HOUSEHOLD WATER TREATMENT SYSTEMS

Domestic water treatment is increasingly popular for people who do not have access to mains water supplies. Household water treatment and safe storage (HWTS) systems allow families to use available water from nearby sources such as springs, wells and rainwater for drinking with reduced risk to health.

Figure 1: A domestic water supply in Peru.
Photo: Soluciones Prácticas.

Simple water treatment systems such as sand filtration or ceramic filtration are sometimes considered to be not as reliable as larger water treatment systems but larger systems often do not provide safe drinking water or are entirely inoperable.

Household water treatment can be important for people without access to a clean source of water and allows the user have some control over the quality of their own water source.

The approach to household water treatment is similar to community water treatment in its approach but on a smaller scale.

It is difficult to get a simple and reliable water treatment process so if it is possible to use a water source that is already clean then water treatment becomes easier. A multi-barrier approach will ensure the best quality of water. This means using a series of treatments from

The following are the basic steps for water supplies

- Start with the best quality water available as treatment procedures are not perfect. Protect the source.
- Sedimentation – the water is allowed to stand
- Filtration – various designs of small-scale water filters have been developed
- Disinfection
- Store safely to avoid recontamination

Source Protection

Ideally the water source should be tested for faecal contamination. Cleaner sources are obviously going to be easier to deal with. There are ways of improving the source if it is not safe; covering wells with a concrete slab, keeping animals away from the source, ensuring rubbish is not thrown down the well, the type of bucket used to extract water etc. Tubewells with handpumps are usually quite well protected from contamination if maintained properly. Others sources such as surface water are not safe without treatment.

Water should be collected and kept in clean containers to prevent contamination.

Also see:
http://www.lboro.ac.uk/well/resources/technical-briefs/34-protecting-springs.pdf
http://www.lboro.ac.uk/well/resources/technical-briefs/47-improving-pond-water.pdf

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However, there may not be a choice of water source and all surface water sources will be contaminated to some extent so treatment will be needed.

Household water treatment methods

There are a number of steps that should be incorporated into the approach to household water treatment outlined below; some are easier to achieve than others.

Sedimentation

Treatment of water can start with letting solids and some pathogens settle out as the water is left to stand. The water is stored in a stationary container for 24 hours and is then poured into another clean container leaving the sediment behind. This natural settling is often done 2 or 3 times to get the good results.

The process can be speeded up by adding coagulants to the water. Coagulants are materials that help the small particles in the water such as sand, silt and clay to combine and form larger clumps, which settle more quickly.

Natural coagulants include; moringa seeds, clearing nuts and prickly pear cactus. These materials need to be processed before they can be used which entails drying and grinding the seeds or beans while the prickly pear cactus needs to be used before the sap dries. Natural coagulants may not be available in all regions however chemical coagulants can be used. These include; aluminium sulphate (alum), polyaluminium chloride (PAC or liquid alum) and iron salts (ferric sulphate or ferric chloride).

Aeration

By increasing the air content of the water it is possible to reduce the concentration on volatile substances, such as hydrogen sulphide. It also helps to oxidizes iron and manganese before settlement or filtration.

Dissolved air is also important for the effective performance of slow sand filters but there may already be sufficient oxygen in surface waters.

Aeration on a small scale can be done by rapidly shaking a container part-full of water.

Larger scale aeration can be done by trickling water through one or more well-ventilated, perforated trays containing small stones.

Filtration

There are many filtration options used with varying sophistication. Some of these are outlined below.

Straining

Old cloth, such as a sari, folded over a few times can be an effective way of removing suspended solids such as sand, silt and clay from drinking water and it can also remove some pathogens. It can cut cases of cholera by half according to research in Bangladesh. This is because cholera is reliant on plankton. It can also filter out many helminths (parasitic worms), eggs and larvae.

The cloth should be fine and tightly woven cotton. It should be folded over to provide multiple layers for the water to pass through and to effectively reduce the pore size from around 100 - 150μm to 20 μm.

The cloth should be washed after use.

Slow sand filters

Sand filters can work well if they are maintained but this is a difficult task and is often neglected which means that the filters often don't work. It is best using a system where filtering can be done easily and maintenance is not going to become an issue. In some cases that might mean a disposable or replaceable filter or a ceramic filter if these are available from a nearby source. In many cases this will not be a realistic option and alternative approaches need to be considered.

Slow sand filters (velocity of 0.1 to 0.2 m/hr) are one approach for household applications. Different grades of sand can filter out physical impurities and can also eliminate pathogens as they develop a layer of algae, bacteria and fungi that feed on the harmful microorganisms in water. This biofilm is called a schmutzdecke. Sand filters will block up over time with inorganic matter but this can be cleaned out by backwashing. Inorganic matter can be removed through rough filtering or by using sedimentation tanks.

