BIOSAND AND CERAMIC FILTERS
TRAINING MANUAL

DEVELOPED
BY

HYGIENE PROMOTION TEAM

WASH DEPARTMENT ACF - LIRA

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1 Introduction

a) ACF
ACF is a Non-Governmental Organisation (NGO). It can also be called Action Contre la Faim (ACF) which is a French phrase meaning Action Against Hunger. ACF began in France in 1979 and currently, it operates in 40 countries worldwide.
ACF first arrived in Uganda in 1980 in Karamoja. In Uganda, ACF has operated in the Districts of Bundibugyo, Adjumani, Kitgum, Nakasongola. Currently, ACF is working in Gulu, Amuru, Moroto, Kaabong, Apac, Oyam, Kisoro and Lira, which was opened in August 2004.
Worldwide, ACF works in the following fields: Water, Sanitation and Hygiene; Nutrition; Food security; and Advocacy. In Uganda, ACF operates in the first three fields.

Water, Sanitation and Hygiene (WASH)
This project includes:
• New and rehabilitated water points such as boreholes, spring protections, shallow wells and traditional water points;
• The construction of institutional latrines and distribution of digging kits;
• Water, sanitation and hygiene promotion.
The WASH programme currently operates in Orum and Olilim sub-counties.

Nutrition
• Detection and treatment of malnutrition
• Nutrition education
• Training and primary health support
• Therapeutic Feeding Centre in Aboke Health Centre IV
The Nutrition programme currently operates throughout Lira, Oyam and Apac Districts.

Food Security
This project involves the distribution of cash for various projects and activities. The Food Security programme operates throughout Orum, Olilim, Okwang and Adwari sub-counties.

b) Water
Water drawn from rivers, lakes, swamplands, boreholes, and cisterns is often contaminated and can cause illness upon ingestion. Waterborne diseases - those caused by the ingestion of contaminated water are a major public health issue in many parts of the world. According to the World Health Organization, lack of access to potable (drinkable) water contributes to approximately 80 percent of premature deaths in developing countries (WHO, 2009).
Although waterborne diseases are easily and quickly spread from person to person, the trans-mission of these diseases can be controlled through practical and low cost methods. Filtration, boiling, and the addition of
Household bleach are ways to remove harmful contaminants from water and ensure that you and your family are consuming clean water.

**What are biosand and ceramic water filters, how do they benefit communities?**

Ceramic water filters are simple, inexpensive and highly effective water filtration systems that clean water using a ceramic pot painted with a solution called colloidal silver. When used properly, filters eliminate 99.98 percent of disease-causing organisms from water, making it safe to drink (PFP, 2006).

Access to clean, filtered water can improve overall health and quality of life. Children suffering from waterborne illnesses often miss school. Sick adults are often unable to work or care for their children. Family, friends, and neighbors of the sick may take on extra responsibilities to assist those who are ill, thereby increasing the likelihood of becoming infected themselves. By using ceramic water filters, entire communities will benefit; individuals will be healthier and communities will be more productive.

### 5. ROLES AND RESPONSIBILITIES OF THE BENEFICIARY
- The family head should always try to retrain the family members on the daily use and maintenance.
- Check on the general condition of the filter regularly.
- Reporting to the VHT or relevant authorities for support and help.
- Ensuring that the filter is in good location especially for CERAMIC filters.
- Carrying out daily maintenance operation to increase on the flow rate and also avoid the smell especially for Biosand filter.
- Keeping the filter raised especially CERAMIC filter and the all surrounding tidy.
- Pouring water daily as required to avoid smell of the water and also to keep the biolayer alive.

### 6. WATERBORNE DISEASE

**Drinking contaminated water often leads to disease.**

Water can be contaminated with human, animal, or chemical wastes. In general, it is best to assume that untreated water is contaminated and drinking it could make you sick. Untreated water is water that has not been filtered, boiled, chlorinated or otherwise purified.

