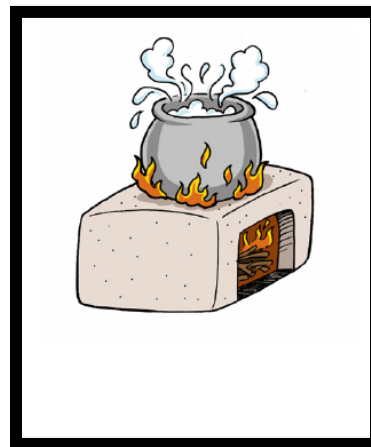
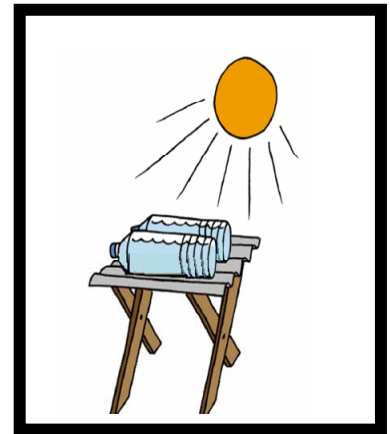
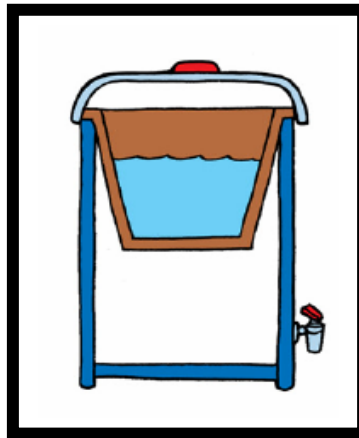
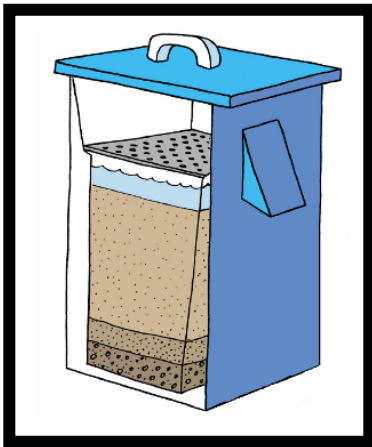


HOUSEHOLD WATER TREATMENT MANUAL



March 2008

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Preface

The Centre for Affordable Water and Sanitation Technology (CAWST) started with the belief that the poor in the developing world deserve safe water and basic sanitation. CAWST also believes that the place to start is to teach people the skills necessary to have safe water in their homes. The goal of the CAWST model is to pass knowledge and skills to organizations and individuals in developing countries through education, training and consulting services. They, in turn, can motivate households to take action and meet their own water and sanitation needs.

CAWST's main strategies are to:

- Make knowledge about water “common knowledge”
- Build the capacity of local public sector organizations, both non-governmental organizations (NGOs) and government agencies
- Focus on household water treatment (HWT)
- Lead with the education and training
- Identify barriers to implementation of water and sanitation projects and ways to overcome them

This approach:

- Empowers, motivates and generates grass roots action within the community
- Provides opportunities for continuous learning and support
- Generates multiple, independent actions required to reach the United Nations (UN) Millennium Development Goals for water and sanitation

Acronyms

| | |
|--------|--|
| CAWST | Centre for Affordable Water and Sanitation Technology |
| EAWAG | Swiss Federal Institute for Environmental Science and Technology |
| ENPHO | Environment and Public Health Organization of Nepal |
| HTH | High test hypochlorite |
| HWT | Household water treatment |
| MIT | Massachusetts Institute of Technology |
| NADCC | Sodium dichloro-isocyanurate |
| NGO | Non-governmental organization |
| NTU | Nephelometric turbidity units |
| PAC | Polyaluminium chloride |
| SANDEC | Water & Sanitation in Developing Countries |
| SODIS | Solar disinfection |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UV | Ultraviolet |
| WHO | World Health Organization |