Slow sand filters improve the microbiological quality of the water but do not provide completely clean water and an additional treatment such as boiling, chlorination or ultra-violet (UV) is often needed.

A simple slow sand filter can be constructed with from an old oil drum and can be upward filter systems or downward filter systems.

Sand filter systems are described in the document *Slow Sand-Filtration Water Treatment Plants* produced by Soluciones Prácticas.

Lifewater International
http://www.lifewater.org/resources/tech_library.html
Designing a Slow Sand Filter
Constructing a Slow Sand Filter
Operating and Maintaining a Slow Sand Filter

Bio sand filters

Bio sand water filters are a form of slow sand filter. They have mostly been used on a domestic scale.

Practical Action has been involved with bio sand filters in Bangladesh and in Peru. They have proved to be an effective way of treating water on a small domestic scale producing around 20 to 60 litres of water an hour.

Also see: *Bio-sand Filters* Practical Action Technical Brief
Also see: *A Small-scale Arsenic and Iron Removal Plant* Practical Action Technical Brief

Some construction guidelines are available at the following website:
http://www.biosandfilter.org/biosandfilter/index.php/item/330

Ceramic filters

Ceramic filters have been made locally for many years and their production is widespread in Asia.

They are usually made from local clay mixed with a combustible material such as sawdust, rice husks or coffee husks.

When the filter is fired in a kiln, the combustible material burns out, leaving a network of fine pores through which the water can flow through.

Colloidal silver is sometimes added to the clay mixture before firing or applied to the fired ceramic candle. Colloidal silver is an antibacterial which helps in pathogen removal, as well as preventing growth of bacteria within the filter itself.

The more common approaches are candle filters and pot filters.

Candle filters are small ceramic cylinders in that fit into the bottom of the water container and allow water to pass through to a second container where it is stored until required. As the water passes through the candle it is filtered although this is done at a slow rate. Sometimes more than one candle filter is used at one time to increase the flow rate.

Pot filters are similar in approach but the filter is larger than the candle style filter. They are approximately 30cm in diameter and 25 cm deep. This equates to an 8 litre capacity. The filter can be flat or rounded at the bottom.

The main risks for ceramic filters is damage producing cracks that make will allow impure water to pass through.

The American Red Cross developed a ceramic water filter in Sri Lanka produced a flat bottomed filter. The design is aimed at family level water treatment. Practical Action has a fact sheet about this which can be seen at *The Ceramic Filter.*

Potters for Peace has been assisting in the production of a low-tech, low-cost, colloidal silver-enhanced ceramic water purifier (CWP) for some years.

Resource Development International (RDI) has set up a factory in Cambodia which is selling a large number of filters: http://www.rdic.org/waterceramicfiltration.htm

Disinfection and sterilisation

Adding citric fruit juice from limes or lemons to filtered water can help in its treatment of cholera but many pathogens are not killed. It is an improvement on treatment at all. The juice of one lime should be added to a litre of water.

See: *How to prevent Cholera* http://www.hesperian.info/assets/environmental/Cholera_EN.pdf

Boiling

Although the majority of bacteria and viruses are rendered harmless very rapidly, boiling water for a few minutes does not necessarily give complete sterilisation.

However, WHO recommends boil water for 1 minutes and adding 1 minute per 1000 metres of elevation.

This is the only treatment that disinfects the water. Boiling does not require any specialist equipment as pots and a stove will already exist in the house.

The main disadvantage is the energy consumption. It will take extra time to collect the fuel or cost more in fuel charges.

Chlorination

Chlorine is an oxidising agent that disinfects water. It is cheap, reliable and easy to add to the water supply but it can produce a nasty taste and there is an on-going cost of around US$3-11/year. It is most effective at treating bacteria but may not treat certain types of protozoa. Chorine products specifically for household water treatment are widely available.

Chlorination is most effective in clear water so should be done after any sedimentation and filtering processes. Chlorine will kill the algae that treats the water in slow sand filters and bio filters. Chlorine should be added in quantities that leave a residual amount of free chlorine in the water of 0.3mg/l after 30 minutes.

Solutions of chemicals containing free chlorine include; bleaching powder, chlorinated Lime, sodium hypochlorite, or HTH.

Alternative treatments include chlorine dioxide Cl_2 or ozone O_3. NaDCC, also known as sodium dichloroisocyanurate or sodium troclosene releases hydrochloric acid which kills micro-organisms.