A community’s water supply can become contaminated if:
- Untreated sewage is deposited or flows into rivers, streams or lakes
- Agricultural chemicals, pesticides, and industrial wastes flow into the water supply
- Animals or humans bathe or leave excrement in or near the water supply
- Dead fish, birds, or other animals are left to decay in the water supply
- Flies come into contact with the water supply
- Containers holding water are not kept clean
- Filtration devices are not properly cleaned or maintained

How are waterborne diseases transmitted?
Waterborne diseases are caused by microorganisms (also called microbes). Microorganisms are tiny creatures that are too small to be seen without a microscope. Bacteria, protozoa, and viruses are types of disease-causing organisms, referred to as pathogens. Pathogens infect humans and animals, and can cause serious illness and sometimes death.

Waterborne diseases are transmitted from person to person through what is called the fecal-oral route of transmission. The pathogens travel from one person’s fecal matter to another person’s mouth through various intermediaries, such as untreated water, flies, or hands. Once the microorganisms are ingested, they cause illness in a new host, completing the cycle of transmission.

Some diseases, such as Typhoid fever, are also transmitted through urine. Exposure to untreated water can also lead to diseases caused by helminthes (worms). These diseases are called water-based diseases. Organisms causing water-based diseases normally infect humans by ingestion or skin penetration, and usually leave their host via feces, urine, and/or sputum. Snails often carry these parasites. Many worms can be seen by the naked eye but some are small enough to require the use of a microscope.

Oil, pesticides and other industrial and household chemicals that run into the water supply may contribute to the spread of waterborne diseases by harming the natural environment and creating favorable conditions for infectious microbes to breed. For this reason, it is important to refrain from dumping chemicals into lakes, rivers, or streams.

The Fecal-Oral Route of Transmission

The Waterborne Disease Transmission Cycle

```
Fecal Matter
  /  
 Water   Hands
    / 
  Flies Food
    / 
  Mouth
```
What are the symptoms of waterborne diseases?
Diarrhea is the primary symptom of waterborne illness. Other common symptoms include nausea, vomiting, body aches, and fever. Although anyone can become infected with a waterborne disease, children are the most susceptible population. Children are more likely to die from waterborne diseases than adults and require special care when they are sick.
Diseases caused by the ingestion or penetration of worms have many of the same symptoms as waterborne illnesses, including diarrhea, abdominal pain, fever, and cough.
Diarrhea and vomiting can quickly lead to dehydration. Dehydration is when the body loses water and electrolytes. Although anyone can become dehydrated, children are most susceptible. Symptoms of dehydration include thirst, decreased urine output, dark-colored urine, headache, dizziness, dry mouth, lethargy, fainting, and seizures. Treating dehydration will be discussed in the following pages.
Some important waterborne diseases to know are:

1 Cholera:
Infectious agent: Vibrio cholera (bacteria)
Symptoms: watery diarrhea, nausea, vomiting

Typhoid Fever:
Infectious agent: Salmonella typhi (bacteria)
Symptoms: diarrhea, constipation, headache, fever, chills, weakness

Dysentery:
Infectious agent: Shigella dysenteriae (bacteria)/Entamoeba histolytica (protozoa)
Symptoms: bloody diarrhea, vomiting, fever

Hepatitis:
Infectious agent: Hepatitis A Virus/Hepatitis E Virus
Symptoms: fever, weakness, abdominal pain, nausea, jaundice
Prevention of waterborne disease

The best way to prevent waterborne disease is to drink only clean, potable water. Detailed information on treating water using ceramic water filtration is discussed in the following pages. Alternative methods, including boiling and treatment with household bleach, are also mentioned.

Purified water should also be used to wash fruits and vegetables. As an extra precaution, produce can be peeled and thoroughly cooked. Before handling food, it is important to wash your hands with clean water and soap, as proper hand washing can significantly reduce the spread of disease. Hand washing is also necessary after potential contact with human or animal waste and whenever hands are visibly soiled.

Bathing and swimming in rivers, lakes or streams may also cause disease. Worms living in water can infect individuals by penetrating the skin or by being swallowed with a mouthful of water. As mentioned previously, snails are common hosts for many parasites. Because snails are attracted to stagnant water, building fast-flowing streams and eliminating water behind dams may help in the prevention of these diseases (The Population Center, 1998).
Treatment for waterborne diseases
It is important for individuals with symptoms suggestive of waterborne disease to promptly seek medical attention. Some waterborne diseases will subside with time but many require medicine such as anti-bacterial or anti-parasitic. A trained medical professional will be able to determine what type of treatment is necessary.
The symptoms of a few waterborne diseases, such as Typhoid fever, can mimic those of malaria. Because it is often difficult to make an accurate diagnosis based on symptoms alone, it is best to confirm with laboratory tests (Water Engage, 2006).
It is important to replace lost fluids as soon as diarrhea begins. This is especially true in children. To prevent dehydration, ensure adequate fluid intake with liquids such as tea, soup, rice water, or fruit juices.
If a person is experiencing moderate dehydration, the World Health Organization recommends treating them with oral dehydration therapy (ORT) - the replacement of fluids and salts.

