The Global Water
TECHNOLOGY- PUSH PROGRAM
for Disinfecting Water in Developing Countries

UPDATE INFORMATION

The Technology-Push Program was "officially" started in Guatemala in March 2007. During a visit, Global Water brought and helped install a liquid chlorine bleach injector (see Disinfection Technology #5 – Liquid Chlorine Bleach Injection). The device was installed into the water supply intake piping of a hospital just outside of the rural city of Nebaj, Guatemala. This was accomplished with the help of the non-profit organization Global Water works with in the Nebaj area known as "Aqua Para La Salud" (or "Water for Health").

The Liquid Chlorine Bleach Injection device has all the characteristics that we are looking for in the Technology-Push Program for equipment applicable for developing countries; these characteristics include:

- Simplicity; easy to install and understand with very few moving parts and fabricated from corrosion-proof materials;
- Requires no electricity; the area of Guatemala where the hospital is located routinely loses electricity, so a non-electrical device is most reliable;
- Uses liquid chlorine as the disinfectant; which is effective, inexpensive and available locally throughout Guatemala as laundry bleach;
- Self-Regulating; the device is self-correcting in that 1-ounce of solution is injected into a pressurized pipe flow for every gallon of flow, regardless of the total water flow in a pipe; for instance, if the flow of water in the pipe is 1-gallon per minute (gpm) the device injects 1-ounce of chlorine solution per minute; if the pipe flow is 2-gpm, the device automatically injects 2-ounces of chlorine solution per minute and so forth; hence the "self-correcting" characteristic.

We will evaluate the device and if it works up to its potential, Global Water will offer the Liquid Chlorine Bleach Injection device to non-profit organizations in developing countries either free of charge or at a reduced cost, depending upon the situation.

Global Water also provides to Aqua Para La Salud a chlorine tablet dispenser (see Disinfection Technology #6 – Chlorine Tablet Dispenser). This device was originally brought to Guatemala because a rural village outside of Nebaj had requested help with disinfecting their water supply. The device is designed for no-pressure, gravity-flow applications. As water flows through the device, a chlorine tablet sitting in a "cradle" in the path of water erodes allowing dissolved chlorine to enter the flow stream. This device cannot be used in a pressurized flow of water (such as in a pipe), but it can be used as piped water flows into a water storage tank open to atmosphere (water cascades into a tank from the open-end of a pipe).

The chlorine tablet dispenser is installed with a valve in its line to regulate flow and a by-pass line is also installed with another valve. By adjusting the two valves, one can regulate the concentration of chlorinated water entering the tank. Admittedly, this adjustment is crude, at

best, but the chlorine tablet dispenser represents one of the simplest forms of disinfection currently known and the tablets are available in Guatemala City.

INTRODUCTION

Global Water is an international humanitarian aid organization that works with water, sanitation and hygiene construction projects in developing countries with an emphasis on rural areas. Global Water has initiated a two-stage project to make selected water treatment technologies more readily available in developing countries. The goal of the project's first stage is to create a clearinghouse data base of disinfection technologies that is applicable to the developing world; this data base will describe the technology and its associated equipment in detail with its capabilities, limitations and cost. In order to create this data base, Global Water will evaluate technologies under semi-field conditions to ascertain their operational characteristics and capability to inactivate, kill or remove microorganisms. The goal of the project's second stage is to implement those disinfection technologies that prove to be most useful for application in developing countries during the project's first stage. Technology implementation will be through water advocacy community-based organizations (also called non-governmental organizations or NGO's) for implementation with support from Global Water.

Most water treatment technologies are not available routinely in developing countries, especially in rural areas. This is because there is not enough money available in rural communities of developing countries to purchase water technology and typically there is no one with the expertise to implement water equipment (either in the developing country itself, or in international aid organization staff working in developing countries). Even if water equipment could be purchased, rural inhabitants would not know how to install, operate and maintain that equipment. Global Water technical staff members are fully aware of the fact that the international aid community has its share of "horror" stories of equipment being brought to a developing country by some well-meaning group (who left soon after installation) only to have it break-down shortly after it was installed and sit inoperable thereafter. We are very sensitive to this reality, but plan to overcome this challenge. Global Water has the technical expertise and connections with local water-advocacy NGO's to provide water supply equipment to developing countries in order to "push" technology that can help people live more healthy and productive lives.

