustainable technologies.
6. For college students and faculty in industrialized countries, working with people in developing countries for sustainable technologies will be a great educational experience for broadening their vision in this global society.

## **CONCLUSIONS**

Solar water pasteurization has made a significant impact on people in the world, improving the quality of their living. It is essential to continue the current activity of providing completed solar water pasteurization kits to developing countries. At the same time, it is also extremely important to make solar water pasteurization more sustainable in developing countries. Manufacturing methods of WAPI makers, developed at CSUS, were introduced. Those methods may be adopted or modified to start WAPI productions in developing countries. The author is eager to develop connections with professionals and volunteers, including participants at this conference, to explore opportunities for sustainable WAPI production and making any other technologies, improving the quality of people's living more sustainable.

## **ACKNOWLEDGMENT**

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