Treating dehydration with oral dehydration solution (ORS)
1. Wash your hands with soap and clean water
2. In a container, prepare a solution of:
   8 teaspoons of sugar
   1 teaspoon of salt
   1 liter of PURIFIED water
3. Stir until all sugar and salt has dissolved
4. Give the solution to dehydrated individuals by mouth as needed, in small amounts
5. Discard and make a fresh batch of ORS every 24 hours
Pay careful attention to the ratio of sugar to salt when preparing this solution. Extremely high levels of salt can cause convulsions. In addition, a solution that tastes too salty may be refused by a child. If you are concerned about the concentration of salt, taste the solution - it should taste no saltier than tears.
Sugar will aid in the absorption of salt and is a necessary component of the solution. Too much sugar, however, may worsen diarrhea. If white sugar is unavailable, molasses and other forms of raw sugar may be substituted.
ORS will not stop or shorten the duration of diarrhea illness; it will only replace fluids and salts that have been lost through diarrhea and vomiting. If the person vomits after drinking ORS, wait ten minutes and administer it again. Normally, vomiting will stop. If vomiting continues, seek medical attention.
It is important to take children and adults with severe dehydration to a medical clinic, as they may need intravenous fluids injected directly into veins.
III. The Colloidal Silver Ceramic Water Filter

How does a colloidal silver ceramic filter work?

A colloidal silver ceramic filter provides potable water by filtering out dangerous microorganisms. The filter consists of a ceramic pot, called the filter element, placed inside a plastic bucket, called a receptacle. The pot is painted with a special solution called colloidal silver, which kills bacteria. Tiny pores in the ceramic pot allow water - but not parasites or bacteria - to pass through. The bucket has a lid to help prevent contamination and a plastic tap to facilitate access to the filtered water.

When contaminated water is poured into the filter, microorganisms become trapped in the ceramic pot and only potable water is allowed to flow through the spigot. Protozoa, helminthes, and most bacteria are too big to pass through the pores and are effectively filtered out. Bacteria that are small enough to pass through the pores are inactivated by the colloidal silver and become incapable of reproducing.

Although the pores are very tiny, they are not small enough to filter out most viruses. The colloidal silver may inactivate some viruses, although more research is needed to determine its effectiveness against viruses. The filter is not effective in removing metals or pesticides.

The filter has the capacity to meet, on average, the daily drinking water needs of a family of 6 people. It filters water at the rate of 1½ to 2½ liters per hour.

When teaching the public about filter use and maintenance, it is important to correctly identify the different parts of the filter. Please refer to the diagram below.

It is clearer to refer to water as “unfiltered” or “filtered,” rather than “clean” or “dirty;” the latter are often used to express the appearance of water and not the extent to which the water is contaminated with microorganisms or chemicals.
Filtration is one of several ways to make water safe to drink. Other methods for purifying water include boiling and treatment with household bleach or bleach-like solutions sold in supermarkets. Before using the methods below, visibly dirty water should first be strained using a clean cloth.

**Boiling**
Boil water up to the required boiling point i.e. 100 Cool (do not add ice). Add a pinch of salt where possible for better taste.

**Household bleach**
Add 1/8 teaspoon regular, unscented, liquid household bleach per gallon water Stir and wait 30 minutes before drinking. For commercial solutions containing bleach, such as Water guard or Pur, please refer to the directions on the container.