BACKGROUND

Tsunami Relief Efforts was the Catalyst for the TECHNOLOGY- PUSH WATER SUPPLY PROGRAM

At the request of a community-based non-profit organization out of Jakarta, Indonesia, Ted Kuepper, Global Water's Executive Director and one of Global Water's technology experts, arrived two weeks after the tsunami destroyed the Indonesian coast in the Province of Aceh. He then spent the next two weeks living in one of the many encampments that had developed just outside the partially-destroyed city of Banda Aceh, the Provincial Capital. During that period of time he interacted with staff members of many international aid organizations that were also in Aceh. Ted was amazed that "first responder" water-related, sanitation-related and hygiene-related equipment was not available from the many international aid organizations despite the obvious equipment needs everywhere. By far, most aid organization staffs were there merely to perform "assessments" of the many needs of the people.

While he was there in the Aceh region, Ted's jobs included drilling a water well and installing simple filtration and chlorination equipment in one of the many encampments for displaced people. The system he created used simple strainer devices within which he placed one-half of

a chlorine tablet. These devices worked very well and disinfected water that was pumped from two wells on the property for all domestic water uses throughout the camp (**for the complete Aceh, Indonesia trip report, see Global Water website: www.globalwater.org**) . The plane ride back to the US was Ted's first opportunity to sit and reflect on all that had happened over the past two weeks; it was then that he realized disinfection could be provided everywhere using the same technique of chlorine tablets (or other simple, non-electric technology) as long as some organization was willing to "step up to the plate" and manufacture, distribute and help people install and maintain the equipment. On that plane ride home from Aceh, Ted outlined the new Global Water **TECHNOLOGY- PUSH WATER SUPPLY PROGRAM**.

Why Disinfect? A complete water supply system consists of a water supply intake, treatment, storage and distribution. Water treatment stages used often in developing countries include sand filtration (such as the Biosand unit) and the SODIS system (a batch solar UV technology). These treatment technologies will reduce the number of disease-causing organisms in water, but will not leave it completely free of such organisms. Disinfection, when applied and controlled properly, is the most practical and effective means of removing and/or inactivating disease-causing organisms. It is disease-causing microorganisms (bacteria, virus and protozoa) that create life-threatening diarrhea diseases largely responsible for the death of children under the age of 5 years old throughout the developing world. Therefore, Global Water believes that disinfection of drinking water holds the highest priority for any water supply technology to be implemented in a developing country.

Appropriate Technology

For many decades and continuing today, the level of technology that is thought usable by developing countries is technology readily maintained by the local population with logistic re-supply items procured locally, as well. That generally means using equipment made from locally available materials that can be repaired by local craftsmen. This is called appropriate technology and it works very well since it is fine-tuned to a local area, its people and its craftsmen's capabilities. It is a low-risk approach that increases the chance of a project to succeed in a remote location when the implementer (organization that installed the equipment) plans to leave the area after installation and does not plan to have contact with the equipment thereafter. Simply put, this approach reduces the risk of failure.

And there have been numerous cases of equipment failures in developing countries. Although most of the failures associated with using equipment-oriented technologies in developing countries were not in the water supply area per se, we must learn from these failures so as not to perpetuate the same mistakes. In each case, the reasons for failure were inherent in the project itself and include:

- Improper equipment;
- No local person or entity responsible for equipment;
- Personnel not properly trained to start;
- No follow-on training or training documents for new personnel;
- Inadequate logistical re-supply; or
- A combination of the above.

In the area of water supply and purification, appropriate technology can dig shallow wells and capture natural springs, provide filtration of turbidity and reduce levels of microorganisms with sand media filters, and can store water using ferro-cement and mason block tanks.

What it typically cannot do is effectively treat a severely microbiologically-contaminated or polluted water source to drinking water quality, or dig water wells beyond modest depths, or store and distribute water in a disinfected condition. However, the technology to do these tasks

does exist outside of the appropriate technology arena and state-of-the-art technology can be harnessed to develop drinking water supplies that far exceed appropriate technology capabilities and expectations. What has been lacking in the past and what is needed to implement technologies above the basic "appropriate" level is for the implementing organization to maintain a relationship with the equipment being installed and those who are using/controlling the equipment. In other words, a long-term approach to equipment projects is necessary in developing countries and has been the missing link preventing success up until recently.

It should be noted that several international aid organizations have recently recognized that appropriate technology cannot satisfy disinfection needs in Africa and have begun distributing small single-use packets containing a chlorine-based compound. More information about these packets can be found in the next section entitled: **Disinfection Technology #1 – Batch Chemical Addition.**

PROGRAM DESCRIPTION

In order to overcome the barriers preventing developing countries from accessing water supply technology, Global Water plans to provide water supply equipment and its logistical re-supply requirements at a nominal fee (or in some cases free-of-charge) to local, community-based water advocacy non-governmental organizations (NGOs) in developing countries. Global Water has worked with a host of local NGOs over the years and we will use these relationships to help implement this program, even in the most remote locations of the world.

