Creative Water Filtration Solutions

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Introduction

Access to safe drinking water has become a huge issue as the climate changes and cultures are left impoverished and without safe water due to wars, natural disasters, and bureaucratic corruption ("Water, a shared responsibility," 2006). The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) reported in 2012 that that "11% of the global population, or 783 million people, are still without access [to] improved sources of drinking water" ("Progress on drinking water and sanitation," 2012). Furthermore, the 2012 UN World Water Development Report reveals the tragic truth that a child dies due to lack of water sanitation every 20 seconds ("UN world water development report," 2012), or about the time it takes for a person to wash their hands.

However, there is some good news: the Millennium Development Goal to halve the proportion of the population without access to safe drinking water was met in 2010, five years ahead of schedule. To help meet that goal, organizations and companies offered incentives to companies to produce innovative, low cost water filtration designs. Non-profits and non-governmental associations (NGOs) also worked with third-world countries to produce natural means of filtering water using ingredients that local populations would have access to. In this paper, we will examine several of these creative water filtration designs. We will discuss the Aquaduct bicycle filter, bone char filters, Moringa seed filters, and the award-winning Lifestraw.

Methodology

Much of my knowledge about this issue comes from my studies and from research. To research the need for water sanitation and how data about this issue is collected, I reviewed

UNICEF and WHO publications and reports on progress made in safe-drinking water and basic sanitation. UNICEF's 2012 Joint Monitoring Programme for Water Supply and Sanitation (JMP) report discussed some of the recent improvements made in data collection ("Progress on drinking water and sanitation," 2012). First, they switched from primarily government data to user-based data acquired through household surveys and population consensuses. They also introduced more categories to existing data sets; for example, they introduced sections on 'piped drinking water on premises' and 'open defecation'. Learning more about creative water filtration solutions involved research from Technology, Entertainment, and Design (TED) talks, academic articles on water filtration, videos on prototype filters, personal fieldwork blogs, and content aggregator websites.

Bicycle Filter

The Aquaduct bicycle filter (Image 1) was designed for and won the Innovate or Die contest hosted by several big name companies like Google. It was designed to address problems like sanitation and transportation in developing countries. As water sources can be miles away from residential areas, people have to walk to and from these sources. This burden usually falls to women and can cause great strain on family economics, as the responsibility to care for young children falls to older children, who then are removed from school.

Image 1- Aquaduct bicycle ("The Aquaduct blog," 2008)

The Aquaduct provides families with the means to quickly get to water sources and filters the unsafe water during the ride back. The filter is powered by the simple mechanics of pedaling. A pump attached to the pedal pulls water from the holding tank at the rear of the bicycle (Image 2). The water is then pumped through a carbon filter to a small tank attached to the handlebars at the front of the bike. The clutch engages or disengages the drive belt from the pedal crank so that the rider can pump water while traveling or while stationary ("Team Aquaduct," 2007).

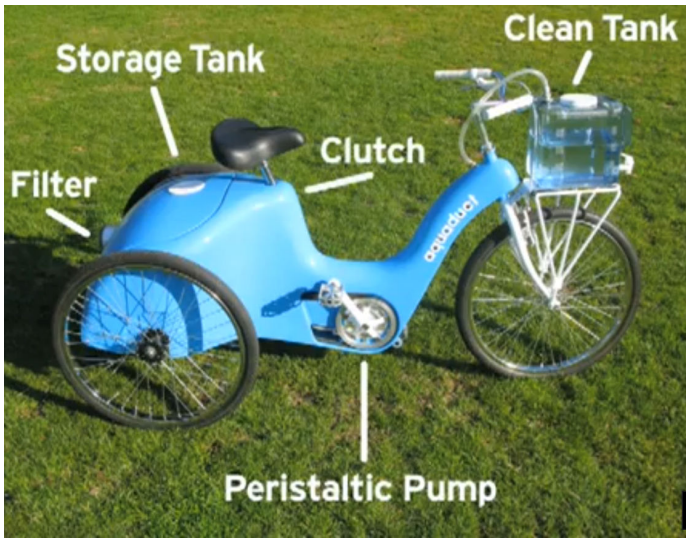

Image 2- Filter mechanism ("Team Aquaduct," 2007)