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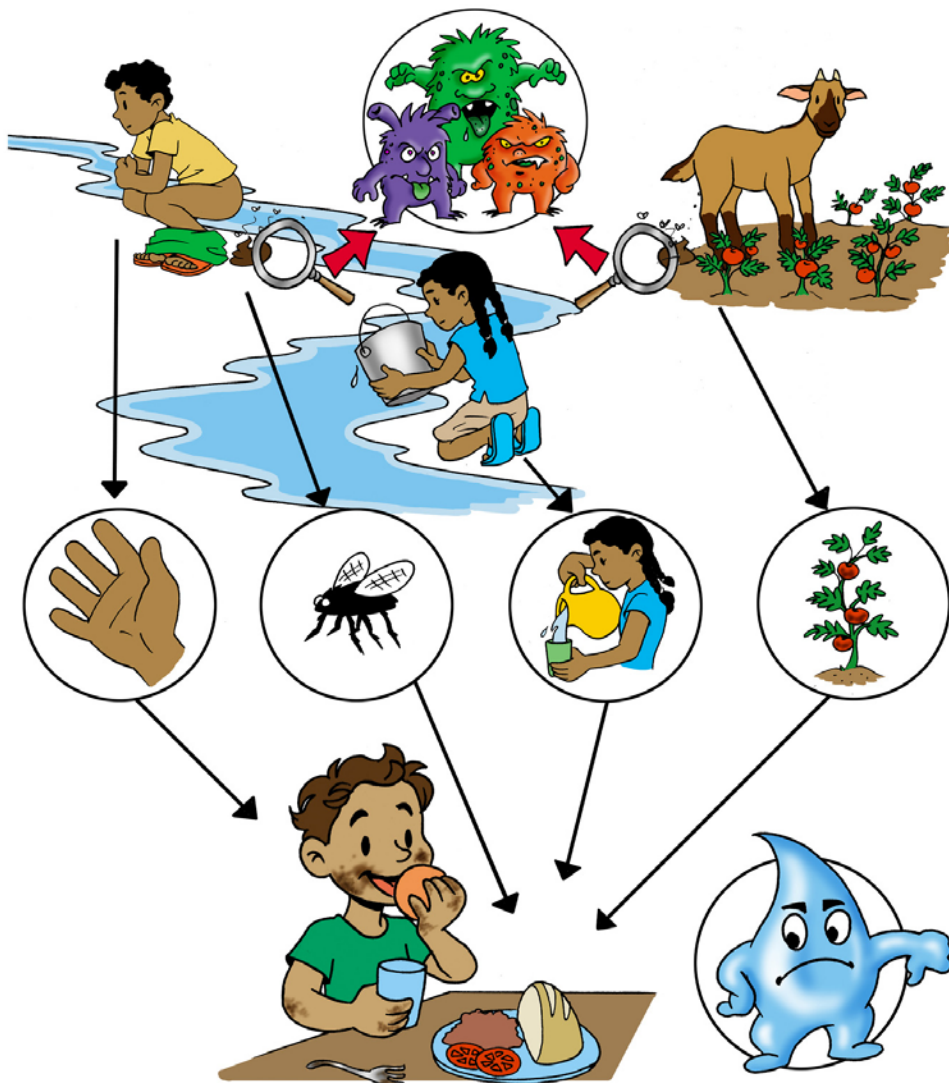
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The Need for Safe Drinking Water

Access to safe drinking water and basic sanitation is a basic human need and a fundamental human right. People need clean water and sanitation to sustain their health and maintain their dignity. Yet in our increasingly prosperous world, 1.1 billion people are denied the right to clean water and 2.6 billion people lack access to adequate sanitation. When people are denied access to water, their choices and freedoms are constrained by ill health, poverty and vulnerability. Water gives life to everything (UNDP, 2006).

Water naturally contains a diverse population of living organisms, such as aquatic plants, animals, algae, bacteria and parasites. Some of these organisms are harmless and others can be harmful to humans. Those of greatest concern to us are pathogens, or disease causing organisms. We sometimes call pathogens other names, such as microorganisms, microbes, germs or bugs, depending on the local language and country.

As shown in the following illustration, pathogens are transferred from faeces to our faces and mouths in many ways.



88% of diarrhoeal disease is attributed to unsafe water supply, inadequate sanitation and poor hygiene. Improved drinking water quality, hygiene and sanitation practices break the transmission routes for pathogens. All three measures implemented together have a much larger effect than any single intervention implemented alone.

- Improved drinking water quality through household water treatment can lead to a reduction of diarrhoea cases by 35% to 39%.
- Improved sanitation reduces diarrhoea cases by 32%.
- Hygiene interventions including hygiene education and promotion of hand washing can lead to a reduction of diarrhoea cases by up to 45%. (WHO, 2004)

Community Versus Household Water Treatment

Water can be treated at a central location, in large volumes, and then distributed through pipelines to the end users. This is often called centralized or community water treatment. Alternatively, small volumes of water can be treated at the point of use. This is commonly called household water treatment since the householders gather the water and treat it with simple, low cost technology in their home.

With both centralized and household water treatment, three steps are commonly used to remove microorganisms and make the water safe to drink: sedimentation, filtration and disinfection.

The main advantage of household water treatment is that it can be adopted immediately in the homes of poor families to improve their drinking water quality. It is also less expensive, more appropriate for treating smaller volumes of water, and provides an entry point for hygiene and sanitation education. There are a wide range of simple household treatment technologies that provide options based on what is most suitable and affordable for the household.

Some limitations of household water treatment are that it requires the end users to be knowledgeable about its operation and maintenance, and they need to be motivated to ensure that it is being used and maintained correctly. As well, most household water treatment technologies are designed to remove microorganisms rather than chemicals.

The Multi-Barrier Approach

A multi-barrier approach is the best way to reduce the health risk of drinking unsafe water. Putting multiple barriers in place can help to protect our health through improved water quality. Barriers which protect water from pathogens can occur in each of the following steps:

- Step 1 – Protecting your water source
- Step 2 – Sedimentation
- Step 3 – Filtration
- Step 4 – Disinfection
- Step 5 – Safely storing your water after treatment

Step 1 – Protecting Your Water Source

Protecting your water source helps to ensure a clean, safe drinking water supply. The following lists various things that we can do which will protect our water from contamination. If we do these around the house and yard, the quality of the water that we consume can be improved.