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colloidal Silver</td>
<td>Kills bacteria and parasites</td>
<td>Must be properly maintained</td>
</tr>
<tr>
<td>Ceramic Water Filter</td>
<td>Removes sediment</td>
<td>and replaced every 3 years</td>
</tr>
<tr>
<td></td>
<td>Filtered water can be used immediately</td>
<td>Does not remove viruses or chemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May clog easily</td>
</tr>
<tr>
<td>Boiling</td>
<td>Simple, requires no special equipment</td>
<td>May require large amounts of fuel</td>
</tr>
<tr>
<td></td>
<td>Kills bacteria, parasites and viruses</td>
<td>Time-consuming</td>
</tr>
<tr>
<td>Bleach (Water guard, Pur)</td>
<td>Kills bacteria, viruses and most parasites</td>
<td>May not kill Cryptosporidium parasites</td>
</tr>
<tr>
<td></td>
<td>Treats large quantities of water at once</td>
<td>Potent chemical</td>
</tr>
<tr>
<td></td>
<td>Inexpensive; easy; lightweight</td>
<td>Must wait for water to be treated</td>
</tr>
</tbody>
</table>

7. THE FILTER

OVERVIEW OF THE BIOSAND FILTER
What is the biosand filter?
The biosand filter is a modified form of the 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 biosand filter suitable for household or small group use. The biosand filter can be produced locally anywhere in the world using materials that are readily available.
The biosand filter should be used as part of a multi-barrier approach which 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 the water source
Step 2 - Sedimentation
Step 3 - Filtration (e.g. biosand filter)
Step 4 - Disinfection
Step 5 - Safely storing water after treatment

FILTRATION PROCESS
The Start of the Run
Sand Layer
- Ideally obtained from clean, crushed rock.
- Screened through 0.7 mm (24 mesh) wire sieve of perforated metal sheet.
- Washed to ensure an Effective Size (ES) of 0.10 to 0.25 mm (prefer 0.15 to 0.20 mm) and Uniformity Coefficient (UC) of 1.5 to 2.5 (prefer <2). See Appendix O Sieve Analysis for more information.

Concrete Filter Body
- Mix concrete (by hand or with mixer).
  - 1 part normal (ordinary or general use) cement (approximately 15 kg [33 lb])
  - 1 part clean gravel 6 mm (1/4”)
  - 1 part clean gravel 12 mm (1/2”)
  - 2 parts clean sand
- Weight when empty - 72 kg (170 lb).
- Weight when full of sand and water - 160 kg (350 lb).

Diffuser Plate
- Required to prevent the disturbance of the sand layer when water is poured into the filter.
- Can be made of various materials that are suitable to be submerged in water such as heavy plastic, acrylic, plexiglass, or galvanized metal.

Outlet Pipe – 6 mm (1/4”) inner diameter (I.D.)
Conducts water from filter base to outside.

Sand Layer – 40 to 50 cm deep
Traps organic and inorganic

Separating Gravel Layer – 6 mm (1/4”) size – 5 cm deep
Prevents sand from plugging under drain gravel.

Underdrain Gravel Layer – 12 mm (1/2”) size – 5 cm deep
Promotes flow of water into outlet pipe.
• 100 holes, no larger than 0.3 cm (1/8”) diameter, are drilled or punched in the material on a 2.5 cm x 2.5 cm (1” x 1”) grid.
• If arsenic removal is desired, the diffuser must be made in a box shape and filled with 5 kg (11 lb) nongalvanized less than 2.5 cm (1”) long iron nails. The hole diameter can be made larger 0.6 cm (1/4”) if excessive iron clogging occurs.
Lid
• Tightly fitting lid prevents contamination of water and unwanted pests.
• Can be made from various materials, usually wood or galvanized metal.

Mold Design
The steel mold used for the biosand filter is designed to produce a good final product, while being easy to use. With good care and maintenance, this mold should be suitable for several years of filter construction. The mold design has gone through eight generations of improvements, but there may still be revisions that would add value.

How does the filter work?
A bucket of contaminated water is poured into the top of the biosand filter. The water simply flows through the filter and is collected in another storage container at the base of the spout. A biological layer (often called the biolayer) of slime, sediment and microorganism develops at the sand surface. Pathogens and suspended material are removed through various physical and biological processes that occur in the biolayer and sand. When water is flowing through the filter, oxygen is supplied to the biolayer by the dissolved oxygen in the water. During pause times, when the water is not flowing, the oxygen is obtained by diffusion from the air. If the standing water layer is kept shallow, enough oxygen is able to pass through to the microorganisms to keep them alive and effective.