The Aquaduct is currently a prototype. The production team says on their website that the prototype is "aimed squarely at demonstrating a concept and raising awareness around the issues of clean water in developing countries" (The Aquaduct blog, 2008). However, the team is working to make the concept into an actual, low-cost product by working with investors and developers. Several challenges to development and distribution would have to be overcome to put this product on the market. First, a bicycle is not likely to be a low cost solution. It could also be difficult to transport into rural areas due to its size and would not be usable in rocky or mountainous terrain. Furthermore, the materials and money required for maintenance and repair may make this bicycle too impractical and expensive for remote and low-income areas.

Bone Char Filters

The strategy of using charred bones for water filtration is common in rural areas heavily affected by heavy metal contamination in water. These bone char filters, as well as wood-char filters, can effectively remove fluoride and other heavy metals from water. Fluoride is endemic in at least 25 countries, concentrating especially in areas in North Africa and South Asia (Image 3). High intake of fluoride in water can lead to fluorosis, a disease characterized by discolored teeth and gums, and in extreme cases, joint and bone deformations (Opinya & Imalingat, 1991). Charring the bones "removes organic matter and greatly increases surface area and fluoride absorption capacity [of the bone]" ("Fluoride mitigation," 2011). Bone char filters can be extremely helpful for areas that have access to livestock bones, but may not have access to other filtration systems. When an animal is killed for food, the bones can be used to make water filters instead of being thrown away.

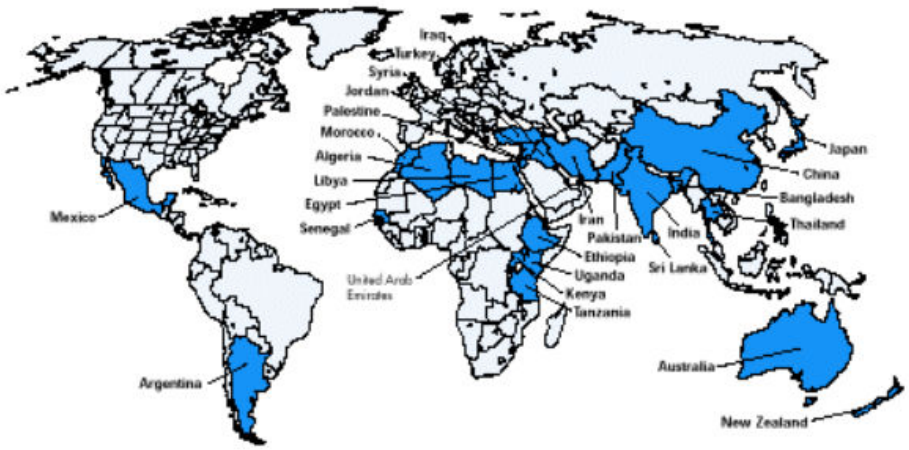

Image 3- World map of high fluoride levels in water ("Fluoride in water," 1999)

To make these filters, bone is broken into small pieces, charred in a low-oxygen and high-temperature environment (Image 4), ground into small pieces, and put in a large holding tank, where gravity helps pull the water through the bone char. Researchers from Addis Ababa University were concerned that filter users could object to the filters for religious reasons, as most of the bones come from cattle, which are considered unclean in many cultures. However, work with community leaders proved successful and the research found that after one year families participating in the study were using filters successfully and with no objections (Esayas, Mattle & Feyisa, 2009). Another case study from Cranfield University evaluated the bone char filters produced and distributed in Kenya by the Catholic Diocese of Nakuru (CDN) (Arrenberg, 2010). Currently, the CDN is the sole producer of bone char filters in Kenya. The CDN is supplied with bone char filters by butchers and game keepers and the filters are delivered to rural areas by bicycle. The evaluation considered options for increased community involvement in the process and made a final recommendation for the CDN to continue to produce the bone char, but to sub-contract the responsibility of distribution, community training, and monitoring to NGOs and community programs.