- Keep a protected and covered well.
- Use a clean rope and bucket to pull water out of a well.
- Build a platform under the pump or tapstand.
- Protect your spring by building a catchment box.
- Collect and store rainwater in covered tanks.
- Keep animals away from water sources by using fences.
- Maintain a separate area for animals to drink.
- Take care of the yard and general environment around the house.
- Protect the source of water by planting trees along creeks and rivers.
- Maintain a well forested area above your water source.
- Locate latrines away from water sources and points of use.
- Build a soak pit for wastewater.

Step 2 – Sedimentation

Sedimentation is a physical treatment process used to remove small particles, such as sand, silt and clay, which make water cloudy. Microorganisms are often attached to suspended material in water, so removing these particles can also help to reduce the biological contamination.

Much of the suspended material can be removed by simply allowing the water to stand and settle for a period of time. This can be done effectively in a small container such as a bucket or pail.

The sedimentation process can be accelerated by adding special chemicals, also known as coagulants, to the water. These chemicals help the small particles in water join together forming larger clumps, making it easier for them to settle to the bottom of the container. Three common chemicals used are aluminium sulphate, polyaluminium chloride (also known as PAC or liquid alum) and ferric sulphate.

Native plants have also been traditionally used in a number of countries in Africa and Latin America to help with sedimentation. For example, prickly pear cactus, dried and ground moringa seeds, broad beans and fava beans have all been used to help sediment water.

Step 3 – Filtration

After sedimentation, the water should then be filtered to further remove suspended material and pathogens. There are various types of filters that are used by households around the world: biosand filter, Kanchan arsenic filter, ceramic pot filter and ceramic candle filter. Straining is also considered a form of filtration.

Step 4 – Disinfection

The final step in water treatment is to remove, deactivate or kill any remaining pathogens through disinfection. There are various methods that are used by households around the world to disinfect their drinking water: chemical disinfection, solar disinfection (SODIS), boiling, pasteurization, and ultraviolet disinfection.

Pathogens can “hide” from disinfecting agents if the water has a lot of organic matter and suspended solids in it. Removing suspended material by sedimentation and filtration will increase the effectiveness of chemical, solar and ultraviolet disinfection methods.

Step 5 – Safe Water Storage

Households go through a lot of work to collect, transport and treat their drinking water. Now that the water is safe to drink, it should be handled and stored properly to keep it safe. Sometimes, the quality of stored water becomes worse than the actual source water. This indicates that the household’s handling and storage practices may be unhygienic and poses a risk for transmitting diseases.

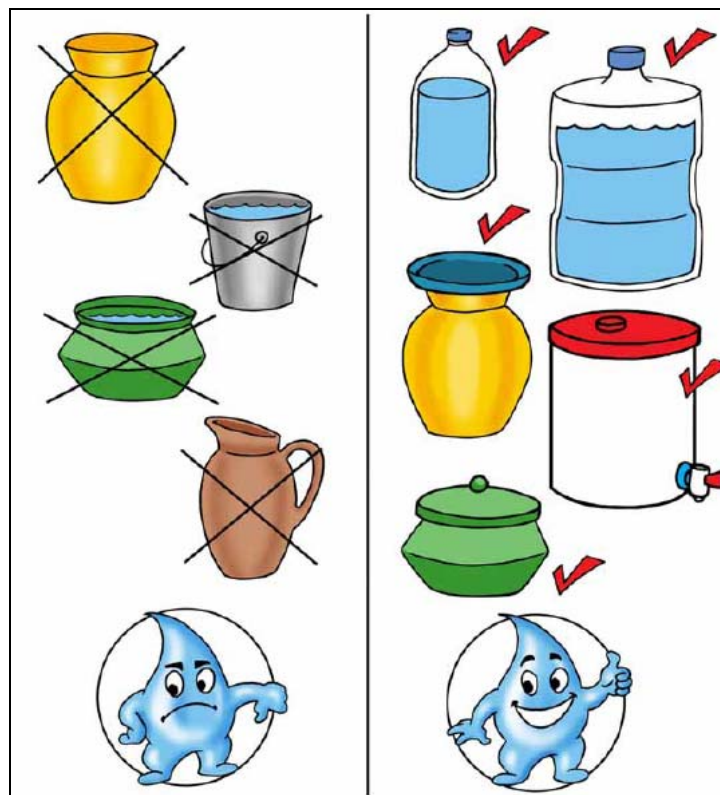
A variety of acceptable designs are used for water containers around the world. For safe water storage, an appropriate container should have the following qualities:

- Strong and tightly fitting lid or cover
- Tap or narrow opening
- Stable base
- Durable
- Comfortable handle
- Allows air to enter as water is poured
- Should not be translucent

Other safe water handling practices include:

- Providing a bucket to collect and store untreated water and using it only for untreated water.
- Providing an appropriate container to store treated water. Never use this container for untreated water.
- Frequently cleaning out the storage container.
- Storing treated water off the ground in a shady place in the home.
- Storing treated water away from children and animals.
- Pouring treated water from the container instead of scooping the water out of it.