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The biosand filter has six different distinct zones: 1) inlet reservoir, 2) standing water, 3) biolayer, 4) biological zone, 5) sand zone, and 6) gravel zone.
**Inlet Reservoir:** Space above the sand and gravel media which allows for a full pail of water.

**Standing Water:** Oxygen diffuses through the standing water to the biolayer.

**Biolayer:** Layer of slime, sediment, and microorganisms which develops at the top 1-2 cm (0.4-0.8”) of the sand surface.

**Biological Zone:** Develops at the top 5-10 cm (2-4”) of the sand surface. The sand absorbs pathogens, iron, and other small particles.

**Sand Zone:** Contains virtually no living microorganisms due to lack of nutrients and oxygen.

**Gravel Zone:** Holds the sand in place which protects the outlet pipe from clogging and allows for the smooth flow of water.

The inlet water contains dissolved oxygen, nutrients and contaminants. The high water level pushes the water through the filter. After passing through the diffuser plate, the inlet water mixes with the standing water.

The standing water is lower in oxygen, nutrients, and pathogens than the inlet water because they were consumed during the pause period. The inlet water provides the oxygen required by the microorganisms in the biolayer.

Sediment and larger pathogens are strained out at the top of the sand.
The water level in the reservoir goes down as it filters through the Sand. The flow rate will slow down because there is less pressure.

Sediment and larger pathogens are strained out and they partially plug the pore spaces between the sand grains. This also causes the flow rate to slow down.

The water flow finally stops. The standing water layer will be at the same height as the outlet of the pipe.

Pathogens in the inlet water are consumed and those from the previous run which were partially consumed are more completely broken down. Pathogen removal increases with time because of the slower flow rate and the decreased size of pore openings.
The biosand filter bed is constructed with three types of media: sand, separating gravel, and under drain gravel. When a bucket of contaminated water is poured into the top of biosand filter, the water simply flows through the different media layers. There are four processes that remove pathogens as the water passes through the filter.

A. Mechanical trapping
Sediment and pathogens are physically trapped in the spaces between sand grains.

B. Predation
Pathogens are consumed by other microorganisms in the standing water and biolayer.

C. Adsorption/Attraction
Pathogens become attached to each other, sediment, and the sand grains.

D. Natural death
Pathogens finish their life cycle or die because there is not enough food and oxygen for them to survive.

Biosand filters have been shown to remove 90-99% of pathogens found in water. The 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* - an indicator of fecal contamination.
• > 99% of protozoa and helminthes.
• 80-90% of viruses (Stabber, 2005)
• 50-90% of organic and inorganic toxicants (Palmateer, 1999)
• 90-95% of iron (Ngai, 2007)
• Most suspended sediments

Based on slow sand filter research, the biosand filter may also remove some heavy metals (Muhammad, 1997; Collins, 1998). There is also a design modification known as the KanchanTM Arsenic Filter that is effective in removing both pathogens and 85-90% of arsenic from source water (Ngai, 2007).

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, 2007; Sobsey, 2007).

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ADVANTAGES OF THE BIOSAND FILTER

Functional
The biosand filter is a ‘point of use’ or household treatment device. Water can be obtained from the closest water supply point, whether that is a river, a stream or a well, and used immediately after filtering. The water supply, treatment, and distribution are all within the control of the individual householder. Effective use of the technology does not require user groups or other community support which are sometimes difficult to develop and sustain. The independence of the household makes this technology extremely suitable for developing countries which often lack the governance and regulatory processes needed for effective and efficient community water systems.

High User Acceptability
The biosand filter is easy to use and it improves the look and taste of water. As well, the filter takes up very little space and can easily fit into most rooms. In fact, previous experience has shown that the filter normally occupies a place of significance in the living room because it is so important to the individual household.

User-friendly
It is simple to operate and maintain the filter. There are no moving parts that require skill to operate. When the water flow through the filter becomes too slow, the maintenance consists simply of washing the top few
centimetres of sand. Operating and maintaining the filter is well within the
capacity of the household users.

**Durable**
The filter box is made of cement concrete with a built-in pipe. It is very
durable since there are no moving
parts during operation. The filter may need occasional replacement of iron
nails (e.g. for arsenic removal)
or wooden components (e.g. the lid) that may deteriorate over time.