Image 4- Charred bones being prepared for grinding in Kenya

("Fluoride mitigation," 2011)

Moringa Seed Filters

This filtration method uses crushed seeds from the Moringa (*Moringa oleifera*) tree (Image 5). It is a soft-wooded tree that is extremely easy to grow and can grow to a maximum height of 20 feet. It has small feathery leaves and the root is extremely similar to that of horseradish trees. Crushed Moringa seeds have been found effective in coagulating particles for easy filtration and effective in reducing the number of bacteria in water (Lea, 2010). It is also often referred to as the "miracle tree" as its leaves have antibiotic properties and the entire tree is extremely nutritious and can be eaten ("Moringa nutritional information," n.d.).

Image 5- Moringa tree (Sharif, 2010)

A case study conducted in Kenya estimated the cost effectiveness of using the Moringa tree seeds for water filtration. The study found that one young tree could be used to filter 6,000 liters of water a year and that the trees would continue to flourish year after year, even after constant harvesting. It concluded that approximately one third of the village where they conducted the study should use Moringa tree seeds for filtration. The researchers also reported no change in taste or pH and reported no unhealthy effects in humans (Levicki, 2005).

Another case study sought to teach local people in rural Senegal villages the value of the Moringa tree. The program, sponsored by UNESCO, targeted women and children. Training seminars were held to teach women, doctors, nurses, community leaders, and midwives how to use the Moringa tree seeds for water filtration and nutrition ("Improving nutrition with Moringa miracle trees in Senegal," n.d.). The training seminars included the use of helpful cartoon to illustrate how to use Moringa seeds (Image 6).