Sometimes it is difficult to find or buy a good storage container. The most important things are to make sure that it is covered and only used for treated water.



Discussion Questions

What issues exist in your community that support the need for household water treatment?

What approaches to household water treatment are currently being used in your community?

Sedimentation Technology Options

Option 1 - Settling

Much of the suspended material can be removed by simply allowing the water to stand and settle for a period of time. This can be done effectively in a small container such as a bucket or pail. Microorganisms like to stick to sediment, so by allowing the sediment to settle out we are removing microbes. Settling, however, can only partially remove turbidity – which is a measure of the suspended solids. The time range may vary from one hour up to two days (the longer the better).

Advantages

- Low cost, free if container is already available
- Simple and easy

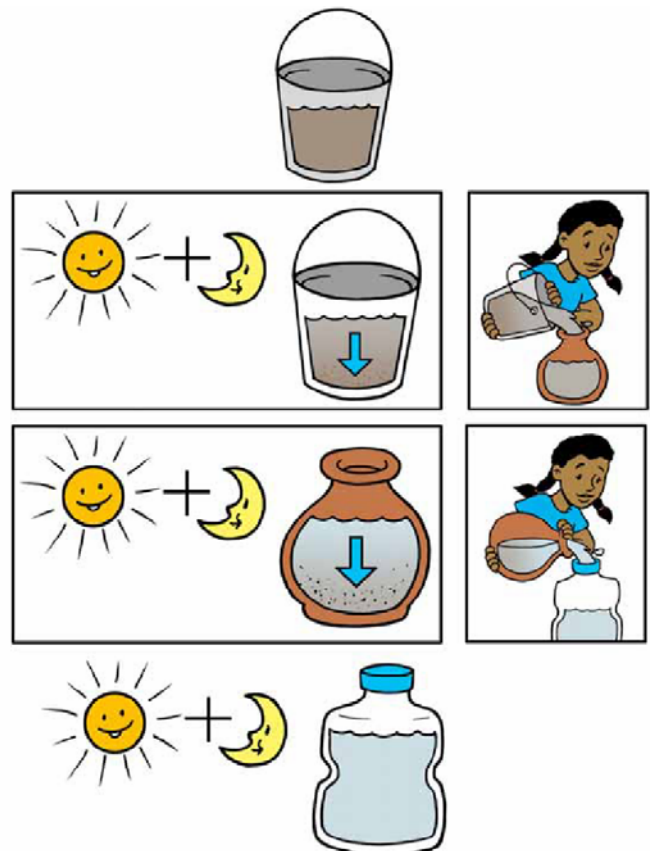
Limitations

- Time intensive
- Partially removes turbidity

3-pot settling is one settling method that can be used by households. It is named so because you will need three buckets or pails for the process. To settle the water:

- Get a bucket of dirty water
- Allow the bucket to sit without moving it for about 24 hours
- Pour the clear water from the bucket to a clean bucket
- Allow the second bucket to sit without moving it for about 24 hours
- Pour the clear water from the bucket to a clean storage container

Cover your pots while they are settling so that more dirt and mosquitoes do not enter the water.



Option 2 – Coagulation Agents

The sedimentation process can be accelerated by adding special chemicals, called coagulants, to the water. These chemicals help the small particles in water join together forming larger clumps, making it easier for them to settle to the bottom of the container.

Advantages

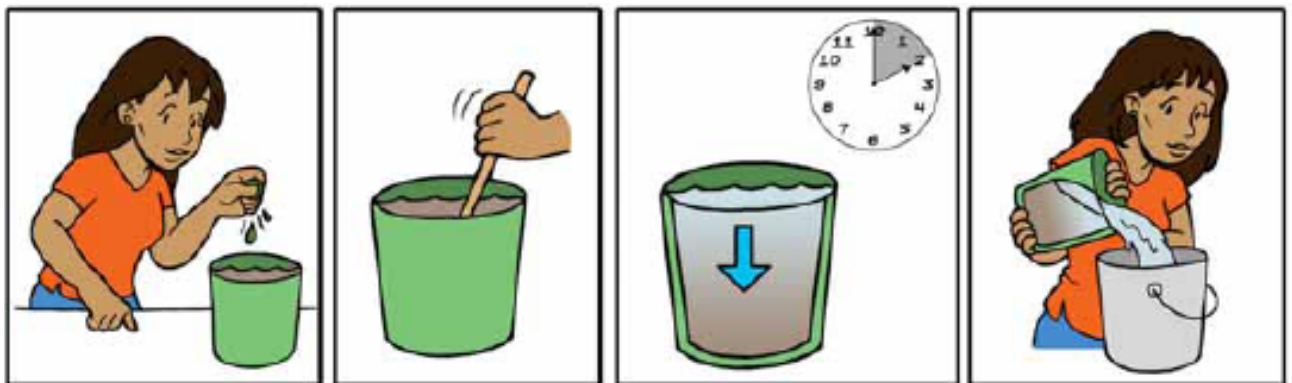
- Chemical coagulants are generally available
- Natural coagulants are free
- Simple and easy
- Currently being used in many parts of the world