Also see: http://www.lboro.ac.uk/well/resources/technical-briefs/46-chlorination.pdf

Ultraviolet (UV) treatment
UV light can be used to kill pathogens in water if the water does not have a large quantity of physical contaminants which would block the light. It can be done on a large or small scale.

At its most basic level SODIS or Solar Disinfection can be carried out by placing water in transparent plastic bottles which are then left out in direct sunlight thus exposing the pathogens' to UV light which destroys them. See http://www.sodis.ch/.

Storage
The approach to storage can also help with treating the water in that a carefully designed system with a slow flow of water from the inlet to the outlet will allow the water to settle and provide enough time for pathogens to die off. The water should be stored for 48 hours in a covered tank.

The book *Environmental Health Engineering in The Tropics* states that "for storage tanks a few small leaks in a tank above ground may not be serious in village circumstances, and perfectly adequate tanks may be built of local building materials such as brick or masonry, especially if galvanized wire is laid between courses to give the walls horizontal reinforcement." The tank should be protected so that it doesn't become a breeding ground for mosquitoes which means it should be covered, have ventilation pipes screened with mosquito proof mesh and steps should be taken to avoid breeding sites downstream from the overflow.

References and further information

WHO - The World Health Organization
http://www.who.int/household_water/en/
WHO established the International Network to Promote Household water treatment and safe storage - HWTS. The informal network inlcudes.
- Center for Affordable Water and Sanitation Technology (CAWST)
- Center for Disease Control (CDC)
- Massachussets Institute of Technology (MIT): conference proceedings, factsheets, and tools
- USAID/CDC Environmental Health topics (see "water treatment" category, and scroll to "sponsored activities/reports")

CAWST - Centre for Affordable Water & Sanitation Technology
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http://www.cawst.org
Household water treatment systems

http://www.cawst.org/en/resources/pubs/category/24-fact-sheets-simplified
Household water treatment systems
http://www.cawst.org/en/resources/pubs/category/25-fact--sheets-academic
Bio-sand filters
http://www.cawst.org/en/resources/pubs/category/23-technical-updates
The full bio-sand filter construction manual
http://www.cawst.org/en/resources/pubs/category/12-biosand-filter-project-implementation

Resource Development International - Cambodia (RDI)
P.O. Box 494
Phnom Penh,
Cambodia
Ceramic Water Filter Handbook: http://www.rdic.org/water-ceramic-filtration.html including appendices on factory layout, technical drawings, a filter efficiency test and many other useful documents.

Lifewater International
http://www.lifewater.org/resources/tech_library.html

Water Treatment
Overview
Methods of Water Treatment
Determining the Need for Water Treatment
Taking a Water Sample
Analyzing a Water Sample
Planning a Water Treatment System
Water Treatment in Emergencies

Household Water Treatment
Designing Basic Household Water Treatment Systems
Operating and Maintaining Household Treatment Systems

Slow Sand Filters
Designing a Slow Sand Filter
Constructing a Slow Sand Filter
Operating and Maintaining a Slow Sand Filter

Manz Water Info
David Manz, PhD.
University of Calgary
Canada
http://www.manzwaterinfo.ca/
Concrete Bio-Sand Water Filter Construction Manuals, Dr. David H. Manz, P. Eng., P. Ag. (May 2008) ACAD Drawings of BSF Steel Mould, Dr. David H. Manz, P. Eng., P. Ag. (April 2010) BioSand Water Filter Guidance Manuals, Dr. David H. Manz, P. Eng., P. Ag. (January 2009, updated July 2010)

Potters for Peace
http://www.pottersforpeace.org/
An organisation devoted to socially responsible development and grass roots accompaniment among potters. The organisation was started by the late Ron Rivera born to Puerto Rican parents in the Bronx USA. Its design of ceramic water filter was developed by Guatemalan chemist, Fernando Mazariegos and has water filter projects worldwide.

The Red Cross
The American Red Cross working with the Sri Lankan Red Cross, has developed a ceramic filter within a plastic bucket which was originally made for the post tsunami situation and is

now being used in general rural situations, details of which are on the Practical Action website. See *The Ceramic Filter*.

Water, Engineering and Development Centre (WEDC)
The John Pickford Building
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United Kingdom
http://www.lboro.ac.uk/well/resources/technical-briefs/58-household-water-treatment-1.pdf
http://www.lboro.ac.uk/well/resources/technical-briefs/59-household-water-treatment-2.pdf

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Promote the 3 pitcher arsenic filtration system for domestic and institutional use.

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OXFAM-DELAGUA portable water testing kit was developed by the University of Surrey and Oxfam.

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