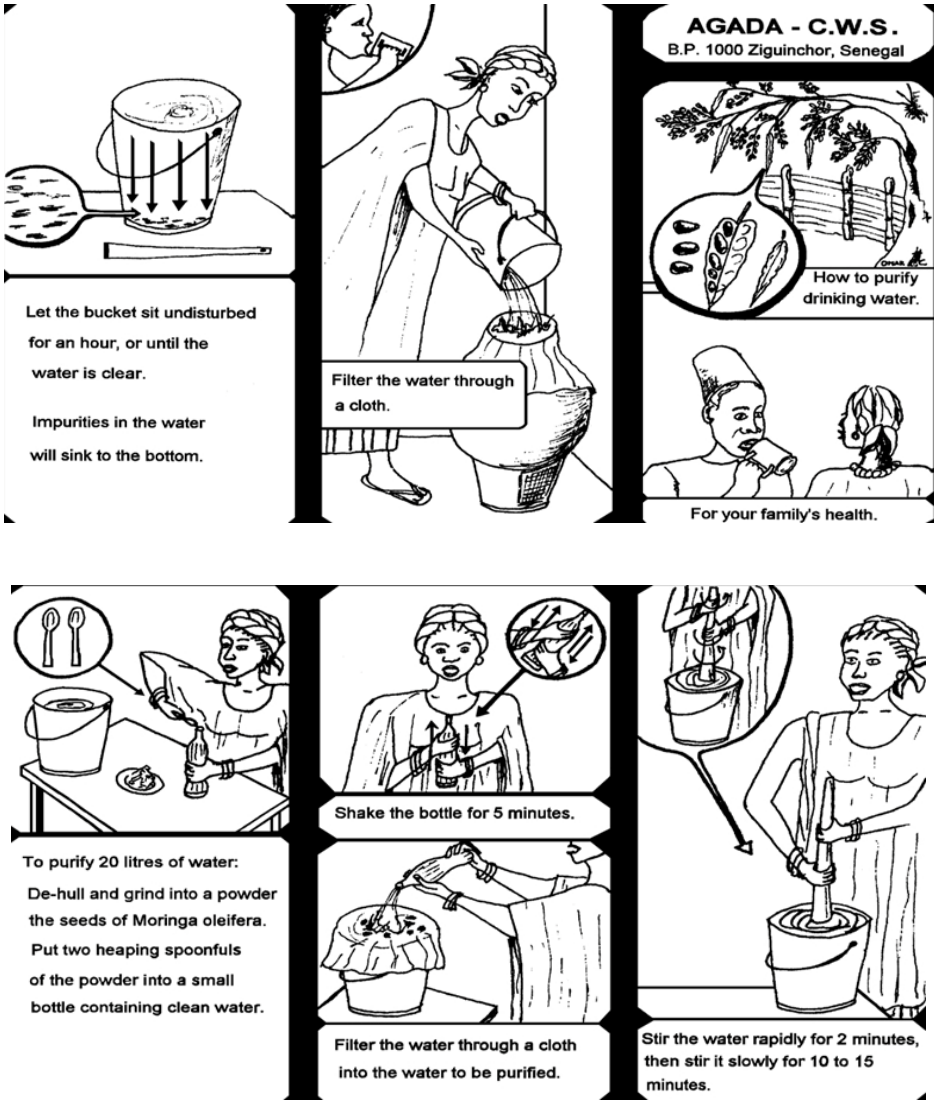

Image 6- Instructions for water filtration with Moringa seeds

("Improving nutrition with Moringa miracle trees in Senegal," n.d.)

Lifestraw Water Filter

The Lifestraw water filter is a filter built into a wide straw (Image 7). It is now used all over the world and can be distributed in bulk for about $3.00USD per straw or can be

individually purchased online for approximately $25.00USD per straw. The traditional Lifestraw is portable and can filter up to 1,000 liters, after which point the filter clogs and will no longer allow water to pass through it. It combines a charcoal filter, iodine crystals, and membrane filters in a straw with a one-inch diameter that can filter 99.99% of bacteria. The family Lifestraw can be mounted on a wall and can filter up to 18,000 liters ("The Lifestraw concept," n.d.).

Image 7- Children using the Lifestraw ("Lifestraw FAQ," n.d.)

The company that designed the Lifestraw, Vestergaard Frandsen (VF), conducted a study in Western Kenya. VF planned a comprehensive health education program around the Lifestraw—they gave free HIV testing, preventative healthcare kits, bed nets, and more. The company involved the Kenyan Ministry of Health and all related ministries and also introduced the idea of the Lifestraw to the population through radio ads, community forums, outreach to medical professionals, and others. Every six months, an evaluation team determines the progress the Lifestraw has made in communities. So far, the evaluators have found that 91% of the filters are being used ("Lifestraw carbon for water," 2012).

A case study conducted by the Delft University of Technology in collaboration with VF found that children under the age of three had difficulty using the Lifestraw, but that there was a severe need for clean water for these ages. VF is currently working on a new design, called Lifestraw Child, that works more like a sippy cup and can be easily held and used by a toddler (Dieh & Christiaans, n.d.).

Image 8- Lifestraw Child (Dieh & Christiaans, n.d.)

Conclusion

In this paper, we discussed the Aquaduct bicycle filter, bone char filters, Moringa seed filters, and the award-winning Lifestraw. Each creative water filter can help in the global problem of water sanitation. Perhaps the best option discussed is the use of Moringa seeds for water filtration. As stated, the tree is extremely easy to grow and the various parts of the tree can be used for nutrition and water filtration. Its multiple uses makes it a great, affordable solution.

Interestingly, case studies on the use of Moringa seeds are difficult to find and it appears that few organizations have included this solution in community health programs. Furthermore, the awards and incentives offered by corporations for low cost water filtration systems are aimed at high-tech solutions. While using tree seeds for water filtration is not necessarily a "sexy" solution in terms of marketing and scientific advancement, Moringa seeds could prove to be even more valuable than high-tech solutions. Health educators and researchers must continue and in some cases, increase, the use of natural water filtration methods. If organizations and governmental forces join together, we can work to reduce the number of sanitation-related deaths and illnesses occurring across the globe.

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