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ACCESS TO SANITATION AND SAFE WATER:
GLOBAL PARTNERSHIPS AND LOCAL ACTIONS

'Sheba' – A new low cost household water filter

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Sheba is a household water filter which helps address four common problems of household water filtration in less developed regions: slow filtration rate, difficulties in cleaning water filters, difficulties in adapting water filters to regional and seasonal variations in influent water and unattractive physical design. The proposed design demonstrates two main innovations: the use of cloth filtration bags to contain the filtration media - the ease of removal of the bags simplifies regular cleaning and permits simple modification of filters as seasonal conditions dictate. Sheba also contains a mechanism to allow the user to manually increase the water flow rate by means of mechanical pressurization. This design was prototyped using simple materials to demonstrate its potential as a low-cost option.

Introduction

Household water filtration systems are often promoted as an excellent manner of increasing water provision to rural populations in less developed countries without access to safe drinking water. The literature contains a number of types of water filters but despite the variety available and their potential for providing improved drinking water, the size of unserved population remains prodigious.

The International Development Design Summit (IDDS) was held over July and August 2007 at the Massachusetts Institute of Technology (MIT) in Cambridge, USA. A team of five participants set out to understand the most common reasons for low filter up-take and design technology to address these needs.

Understanding the Market

Significant contextual information was contained within the team, with three team members living in India and one living in the Tibetan Autonomous Region of China. To broaden the information base, five IDDS participants from Guatemala, Pakistan, Tanzania, Ghana and Tibet were surveyed about:

- Locally available water filtration
- Local water filtration practices
- The ideal water filter design
- Locally acceptable price
- Local water sources
- Local water gathering practices
- Household water usage

The results from this survey and team knowledge (supplemented by reviews of the literature) found that the most common problems preventing widespread rural dissemination of household water filters are:

- Slow filtration rate
- Difficultly in cleaning filters
- Unreliable water quality
- Unattractive and bulky design

Team Goals

To address these requirements as well as others, implicitly required to serve poor rural households, the team worked to satisfy the following requirements:

- Made with locally available materials.
- Affordable to buy (estimated at 1 month salary or $10) and operate (estimated $4/year)
- Bacterially purify water (to UN standards)
- Easy to operate (women and children should be able to use it)
- Easy to clean (by women/children over 10 years within 2 hours with no special tools)
- Easy to maintain (with locally available tools and parts available from district towns)
- Can be constructed and assembled by a locally skilled person
- Makes sufficient water for an average family (estimated 6 people at 3L each = 18L daily)

Design

The key concept in the filter design is the use of an external container, initially a bucket, within which filtration materials are stacked. Loose materials are contained within cloth filter bags. The design is pictured in Figure 1. Raw water is poured into the top-most container and this passes through a pipe to the bottom bucket which contains the filtration materials. The centre bucket acts as a reservoir for clean water. An appropriately sized centre pipe would allow the use of a pressurizing rod to force water through the filtration layers, thus increasing the flow.

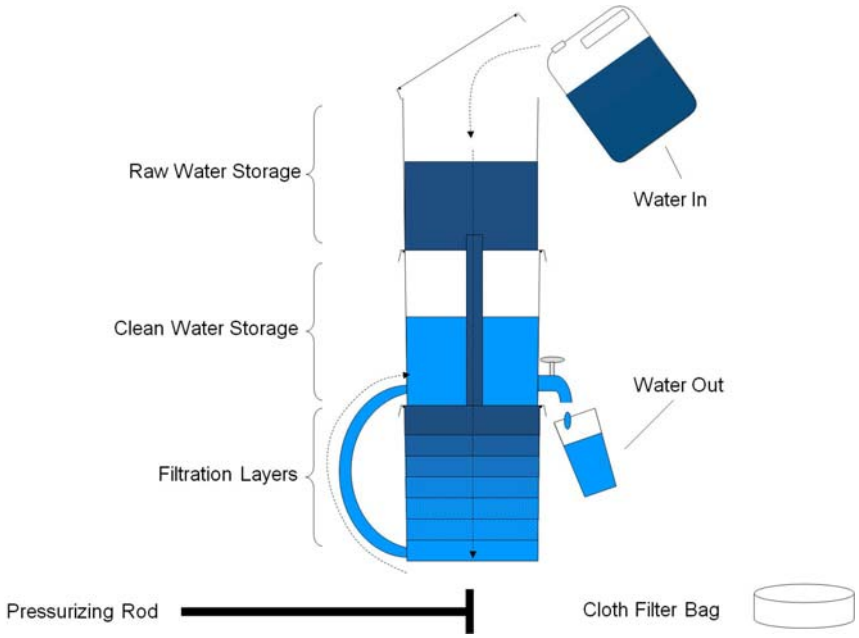

Figure 1. Sheba filter design

Filtration

This design makes the addition and removal of materials simple, allows the use of a large variety of filtration materials and carries the potential for users to customize their filters seasonally.