**Sufficient Water Quantity**
The recommended flow rate for a biosand filter is 0.6 L/minute (measured
when the filter box is full of
water). Based on this flow rate and the time required for pause periods, the
biosand filter can effectively
treat 60-80 L/day.

**Affordable**
The cost of a concrete biosand water filter varies from country to country
and ranges from US$12-30
depending on the material and labour costs. Its main components (concrete, sand and gravel) are readily
available in all developing countries. Manufacturing the filters involves a
significant amount of manual
labour to mix the concrete and pour it into the filter mold. The skills
required to do this are readily
available in developing countries at a very low cost. The labour can also be
provided by the individual
home owner.

**Limitations**
The biosand filter cannot remove some dissolved substances (e.g. salt,
hardness), some organic chemicals
(e.g., pesticides and fertilizers), or color, and cannot guarantee that the
water is pathogen free. The biosand
filter should be used as part of the multi-barrier approach for providing safe
water. Similar to other types of
water filters, it is recommended to disinfect the water after it has passed
through the biosand filter.

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**BIOSAND FILTER OPERATION**

**Water Source**
The biosand filter can use any water source such as rainwater, deep
groundwater, shallow groundwater, rivers, lakes or other surface waters.
The source should be the cleanest available since the filter is only able
to remove a certain percent of the pathogens. If the source water is highly
contaminated, the outlet water may still have some contaminants.
The same source of water should be used consistently because the biolayer
cannot quickly adapt to different water quality. Over time, the
microorganisms in the biolayer become used to a certain amount of
contamination from the source water. If different source water with a
higher level of contamination is used, the biolayer may not be able to consume all of the pathogens. It may take the biolayer several days to adapt to the new source water and level of contamination. Experiments have shown that the largest portion of bacteria from a more contaminated source water show up in the filtered water the next day (see Summary Table: Contaminant Removal Efficiency of the Biosand Filter.

The turbidity (cloudiness in water) of the source water is also a key factor in the operation of the filter.

Nephelometric turbidity units (NTU) measure the level of suspended matter (organic and silt particles) in water. If the turbidity is greater than 50 NTU, the source water should be settled or strained before it goes through the biosand filter. A simple test to measure the turbidity is to use a 2 liters clear plastic soft drink bottle filled with the source water. Place this on top of large print such as the CAWST logo on this manual. If you can see this logo looking down through the top of the bottle, the water probably has a turbidity of less than 50 NTU.

**Establishing the Biolayer**
The biolayer is the key pathogen removing component of the filter. Without it, the filter removes some contamination through screening of the sediment and microorganisms (only 30-70% removal efficiency). The ideal biolayer will remove 90-99% of pathogens. It may take up to 30 days to establish the biolayer.

During that time, both the removal efficiency and the oxygen demand will increase as the biolayer grows.

The biolayer is NOT usually visible - it is not a green slimy coating on top of the sand.

The water from the filter can be used during the first few weeks while the biolayer is being established, but disinfection, as always, is recommended during this time.

Figure 1 illustrates how the biolayer is established. The process may vary as some filters require a shorter or longer period of time to establish the biolayer depending on the source of water being used.

**Flow Rate**
The biosand filter has been designed to allow for a filter loading rate (flow rate per square meter of filter area) which has proven to be effective in laboratory and field tests. This filter loading rate has been determined to be not more than 600 liters/hour/square meter.

The recommended flow rate for the standard concrete biosand filter shown in this manual is 0.6 L/minute measured when the inlet reservoir is full of water. If the flow rate is much faster, the filter may become less efficient at removing pathogens. If the flow rate is much slower, the household user may become impatient and not use the filter at all even though the filter is working well at removing pathogens. Since the flow rate is controlled by the size of the sand grains, it is very important to select and prepare the sand according to the instructions provided in Appendix B.
Pause Period
The biosand filter is most effective and efficient when operated intermittently and consistently. A recommended pause period is 6 to 12 hours with a minimum of 1 hour and a maximum of 48 hours. The pause period is important because it allows time for the microorganisms in the biolayer to consume the pathogens in the water. As the pathogens are consumed, the flow rate through the filter may be restored. If the pause period is extended for too long, the microorganisms will eventually consume all of the nutrients and pathogens and then eventually die off. This will reduce the removal efficiency of the filter when it is used again.