Limitations

- Costs are variable depending on coagulant
- Partially removes turbidity and some microorganisms

Different chemicals are used in different countries. Three common chemicals used are aluminium sulphate, polyaluminium chloride (also known as PAC or liquid alum), and ferric sulphate. Each type of chemical has specific directions for using it properly. You will need to read the label and follow the directions on the chemical's package. In general, the following steps are used:

- Add some chemicals to the dirty water
- Stir the water with a stick or spoon
- Let it settle for a couple of hours
- Pour the clear water to a clean storage container



Native plants have also been traditionally used in a number of countries in Africa and Latin America to help with sedimentation. For example, prickly pear cactus, dried and ground moringa seeds, broad beans and fava beans have all been used to help sediment water.

Prickly pear cactus leaves are also known as raquet in Haiti and parts of Latin America. There are different ways people use prickly pear cactus leaves. One way is to do the following steps:

- Cut a small piece of leaf – 5 cm (2 in) long
- Extract the sap into the dirty water. To do this:
 - If the leaf is soft enough, squeeze the leaf with your fingers,
 - If the leaf isn't soft enough, scratch the leaf with a knife or rub the cut ends of two pieces of leaf together
- Stir the water with a spoon or stick for a few minutes
- Let it settle for a couple of hours or until the water is clear
- Pour the clear water into a clean storage container



There are also different ways people use moringa seeds or beans to sediment their water. One way to use moringa seeds is to do the following steps:

- Let the seeds dry out in the sun
- Grind up some seeds
- Add a handful of ground seeds to a bucket of dirty water
- Stir the water with a spoon or stick for a few minutes
- Let it settle for a couple of hours
- Pour the clear water into a clean storage container
- The seeds will be left at the bottom of the bucket. They should be thrown out with the rest of the household garbage.



Discussion Questions

Why is sedimentation an important step in household water treatment?

The use of moringa seeds is an example of a traditional way of treating water. Are you aware of any other local practices to sediment water?

Filtration Technology Options

After sedimentation, the water should then be filtered to further remove suspended material and pathogens. There are various types of filters that are used by households around the world: biosand filter, Kanchan arsenic filter, ceramic pot filter and ceramic candle filter. Straining is also considered a form of filtration.

Option 1 – Straining

A clean, cloth fabric can be used to strain particles out of water. Typically in south Asia, a sari cloth is folded 7 to 8 times and used as a filter. Water is poured through the folded sari cloth and collected in a bucket underneath. Sari cloth filters are known to reduce the risk of cholera by filtering out particles and plankton which harbor the cholera bacteria.

Advantages

- Low cost, free if extra saris are available
- Time required is minimal, simply the time it takes to pour water through the cloth
- Simple and easy
- Reduces turbidity
- Known to reduce the risk of cholera

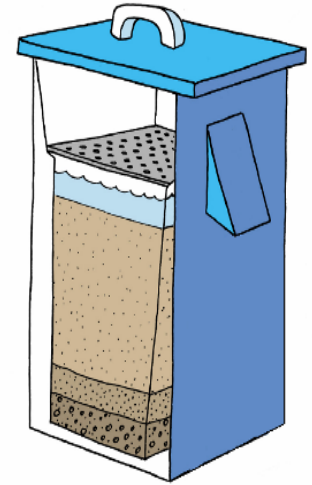
Limitations

- Requires extra washing of sari after use



Option 2 – Biosand Filter

The biosand filter is an adaptation of a traditional slow sand filter in such a way that the filters can be built on a smaller scale and can be operated intermittently. These modifications make the filter suitable for use at the household or small group level. The biosand filter can be produced locally anywhere in the world using materials that are readily available.



A biosand filter consists of a concrete box that is filled with layers of sand and gravel. A biological layer (often called a biolayer) of slime, sediment and microorganisms develops at the sand surface. To use the filter, water is simply poured through the top and collected in another storage container at the base of the spout. Water slowly passes through the biolayer, sand and gravel. Pathogens and suspended material are removed through various physical and biological processes that occur in the biolayer and sand.

The biosand filter has been tested by various government, research, and health institutions, as well as by non-governmental agencies in both laboratory and field settings. Overall, these studies have shown that the biosand filter removes:

- > 97% of E. coli - indicator of faecal contamination (Duke et al., 2006; Stauber et al., 2006)
- > 99% of protozoa and helminths (Palmateer, 1999)
- 80-90% of viruses (Stauber, 2005)
- 50-90% of organic and inorganic toxicants (Palmateer, 1999)
- 90-95% of iron (Ngai, 2007)
- Most suspended sediments

Preliminary health impact studies estimate a 30-40% reduction in diarrhea among all age groups, including children under the age of five, an especially vulnerable population (Liang et al., 2007; Sobsey et al., 2007).