Stacking system including cloth bags

- Cloth bags can be made locally and cheaply using nylon. A layered design eliminates the need for a special closure.
- The cloth material in the bags acts as an extra layer of filtration.
- Materials such as ceramic disks can be directly placed into the bucket. Loose materials such as sand or gravel can be placed into the cloth bags.
- The material, contained within bags, is easy to remove for cleaning. Materials such as sand can be cleaned within bags and easily returned to the filter.
- For modification of filtration, new layers can be added (such as for rainy season turbidity, an additional roughing layer could be added or for arsenic removal, a layer of rusty nails)

Filtration materials

A wide variety of filtration materials could be used in combination, including:

- Sand

- Gravel
- Activated Charcoal – for odours, tastes and some chemicals
- Iron filings (or ungalvanized rusted iron nails) – for arsenic
- Porous Ceramic (potentially including silver)
- Other common local materials

Physical Design

Forced Filtration

The design of the filter allows water to flow via gravity during normal operation, but has the potential for the use of forced filtration to increase flow rates when the need arises. The user adds pressure by using a plunger-type mechanism within the water column.

Initial tests indicate that the efficacy of forced filtration depends on the filtration materials employed in the filter. Tests using a biosand-type filtration media found that filtration effectiveness was reduced under pressure. A ceramic filtration media has not been used, but it is believed that this will offer better results.

Attractiveness

Sheba has been designed to promote easy loading and abstraction of water by allowing users to load the top-most bucket and abstract from the middle bucket, a comfortable distance from the ground. The use of household-type materials (such as plastic) are thought to be more attractive than wood or concrete and thus make the inclusion of the filter into a household easier to achieve.

Low Cost

The design was undertaken considering the need to produce a final product with a low overall cost. Plastic buckets are nearly universally available, relatively inexpensive and can be sourced from a variety of suppliers. The number of connections has been minimized to reduce material and labour costs (as well as to reduce the chance of failures).

Testing

A prototype was built using the design depicted in Figure 1 and filtration layers as shown in Figure 2. Team attempts to create a ceramic filter disk within the course of the summit were unsuccessful and thus this was not tested.

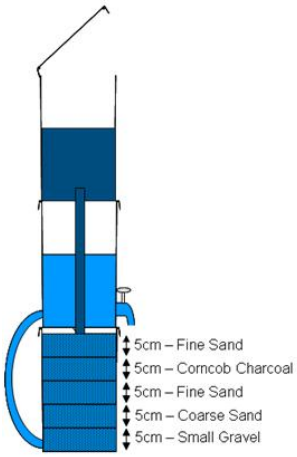

Figure 2. Testing setup

The bacterial-removal efficacy of the filter was compared to other filtration methods – the input water used was river water from Boston's Charles River. Test results are presented in Table 1.

Table 1. Test results

Treatment	Forced Filtration	Smell/Colour/ Clarity	Total Coliforms (per 100mL)
None (Charles River water)	No	Yellow, turbid, some odour	120
Boiled	No	No colour, clear, no smell	0
Flocculated with Alum (20 minute contact time)	No	Yellowish, some turbidity, odour	50
Sheba filter	No	No colour, clear, no smell	99
Sheba filter	Yes	Not performed (due to leakage)	Not performed (due to leakage)

Costs

The costs, estimated in the South Indian context, are Rs. 300 for materials and Rs. 100 for labour. Thus the total cost of the filter is estimated to be Rs. 400 or about $10USD.

Discussion

The concept has been demonstrated as possible at a low price point. The use of bags simplified assembly, reassembly and cleaning of the filter. The forced filtration mechanism was shown to work initially but after testing, the seals suffered from wear and maintaining pressure was no longer possible. Further design work is necessary to improve the sealing mechanism and trials with users will help to ensure that their needs are met by this design.

The bacteriological filtration performance was inadequate but the cause of this is undetermined – potential causes include insufficient time for the *schmutzdecke* to grow in the fine sand layer, insufficient thicknesses of fine sand layers and the potential of raw water flowing around the edges of the filtration bags directly into the reservoir. Thus judicious selection of filtration materials and layer thicknesses is essential.

Next Steps

- Build a prototype in Tamil Nadu
- Develop a reference design delivering with specified filtration materials
- Test forced filtration with ceramic

Conclusions

An innovative new design has been proposed to address some common problems affecting household water filters. Key innovations include the containment of filtration materials in cloth bags to make it easier to clean the filters, and the use of a manual mechanism to pressurize the filter to increase the flow rate. Initial tests were demonstrated the potential of the idea, but further work is required on selection of filtration materials and layer thicknesses.

Keywords

Water filtration, household water filtration, forced filtration, biosand filter, ceramic clay filter, water treatment

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