Water Depths
Correct installation and operation of the biosand filter has a water level of approximately 5 cm (2”) above the sand during the pause period. A water depth of greater than 5 cm (2”) results in lower oxygen diffusion and consequently a thinner biological zone. A high water level can be caused by a blocked outlet pipe or by an insufficient amount of sand. A water depth less than 5 cm (2”) may evaporate quickly in hot climates and cause the biolayer to dry out.

Filtered Water Quality
The final step in household water treatment is to remove, deactivate or kill any remaining pathogens in the filtered water 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.

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 can be found in different forms:
- Sodium hypochlorite (e.g. household bleach)
- Sodium dichloroisocyanurate (NADCC), marketed under the trade name of Aquatabs or others
- Calcium lime, sometimes referred to as chlorinated lime (e.g. bleaching powder)
- Calcium hypochlorite, also known as high test hypochlorite (HTH) used in products such as PUR
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Chlorine must be added in sufficient quantities to destroy all pathogens, but not so much that taste is adversely affected. 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. Also, it is important to know the strength of the chlorine product since they can vary from 0.5 to 70% available chlorine.

Solar Water Disinfection (SODIS)
SODIS is a simple and low-cost technology that uses solar radiation and temperature to destroy pathogenic 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 six hours.

**Boiling**
Boiling water at 100oC will kill most pathogens and many are killed at 70 degrees celsius. 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 it environmentally and economically unsustainable. As well, boiling water in the home can also contribute to poor indoor air quality and lead to respiratory health issues.

**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 degrees celsius 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.

**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. All of them require some a source of electricity (for example, battery, solar power) and some of these systems can be expensive.

**Maintenance**
Over time, the pore opening between the sand grains will become clogged with sediment. As a result, the water flow rate through the filter will slow down. To clean the filter, the surface of the sand must be agitated to re-suspend the sediment in the standing water. The dirty water can be removed using a small container. The process can be repeated as many times as necessary to regain the desired flow rate. After cleaning, it will take the biolayer up to a week to reestablish itself and return the removal efficiency to its previous level, see Figure 1.
CERAMIC WATER FILTER

How does a colloidal silver ceramic filter work?
A colloidal silver ceramic filter provides potable water by filtering out dangerous microorganisms. The filter consists of a ceramic pot, called the filter element, placed inside a plastic bucket, called a receptacle. The pot is painted with a special solution called colloidal silver, which kills bacteria. Tiny pores in the ceramic pot allow water - but not parasites or bacteria - to pass through. The bucket has a lid to help prevent contamination and a plastic tap to facilitate access to the filtered water.

When contaminated water is poured into the filter, microorganisms become trapped in the ceramic pot and only potable water is allowed to flow through the spigot. Protozoa, helminthes, and most bacteria are too big to pass through the pores and are effectively filtered out. Bacteria that are small enough to pass through the pores are inactivated by the colloidal silver and become incapable of reproducing.

Although the pores are very tiny, they are not small enough to filter out most viruses. The colloidal silver may inactivate some viruses, although more research is needed to determine its effectiveness against viruses. The filter is not effective in removing metals or pesticides.

The filter has the capacity to meet, on average, the daily drinking water needs of a family of 6 people. It filters water at the rate of 1½ to 2½ liters per hour.

When teaching the public about filter use and maintenance, it is important to correctly identify the different parts of the filter. Please refer to the diagram below.

It is clearer to refer to water as “unfiltered” or “filtered,” rather than “clean” or “dirty;” the latter are often used to express the appearance of water and not the extent to which the water is contaminated with microorganisms or chemicals.

Picture of a CERAMIC filter
Filtration is one of several ways to make water safe to drink. Other methods for purifying water include boiling and treatment with household bleach or bleach-like solutions sold in supermarkets. Before using the methods below, visibly dirty water should first be strained using a clean cloth.

**Boiling**

Boil water for 3 minutes.
Cool (do not add ice).
Add a pinch of salt for better taste.

**Household bleach**

Add 1/8 teaspoon regular, unscented, liquid household bleach per gallon water
Stir and wait 30 minutes before drinking.
For commercial solutions containing bleach, such as Water guard or Pur, please refer to the directions on the container.

