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Research needed on household level intermittent slow sand filters

Introduction

In most developing countries clean drinking water is scarce. Large parts of the population rely on contaminated water and the incidence of waterborne disease is high. The cost of unsafe drinking water is huge in terms of human suffering and severely hinders sustainable development.

Household-level intermittent filtration

The so-called 'bio-sand filter' offers a household solution that is able to produce greatly improved drinking water from polluted surface water. Already promoted by several humanitarian aid organizations[1], tens of thousand of bio-sand filters are now in use throughout the developing world. It is the only filter *specifically* designed for use in the bush, by poor, uneducated users, and it has the great advantage of not requiring the recurring costs associated with other (chemical) household water treatment methods. Field studies have proved that rural people are keen to purchase these filters once they have understood the benefits, and that the filters continue to produce clean water for many years afterwards[2].

Slow sand filtration as a single treatment process is extremely effective. It is ranked second only to desalination / evaporation in terms of pathogenic, chemical and physical improvement of water[3]. However, this data concerns continually operated systems. Showing great potential, the specific performance of the intermittent household filter has been researched, but only through limited studies[4]. Since some processes involved in continuous and intermittent sand filtration are inherently different, more research is therefore needed on the efficacy of the intermittent filter. This is especially important considering the large numbers of people already using household filters throughout the developing world.

Limitations of research to date

There appears to be a definite gap in past research done on the intermittent household filter, which covers two main areas. Firstly, there has been a lack of direct pathogen studies. Most previous studies have concentrated solely on the detection of *E. coli* indicator bacteria as a measure of efficacy. However, there are reliability issues related to using these bacteria to correlate to pathogen removal, especially viruses.

Secondly, past studies have been carried out mainly on standard filters, with few of the design parameters changing. Although the current design of filter produces greatly improved water at present, there are some variables that need to be researched. While user-related issues in the bush have been found to be a major reason for poorly functioning filters, specific research on key parameters such as hydraulic loading may result in a more field-proof design with a wider tolerance for the often less than

[1] Including Medair, Samaritan's Purse, Food for the Hungry and others.
[2] Fewster, E.; Mol, A.; Wiessent–Brandsma, C. (2004) *The long term sustainability of household bio-sand filtration.* People Centred Approaches to Water and Environmental Sanitation. 30th WEDC Conference, Vientiane, Lao PDR 2004.
[3] Shaw, R. (Ed) (1999). *Running Water: more technical briefs on health, water and sanitation.* Intermediate Technology, London, UK, p.103.
[4] Undertaken by several reputable universities such as MIT, the Universities of Calgary and North Carolina; and other organisations such as Medair and Samaritan's Purse. For details, see www.biosandfilter.org/biosandfilter/index.php/item/297.

ideal circumstances encountered in the field. This in turn would ensure more constant pathogen removal rates.

Research needed

There are various parameters that are not well documented with regards to the household intermittent sand filter. These research gaps are summarised below:

1. Evidence of direct pathogen removal is limited, especially regarding viral removal. Testing on up to 6 different pathogens is proposed. These are:

   - Hepatitis A virus (or Echo 12 virus);
   - *Clostridium perfringens* bacteria spores: these are more resistant to degradation than bacteria. Removal level of these micro-organisms would indicate a degree of treatment efficiency;
   - *Cryptosporidium parvum* oocysts: data from such research could be correlated to previous studies on intermittent filters and oocyst removal. Oocysts are also very resistant to removal. Their fate would indicate filter treatment efficiency;
   - MS-2 virus: this is an indicator virus that has the advantage that they are one of the hardest to remove by adsorption to granular media. Again, removal would show efficient filtration;
   - PRD1 virus: an indicator virus
   - *Escherichia coli* bacteria: these are indicator bacteria – the advantage for testing for them is that the removal of other pathogens could be directly correlated to removal of these indicator bacteria.

2. Data on the effect of hydraulic loading and sand size is limited. Previous research indicates that higher hydraulic loading rates, which in turn can cause higher flow rates have been known to cause more breakthroughs of pathogens. For example, more breakthroughs of *Cryptosporidium parvum* oocysts have been found to occur when using coarser sand (D_{10} 0.9 mm), yet only with a hydraulic load of greater than 4cm. Testing is therefore needed to build on this research. Testing on two sand sizes is proposed, including the coarsest sand size that is usually found in the African bush (somewhere in the range of D_{10} between 0.15 and 0.9 mm) – this is to simulate real conditions during filter installation, since control over sand type used is difficult to achieve in reality. The sand sizes should then be tested at different hydraulic loads, with one of these being the same as the standard used currently in concrete filter production. The study will indicate at what hydraulic load breakthrough occurs for the various pathogens. This can then feed back to an improved filter design.

In addition to this data, the relationship of *E. coli* and other specific pathogens in the effluent of the intermittent filter can be quantified during the research. This would greatly enhance the interpretation of past data since most research on intermittent filter efficacy has concentrated on *E. coli* removals only.

The research should also attempt to relate the findings of pathogen levels found in the filter effluents to the infective doses for those specific pathogens. In this way, the effluent from intermittent filters can be evaluated against the likelihood of catching water-borne disease.

Research proposition

Dr Mark Sobsey from University of North Carolina started research in September 2004, mainly looking into parameter 1 above. BushProof is currently advocating that additional research be done on parameter 2 above, namely the effect of hydraulic loading and sand size on pathogen removal. BushProof would be interested to collaborate with interested parties, in order to bring our field experience to the laboratory.

Organisational information

BushProof is a registered company both in the UK and Madagascar that has been set up by three humanitarian aid workers. We believe that basic products which are essential to good health and well-being should be available to people living in developing countries, even if they are poor. To be sustainable, such products must be very easy to use and maintain and should be sold commercially for prices that even the poor majority can afford. Apart from research on the household bio-sand filter, BushProof is starting up other initiatives. These include the local production of the Canzee hand pump and well jetting. The Canzee is a cheap yet efficient pump that has no significant wearing parts and can be maintained at village level using local materials only - more details available at www.canzee.com. Well jetting has proved to be a huge success in rapid water provision in both Sudan and Madagascar – check out www.bushproof.com/jetting. Also check www.biosandfilter.org, an information resource website on sand filtration maintained by BushProof.

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