With Global Water's help, these local NGOs will install, operate and maintain the equipment. This connection with a local NGO is a crucial and important aspect of our concept and the real reason why Global Water's **TECHNOLOGY- PUSH PROGRAM** will be able to function in a rural environment of a developing country. State-of-the art equipment, no matter how simple it may be, must have a local advocate who is interested in seeing that piece of equipment operate no matter what obstacles arise; and those obstacles include: communication, transportation, training, logistical re-supply of parts and consumables, weather, vandalism, theft and conflict/war.

Finally, it is desirable that local NGOs overseeing water supply equipment create a simple payment system where recipients of disinfected water pay a stipend to help maintain the equipment. We recognize that a stipend pay-back system may be difficult to initiate in many rural areas of the world, but where it can be implemented, it would insure sustainability of a water supply project and consequently, Global Water will work with local NGOs to make this happen if at all possible.

Global Water is starting the **TECHNOLOGY- PUSH PROGRAM** with disinfection equipment that can prevent microorganisms in water from causing disease. Specifically, Global Water is starting our program with a variety of technologies and equipment devices that will cover most disinfection applications in the developing world environment. It is anticipated that no one device will satisfy all applications in the developing world, so Global Water's approach is to develop an array of devices and technologies to "cover the bases."

This project has the potential to create a clearinghouse of disinfection technology data that will be useful for many NGOs all around the world. The database will include all the information needed by organizations wanting to implement water treatment technologies to prevent microorganism-related diseases. It is anticipated that the Global Water website will be the primary repository of this data, but other means of information dissemination will be implemented, as well.

Here is a description of the disinfection technologies to be evaluated during the first stage of this project. During the second stage, some of these technologies will be made available through Global Water to local, water advocacy NGOs in developing countries:

Disinfection Technology #1 – Batch Disinfectant
Purpose: This technology is designed to kill microorganisms in a container of water (commonly known as a "batch" mode since each container contents is disinfected separately).
Brief Description: There are a variety of batch addition technologies available today for developing countries that include: Proctor & Gamble PUR sachets that allow a 10 Liter quantity (2.6 gallons) of high-turbidity water to be disinfected using a ferric sulfate coagulant and a chlorine-based disinfectant; Aquatabs, a chlorine-based disinfectant tablet that will disinfect several different quantities of low-turbidity water; and Silverdyne, a colloidal silver-based mineral additive that will disinfect several different quantities of high or low turbidity water.
Water Production: This technology has been created usually for relatively small quantities of water in a container at the point of use, often in the 4-10 Liters size range. However, Aquatabs come in several different tablet sizes that will accommodate quantities up to 1,000 Liters of water; also, Silverdyne can be used with a wide range of water quantities with the ratio of 1-3 drops of Silverdyne per 2-liters of water.
Requirements: Water to be disinfected must be placed in a container or tank.
Limitations: The PUR sachets and Silverdyne additive can accommodate high-turbidity water, but Aquatabs should only be used with a low-turbidity water source.
Other: The PUR and Aquatabs are packaged for one batch quantities; multiple packages are used for larger quantities of water; Silverdyne is a liquid and comes in a bottle so it can accommodate different quantities of water from its original packaging.

Disinfection Technology #2 – Photochemical - Enhanced Solar Bottle System (Optimized SODIS System)
Purpose: This technology is designed to kill microorganisms (bacteria, virus and protozoa) by use of solar UV and solar heating inside 2-liter plastic "soda" bottles (or similar containers) available locally.
Brief Description – Current Technology: The Solar Water Disinfection (SODIS) technology was developed by the Swiss Federal Institute for Environmental Science and Technology to provide small "batch" amounts of disinfected drinking water to individuals and families in developing countries. The original SODIS system uses 2-liter P.E.T. plastic soda bottles that are partially filled with water, shaken to entrain oxygen and placed in the sun for a period of approximately 6 hours. While sitting in the sun, water inside the bottle is treated by the ultraviolet (UV) rays that travel through the P.E.T. plastic containers and the water experiences heating, as well. This combination of UV and heating has proven to disinfect water to varying degrees in each bottle. However, testing of SODIS-treated water containing bacteria has shown that bacteria can reactivate and multiply after a period of time and continue to grow making the SODIS concept marginally effective if the treated water is not consumed within a certain period of time. It should be noted that this limitation is common for UV systems since UV light does not kill microorganisms, per se, but rather disrupts a microorganism's ability to reproduce quickly. If a treated water is not consumed, eventually, some microorganisms can mutate into new forms that can reproduce again. Since the concept is so simple, the SODIS has received a lot of notoriety and is being implemented by the Peace Corps and several international aid organizations.
New Technology: The unit Global Water wants to develop utilizes a photochemical UV catalyst placed inside the original 2-Liter bottles to kill microorganisms in half the time required by the original SODIS concept (2-3 hours versus 6 hours). The UV catalyst can effectively kill