Advantages

- Affordable, no on-going costs
- Made from locally available materials
- Functional and durable
- High user acceptability
- Simple and easy to use
- Can effectively treat 60-80 L/day
- 90-99% pathogen removal efficiency

Limitations

- Heavy, should not be moved after installation
- May need to sediment water before using filter, turbidity should be less than 50 NTU
- Can not remove some dissolved substances (eg. salt, hardness), some organic chemicals (pesticides and fertilizers) or color
- Can not guarantee that water is pathogen free

Option 3 – Kanchan Arsenic Filter

The Kanchan™ arsenic filter was developed at the Massachusetts Institute of Technology (MIT) in collaboration with the Environment and Public Health Organization of Nepal (ENPHO). The filter can remove both pathogens and arsenic contamination. The design is similar to the biosand filter, but 5 kg (11 lb) of non-galvanized iron nails and a layer of brick chips are added. The iron nails quickly rust and become an excellent adsorbent for arsenic. The purpose of the brick chips is to protect the underlying iron nails from dispersing due to the force of the incoming water. In addition to the concrete version of the filter, the MIT-ENPHO team has developed a small plastic version using water buckets available in Nepal.

The Kanchan™ filter can remove 85% to 95% of arsenic from source water (Ngai, 2007). The iron nails will lose their capacity in 3 to 5 years if the source water has up to 500 ug/L of arsenic. At that time, replacement of the iron nails is necessary. However, the exact replacement period will depend on a variety of factors such as the usage rate and water chemistry.

Advantages

- Affordable, minimal on-going costs
- Made from locally available materials
- Functional and durable
- High user acceptability
- Simple and easy to use
- High pathogen removal efficiency
- 85-95% arsenic removal efficiency

Limitations

- Heavy, should not be moved after installation
- May need to sediment water before using filter
- Can not remove some dissolved substances (eg. salt, hardness), some organic chemicals (pesticides and fertilizers) or color
- Can not guarantee that water is pathogen free

Option 4 – Ceramic Pot Filters

After Hurricane Mitch in October of 1998, the rural water supply of Nicaragua was largely contaminated. This prompted Potters for Peace to begin a Ceramic Water Filter production workshop near Managua using a design developed by a Guatemalan industrial engineer, Fernando Mazariegos. Potters for Peace now conducts training in several countries including Cuba, El Salvador, Ghana, Mexico, Honduras, Indonesia, Kenya, and Guatemala among others (Potters for Peace, nd).



The filter element is an open-top clay cylinder. The filter is sometimes coated with colloidal silver, which helps to reduce the number of microorganisms in the water. The clay cylinder is placed in a plastic or ceramic receptacle with a lid and faucet. Pathogens and suspended material are trapped on the ceramic material as water is poured through the filter. If properly constructed and operated, a ceramic filter can be very effective in producing good quality water.

Advantages

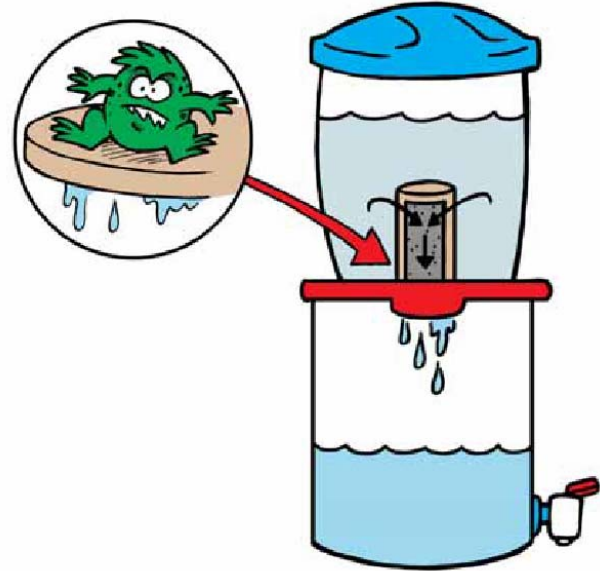
- Low cost, one new model projected at US\$3.50 for the two container system
- Made from locally available materials
- Easy to transport
- High user acceptability
- Simple and easy to use
- 99-100% pathogen removal efficiency

Limitations

- Slower flow rate, 1.5 to 3 litres per hour
- Breakable and needs to be replaced when damaged
- Needs to be replaced every 3 years or when the flow rate is too slow after cleaning
- May need to sediment water before using filter
- Need to clean filter regularly if source water is dirty, reducing lifespan of filter
- Can not guarantee that water is pathogen free

Option 5 – Ceramic Candle Filters

A candle filter consists of two containers and one or more ceramic filter elements, shaped like a thick candle, screwed into the base of the upper container. Water is poured into the upper container and then allowed to filter through the ceramic filter element into the lower collection vessel. Candle filters can have very low flow rates, so it is common to find filters with two or more candle filter elements (Dies, 2003).



Candle filters are used in various countries and the most common type of ceramic water filter used in India and Nepal. They are commercially manufactured by a range of companies around the world. The best known manufacturer is probably the Swiss company called Katadyn® who produces the Katadyn® Drip Filter.