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colloidal Silver</td>
<td>Kills bacteria and parasites</td>
<td>Must be properly maintained and</td>
</tr>
<tr>
<td>Ceramic Water Filter</td>
<td>Removes sediment</td>
<td>replaced every 3 years</td>
</tr>
<tr>
<td></td>
<td>Filtered water can be used immediately</td>
<td>Does not remove viruses or chemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May clog easily</td>
</tr>
<tr>
<td>Boiling</td>
<td>Simple, requires no special equipment</td>
<td>May require large amounts of fuel</td>
</tr>
<tr>
<td></td>
<td>Kills bacteria, parasites and viruses</td>
<td>Time-consuming</td>
</tr>
<tr>
<td>Bleach (Water guard, Pur)</td>
<td>Kills bacteria, viruses and most parasites )</td>
<td>May not kill Cryptosporidium parasites</td>
</tr>
<tr>
<td></td>
<td>Treats large quantities of water at once</td>
<td>Potent chemical</td>
</tr>
<tr>
<td></td>
<td>Inexpensive; easy; lightweight</td>
<td>Must wait for water to be treated</td>
</tr>
</tbody>
</table>

**Filter Use**

Touching any of these surfaces with **dirty hands may contaminate** the filter:
The outside of the ceramic pot
The inside of the receptacle
Always wash and rinse all filter parts with filtered or boiled water.

Directions for preparing a new filter for first-time use:
1) Wash hands with soap and clean water.
2) Wash lid of receptacle with soapy water. Rinse well. Place ceramic pot on lid.
3) Clean receptacle in one of two ways:
IF RECEPTACLE IS PLASTIC:
1. Clean with soapy water. Rinse well.
2. Disinfect using a chlorine solution (1 tablespoon chlorine per gallon clean water).
3. Leave the solution in the receptacle for 30 minutes.
4. Drain the solution through the tap.

IF RECEPTACLE IS CLAY:
1. Prepare a chlorine solution (1 tablespoon chlorine per gallon clean water).
2. Scrub the receptacle using the chlorine solution and a toothbrush.
   Do not use soap to clean a clay receptacle.
3. Let the chlorine solution sit in the receptacle for at least two hours.
4. Drain the solution through the tap.

Disinfect only the receptacle and never the ceramic pot.
4) Fill the filter element with potable water and allow it to filter through. Repeat this twice more and dispose of the water. The filter is now ready for use.

Directions for everyday filter use:
1) Find a suitable location for the filter. The filter should be off of the ground and somewhere where it will not be easily damaged. If possible, secure the filter to a wall/post.
2) Pour unfiltered water into the filter element. If the water is visibly dirty, a thick cloth may be tied over the filter and used as a strain. The filter will perform its job faster if the ceramic pot is filled with water.
3) Keep the lid on to keep away flies, mosquitoes, dust and other contaminants.
   Do not filter chlorinated water through the filter element except when cleaning.
Over time, chlorinated water will erode the silver and may lessen its antibacterial properties.
Filter Maintenance

Cleaning the Filter

Clean the filter once each month or when the flow rate slows noticeably. Scrubbing the ceramic pot more often will increase the likelihood of contamination. In addition, each time the ceramic pot is scrubbed, a small amount of clay/silver is lost.

To clean the filter:

1) Wait until the ceramic filter element is empty and has finished filtering before beginning the cleaning process. Do not remove the filter element while it contains water.
2) Wash hands with soap and clean water.
3) Using soapy water, clean the lid. Set the lid out to dry, with the inside surface facing up.
4) Lift the ceramic filter element from the receptacle. Touch only the rim and NEVER handle the filter element with soiled hands.
If using a plastic lid, place the ceramic pot on top of the lid.
If using a ceramic lid, find another clean surface to set the pot.
5) Using water, scrub the inside of the ceramic pot with a brush. Do not use soap.
6) Clean and disinfect the receptacle with chlorine solution as discussed previously.
7) Place the ceramic pot into the receptacle as soon as it has been cleaned.

Replacing the Filter

Replace the ceramic pot in ALL of the following circumstances:
If it becomes cracked. (Even the smallest crack may allow bacteria to pass through.)
If the flow rate becomes too slow and is not increased by cleaning

After three years
If the receptacle, lid, or tap become damaged, they should be replaced as well.
If the filter is maintained properly, it should last for approximately three years.