microorganisms without the possibility of bacteria reactivation making the SODIS concept a legitimate disinfection technology.
Water Production: One of these devices can disinfect 1.5 liters (0.4 Gallons) per bottle of water daily. Multiple bottles are used for higher quantities with a quantity of 4-6 bottles typical at an installation.
Requirements: Bottles must be placed in sun without anything shading the location during the day; ideally, the device will be installed facing south at a 45 degree angle; if possible, on top of a roof or similar structure; no electricity necessary.
Limitations: The sun; on cloudy days this device may not work effectively, as UV and solar heating will be reduced accordingly. However, a photochemical UV catalyst should allow disinfection to occur even on cloudy days more effectively than the original SODIS system; this capability must be determined during a first stage evaluation. Being a batch mode concept utilizing 2-Liter plastic "soda" bottles, water production is modest and only suitable for an individual or family.

Disinfection Technology #3 – Solar Pasteurization Device
Purpose: This technology is designed to kill microorganisms (bacteria, virus and protozoa) by use of solar heating creating pasteurization temperatures inside a solar heating device.
Brief Description: The unit Global Water wants to evaluate is called the SunRay 1000 and is marketed by Safe Water Systems to developing countries and other remote areas without electricity. It resembles a solar hot water heater that is placed on a roof of a house. When the assembly is placed in the sun, the heating chamber is designed to allow pasteurization temperatures (about 160 degrees F / 70 degrees C) to occur inside the device. Pasteurization is a very established disinfection technique that has potential to provide consistent disinfection results using only solar heating.
Water Production: One of these devices can disinfect 1,000 liters (264 Gallons) per sunny day. Multiple heating chambers could be used for higher quantities at an installation.
Requirements: The heating chamber must be placed in sun without anything shading the location during the day; ideally, the device will be installed facing south at a 45 degree angle; if possible, on top of a roof or similar structure; no electricity necessary.
Limitations: The sun; on cloudy days this device may not work effectively, as solar heating will be reduced accordingly. However, disinfection may occur even on cloudy days; this capability must be determined during a first stage evaluation. This is a batch mode concept with the capability to produce enough drinking, cooking and bathing water for multiple families.

Disinfection Technology #4 – Disinfectant Resin
Purpose: This unit is designed to kill microorganisms (bacteria and virus) in a flow of water inside a pipe. It uses a resin media that can be rejuvenated with liquid chlorine bleach available in developing countries. As an alternative, a similar resin is available that is rejuvenated with a liquid bromine solution.
Brief Description: Chlorine is the chemical disinfectant of choice in the US and many other developed countries in the world. For large installations, chlorine is administered by means of a liquid or gas. In addition, devices exist that use solid tablets for small flows. This technology uses a new solid resin media that contains a chlorinated compound that kills microorganisms upon contact (as water flows through the media) and places a very small residual of free chlorine into the water, as well. When the media is spent, it can be rejuvenated on site by flowing liquid bleach (with a reduced pH) over the media. Liquid bleach is available in all developing countries because of its use in laundry applications so it is available virtually everywhere. This device must be used with a piped supply of water.

Water Production: This device can accommodate virtually any flow rate depending upon the size of the resin housing used and consequently the quantity of resin installed. The rate of chlorine contact is automatically adjusted as flow varies through the housing. The true capability of this technology must be determined during a first stage evaluation.
Requirements: Water to be disinfected must flow in a pipe; no electricity is necessary;
Limitations: Liquid bleach or tablets must be used to rejuvenate resin periodically (or continuously) and must be procured locally; this capability must be determined during a first stage evaluation.
Other: A simple chlorine testing device will be supplied with each dispenser; also, carbon cartridges are available to remove the taste of chlorine at the point of use, if necessary.