Advantages

- Made from locally available materials
- Easy to transport
- High user acceptability
- Simple and easy to use

Limitations

- Can be more expensive than other filters
- Slower flow rate, 1.5 to 3 litres per hour
- Clay candle can break or crack easily, needs to be replaced when damaged
- Needs to be replaced more often than other filters
- Quality varies depending on product manufacturer
- May need to sediment water before using filter
- Need to clean filter regularly if source water is dirty, reducing lifespan of filter
- Can not guarantee that water is pathogen free

Discussion Questions

Which filter design would be the most appropriate for your community? Why?

Disinfection Technology Options

The final step in water treatment is to remove, deactivate or kill any remaining pathogens through disinfection. There are various methods that are used by households around the world to disinfect their drinking water: chemical disinfection, solar disinfection, boiling, pasteurization, and ultraviolet disinfection.

Pathogens can “hide” from disinfecting agents if the water has a lot of organic matter and suspended solids in it. Removing suspended material by sedimentation and filtration will increase the effectiveness of chemical, solar and ultraviolet disinfection methods.

Option 1 – Chemical Disinfection

Chlorination is the most widely used method for disinfecting drinking water. Disinfecting water with chlorine will kill bacteria and viruses, but it does not deactivate parasites like giardia, cryptosporidium and worm eggs. Chlorine must be added in sufficient quantities to destroy all pathogens, but not so much that taste is adversely affected.

Chemical disinfection using chlorine has the benefits of being relatively quick, simple, and cheap and allows a residual amount of chlorine to remain in the water to provide some protection against subsequent contamination.

Advantages

- Effectively kills bacteria and viruses
- Provides residual chlorine for some protection against re-contamination
- Inexpensive, costs approximately US\$0.40-0.80 per family per month
- Widely available in different countries
- Easy to transport
- Relatively quick
- Simple and easy to use

Limitations

- Does not deactivate parasites like giardia, cryptosporidium and worm eggs
- Requires clear water to be most effective
- Taste is unacceptable to some users
- Dosage is product specific
- Requires that users purchase chlorine on a continuous basis

Determining the right amount can be difficult because substances in the water will react with the disinfectant, and the strength of the disinfectant may decline over time depending on how it is stored (CDC, 2003). The following table lists common chlorine products and their typical content or percentage strength.

Comparison of Chlorine Products

| Product | Strength | Remarks |
|--|---|---|
| High Test Hypochlorite (HTH) (calcium hypochlorite) | 65% - 70% | Usually in granular form. Stable (\approx 2% active chlorine loss per year). |
| Chlorinated lime (bleaching powder) | 30% | Usually in powder form. Not stable. |
| Household bleach (sodium hypochlorite) | 2.5% – 10% | Liquid form. Not stable; only use if manufactured recently (< 3 months), and stored away from heat and light. |
| Sodium dichloro-isocyanurate (NaDCC), used in products such as "Aquatabs". | 50% - 60% as granules. 5 mg to > 5 g active chlorine per tablet. | Usually in tablet form, also available in granular form. Tablets pre-dosed for water treatment. Very stable (shelf life \approx 5 years). |

The chlorine content should be listed on the product's labeling or packaging. In some markets around the world, chlorine solutions specifically produced for household water treatment are readily available. For example, in Nepal, the brand Piyush is available as a 0.5% chlorine solution in a 60 ml bottle.



Option 2 – Solar Water Disinfection (SODIS)

SODIS is a simple and low-cost technology that uses solar radiation and temperature to destroy bacteria and viruses present in water. Its efficiency in killing protozoa depends on the water temperature reached during solar exposure.

SODIS is ideal to treat small quantities of water. Water is filled into transparent plastic bottles and exposed to full sunlight for a minimum of six hours. During the exposure, the sun's UV-A radiation and increased water temperature destroys the pathogens (EAWAG/SANDEC, nd).

Advantages

- Effectively kills 99.9% of bacteria and viruses
- Free if plastic bottles are reused
- Relies on renewable energy and reduces need for traditional energy sources such as firewood and kerosene/gas
- Ideal to treat small quantities of water
- Does not change the taste of the water
- Bottles are convenient for safe water storage and transportation
- Simple and easy to use

Limitations

- Time consuming
- Requires relatively clear water to be most effective (turbidity less than 30 NTU)
- Requires sufficient solar radiation, therefore depends on weather and climatic conditions
- Not useful to treat large volumes of water



Option 3 – Boiling

Boiling water at 100°C will kill most pathogens and many are killed at 70°C. The recommended boiling time is one minute at sea level, adding one minute for every additional 1000 meters in altitude. The main disadvantages of boiling water are that it uses up fuel and it is time consuming, making the process environmentally and economically unsustainable. There is also a concern about respiratory health issues caused by boiling water indoors.