Disinfection Technology #5 – Liquid Chlorine Bleach Injection
Purpose: This unit is designed to kill microorganisms (bacteria and virus) in a flow of water inside a pipe. It uses common liquid chlorine bleach available in developing countries as laundry bleach.
Brief Description: With this device, chlorine is injected as a liquid directly into a piped flow of water. The devices Global Water is interested in use no electricity as they use the flow of water through the device, itself, to inject a liquid solution into a pressurized flow of water. Also, these devices have a self-correcting capability in that they inject more solution as flow through the device increases (and less solution as flow decreases through the device). Liquid bleach is available in all developing countries because of its use in laundry applications so it is available virtually everywhere. This device must be used with a piped supply of water.
Water Production: This device can accommodate virtually any flow rate although each device is rated at a particular range of flows.
Requirements: Water to be disinfected must flow in a pipe; no electricity is necessary;
Limitations: Liquid bleach must be procured locally and mixed with water to create the disinfecting solution.
Other: A simple chlorine testing device will be supplied with each dispenser; also, carbon cartridges are available to remove the taste of chlorine at the point of use, if necessary.

Disinfection Technology #6 – Chlorine Tablet Dispenser
Purpose: This unit is designed to kill microorganisms (bacteria and virus) by use of dissolving chlorine tablets in an un-pressurized flow of water through the device.
Brief Description: These are chlorine dispensers that allow chlorine tablets to dissolve in a flow of water; this releases free chlorine to kill microorganisms as water flows through the dispenser. Most of these devices are designed to be used in a non-pressurized water flow, such as on the inlet of a water tank. However, there are some chlorine dispenser designs that allow tablets to be used in a pressurized pipe flow, as well. The device Global Water envisions utilizes a clear, plastic housing that can be used in an un-pressurized flow of water, especially useful as water cascades into the top of a tank. Clear plastic will allow operators to easily observe when tablets must be replaced. Tablets that are very slow dissolving will be tested for this device to maximize longevity of consumables. This device must be used with a piped supply of water. This type of device has historically been the most simple device available to disinfect a piped flow of water.
Water Production: This device can accommodate virtually any flow rate since more tablets can be placed inside the chlorine dispenser if need be; however there is a practical limit as the re-supply of tablets becomes a logistical challenge.
Requirements: Water to be disinfected must flow in a pipe; no electricity is necessary; typical installation is just before water cascades into a storage tank.

Limitations: Tablets must be replaced routinely; therefore a periodic supply of chlorine tablets is necessary.
Other: A simple chlorine testing device will be supplied with each dispenser; also, carbon cartridges are available to remove the taste of chlorine at the point of use, if necessary.

Disinfection Technology #7 – Filter Systems
Purpose: Filters are designed to physically remove microorganisms (bacteria, virus and/or protozoa). There are a wide variety of filters that can accomplish physical removal; the types that Global Water plans to investigate includes the following: 1) a small slow-sand filter (or Biosand filter), 2) a microfiltration (MF) or ultrafiltration (UF) membrane module, and 3) an electrostatic filter. These filters are all very different from one another and deserve individual testing and evaluation. The Biosand filter relies on a layer of biological activity to consume additional microorganisms as they penetrate the layer with contaminated water flowing through the filter. The MF or UF membrane has holes (or pores) small enough to restrict passage of microorganisms while allowing water to flow freely through the membrane structure. The electrostatic filter uses positively-charged media to "grab" microorganisms (negatively-charged) and hold them indefinitely in its media matrix.
Brief Description: A UF membrane acts as a barrier to microorganisms and can effectively remove all microorganisms using only gravity-induced pressure. Membranes similar to the one that will be evaluated are now being commercially used for municipal water and wastewater treatment specifically to remove microorganisms. This type of device has the potential to be a very simple device to disinfect water either in a pipe flow of water or in batch mode. A positively-charged filter also has the capability to filter microorganisms from a flow of water; these devices take the form of a 10-inch to 20-inch long cartridge filter. A Biosand filter is very small slow-sand filter (about 0.10 gallons per minute per square foot of filter surface area) that has media kept submerged at all times in order to develop a layer of biological activity; this active layer contains microorganisms that feed on other microorganisms that try to flow through as water is manually poured into the top of the filter.
Water Production: Filters can accommodate virtually any flow rate since more membranes or cartridge filters or square footage media tanks can be installed as needed. In particular, membranes and cartridge filters represent a modular type of treatment option that can be very simple to install and operate.
Requirements: Water can be pored through such a device into a container or the device can be installed into a pressurized distribution pipe. No electricity is necessary, but at least 2-psi (4-feet of head) pressure is usually necessary to force water through a membrane.
Limitations: Membranes must be either cleaned in place or replaced as needed; cartridges would probably have to be replaced, rather than cleaned. The active layer in a Biosand filter can be partially removed when its pressure drop increases too much to pour water through it.
Other: Since this is a non-chemical method of disinfecting, there are no taste issues associated with a membrane or cartridge filter device; however, no residual disinfectant capability is available either. Global Water plans to only use membranes that can be cleaned with chlorine bleach, a cleaning solution readily available in developing countries.

Funding and partners are being sought to support this work.
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