Advantages

- Effectively kills most pathogens
- Does not change the taste of the water
- Simple and widely accepted

Limitations

- Time consuming
- Relies on traditional energy sources such as firewood and kerosene/gas, contributes to deforestation problems in many countries
- Linked to respiratory health issues caused by indoor air pollution

Option 4 – Pasteurization

Pasteurization is the process of disinfecting water by heat or radiation. Water pasteurization achieves the same effect as boiling, but at a lower temperature of 70-75°C over a longer period of time. A thermometer or indicator is needed to tell when the pasteurization temperature is reached. A simple method of pasteurizing water is to simply put blackened containers of water in a solar box cooker, an insulated box made of wood, cardboard, plastic, or woven straw. Common solar box cookers can pasteurize water at a rate of about 1 litre per hour.

Advantages

- Effectively kills over 99% of bacteria and viruses
- Relies on renewable energy and reduces need for traditional energy sources such as firewood and kerosene/gas
- Can be built with local materials or purchased commercially
- Does not change the taste of the water
- Simple and easy to use

Limitations

- Time consuming
- Requires relatively clear water to be most effective
- Requires sufficient solar radiation, therefore depends on weather and climatic conditions

Option 5 – Ultraviolet (UV) Disinfection

UV disinfection works by disabling the DNA of the microorganisms in the water. The microorganisms soon die since they are unable to replicate. There are various manufacturers of commercial and household UV systems around the world, some of which can be costly. The treatment time and flow rate will vary with the technology. They all require a source of electricity, such as battery or solar power.

Advantages

- Effectively kills most pathogens
- Relatively quick, though flow rate depends on technology
- Does not change the taste of the water
- Simple and easy to use

Limitations

- Relatively expensive
- On-going operation costs (e.g. bulb replacement)
- Must be commercially purchased from a manufacturer
- Requires a source of electricity
- Requires relatively clear water to be most effective

Discussion Questions

Which disinfection option(s) would be the most appropriate for your community? Why?

What barriers exist for households to practice disinfection?

Summary of Key Points

- Access to safe drinking water and basic sanitation is a basic human need and a fundamental human right.
- Household water treatment occurs when householders gather small volumes of water and treat it with simple, low cost technology in their home.
- The main advantages of household water treatment are that it can be adopted immediately, it is less expensive and more appropriate for treating smaller volumes of water, and provides an entry point for hygiene and sanitation education.
- Some disadvantages of household water treatment are that it requires end users to be knowledgeable and motivated about its correct operation and maintenance.
- Although there are several contaminants in water that may be harmful to humans, the first priority is to ensure that drinking water is free of pathogens that cause disease.
- Three steps are commonly used to remove microorganisms and make the water safe to drink: sedimentation, filtration and disinfection.
- A multi-barrier approach is the best way to reduce the health risk of drinking unsafe water. Barriers which protect water from pathogens can occur in each of the following steps:
 - Step 1 – Protecting your water source
 - Step 2 – Sedimentation
 - Step 3 – Filtration
 - Step 4 – Disinfection
 - Step 5 – Safely storing your water after treatment
- Sedimentation is a physical treatment process used to remove small particles, such as sand, silt and clay, which make water cloudy.
- There are various types of filters: biosand filter, Kanchan arsenic filter, ceramic pot filter and ceramic candle filter.
- Disinfection is the final step in the water treatment process to remove, deactivate or kill any remaining pathogens.

Self Assessment

1. Discuss why there is a need for household water treatment.
2. Explain the multi-barrier approach to safe water.
3. How can the sedimentation process be accelerated?
4. Describe how can the biosand filter be adapted into the Kanchan arsenic filter.
5. What are the advantages and limitations of using chemical disinfectants?
6. List three main features of a safe water storage container.
7. Identify three safe water handling practices.

Additional Resources

Natural Coagulants:

Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean. Available at: www.oas.org/usde/publications/Unit/oea59e/ch22.htm

Chemical Coagulants:

PUR. Available at: www.purwater.com

Biosand Filter:

Centre for Affordable Water and Sanitation Technology. Available at: www.cawst.org

Arsenic Removal:

Kanchan Arsenic Filter Project. Available at: http://web.mit.edu/watsan/worldbank_summary.htm

Ceramic Pot Filters:

Potters for Peace. Available at: www.pottersforpeace.org

Chemical Disinfection:

Center for Disease Control and Prevention (2003) Safe Water Systems for the Developing World: A Handbook for Implementing Household-Based Water Treatment and Safe Storage Projects. Available at: www.cdc.gov/safewater/manual/sws_manual.pdf

Solar Disinfection:

The Swiss Federal Institute for Environmental Science and Technology (EAWAG), Department of Water and Sanitation in Developing Countries (SANDEC). Available at: www.sodis.ch

Pasteurization:

Safe Water Systems. Available at: www.safewatersystems.com

UV Disinfection:

UV Tube, University of Berkeley. Available at: <http://uvtube.berkeley.edu/>

MEDRIX. Available at: www.medrix.org/water.html

Safe Water Storage:

Center for Disease Control and Prevention (2003) Safe Water Systems for the Developing World: A Handbook for Implementing Household-Based Water Treatment and Safe Storage Projects. Available at: www.cdc.gov/safewater/manual/sws_manual.pdf

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