Introduction to Household Water Treatment and Safe Storage

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Acronyms

CAWST	Centre for Affordable Water and Sanitation Technology
CBO	community based organization
DALY	disability-adjusted life years
HIV/AIDS	human immunodeficiency virus/acquired immunodeficiency syndrome
HWT	household water treatment
HWTS	household water treatment and safe storage
MDG	Millennium Development Goal
NGO	non-governmental organization
PAC	polyaluminium chloride
POU	point of use
SODIS	solar water disinfection
TDS	total dissolved solids
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNICEF	United Nations Children's Fund
UV	ultraviolet
WHO	World Health Organization
JMP	Joint Monitoring Programme for Water Supply and Sanitation

Abbreviations

L	litre
mg	milligram

1 The Case for Managing Water in the Home

Household water treatment and safe storage (HWTS) is an essential component of a global strategy to provide safe water to the 884 million people who currently live without it and the millions more who suffer from contamination of their improved water sources.

Health can be compromised when pathogens (microorganisms that cause disease) contaminate drinking water. This contamination can occur at the source or within a piped distribution system. Even unhygienic handling of water during transport or within the home can contaminate previously safe water. For these reasons, many of those who have access to improved water supplies through piped connections, protected wells or other improved sources are still, in fact, drinking contaminated water (WHO, 2007).

At any given time close to half the people in the developing world are suffering from one or more of the main diseases associated with inadequate provision of water and sanitation, such as diarrhea, guinea worm, trachoma and schistosomiasis (UNDP, 2006). Diarrhea occupies a leading position among infectious diseases as a cause of death and illness –
killing more people than tuberculosis or malaria each year.

Evidence from both research and implementation experience suggests that HWTS:

* Dramatically improves microbiological water quality

* Significantly reduces diarrheal disease

* Is among the most effective water, sanitation and health interventions

* Is highly cost-effective

* Can be quickly implemented and taken up by vulnerable populations

This Sectiondefines household water treatment and safe storage and presents the evidence of its effectiveness. It also discusses the circumstances under which HWTS is most applicable and how it contributes to the Millennium Development Goals (MDG).

1.1 What is Household Water Treatment and Safe Storage?

Household-level approaches to drinking water treatment and safe storage are also commonly referred to as managing the water at the point of use (POU). The family members gather water, preferably from an improved source, and then treat and store it in their home.

Using the **multi-barrier approach** is the best way to reduce the risk of drinking unsafe water. Each step in the process, from source protection, to water treatment and safe storage, provides an incremental health risk reduction. Both community and household systems follow the same basic water treatment process: sedimentation, filtration and disinfection. The main difference is the scale of the systems that are used by individuals and communities.

Figure 1.1: Multi Barrier Approach to Safe Water

Household Water Treatment

Source Protection	Sedimentation	Filtration	Disinfection	Safe Storage
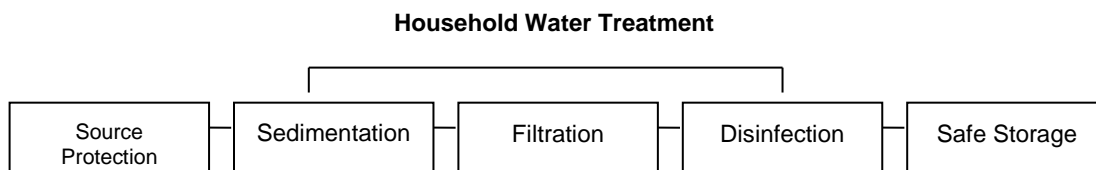
Household water treatment technologies that will be discussed further in Section 2 include: sedimentation (settling, coagulation), filtration (straining through a cloth, biosand filters, ceramic filters, membrane filters) and disinfection (chlorine, solar, ultraviolet, pasteurization, boiling).

The money and resources needed to construct, operate and maintain a community water treatment system are not always available in many countries. To reach the MDG target for safe water using community systems would necessitate an investment of tens of billions of dollars each year to connect households (Hutton and Bartram, 2008).

The main advantage of household water treatment and safe storage (HWTS) is that it can be adopted immediately in the homes of poor families to improve their drinking water quality. It is proven to be an effective way to prevent diseases from unsafe water. HWTS lets people take responsibility of their own water security by treating and safely storing water themselves.

HWTS is also less expensive, more appropriate for treating smaller volumes of water, and provides an entry or starting point for hygiene and sanitation education. There are a wide range of simple HWTS technologies that provide options based on what is most suitable and affordable for the individual household. By adopting HWTS, households are empowered to take charge of their own water quality.

Some limitations of HWTS are that it requires families to be knowledgeable about its operation and maintenance, and they need to be motivated to use the technology correctly. As well, most HWTS technologies are designed to remove pathogens rather than chemicals. There are household-scale technologies that can remove substances such as iron, manganese, undesirable odors, and turbidity, and in many cases these need to be reduced first anyway before pathogen-removal technologies can work.

An increasing amount of research suggests household water treatment and safe storage (HWTS):

- Dramatically improves microbial water quality

- Significantly reduces diarrhea

- Is among the most effective of water, sanitation and health interventions

- Is highly cost-effective

- Can be quickly implemented and taken up by vulnerable populations

(WHO, 2007)

1.2 Preventing Diarrhea

Diarrhea occupies a leading position among diseases as a cause of death and illness, killing 1.8 million and causing approximately 4 billion cases of illness annually. 90% of diarrheal deaths are borne by children under five, mostly in developing countries (WHO, 2004).

Figure 1.2.1: Leading Causes of Deaths from Infectious Diseases
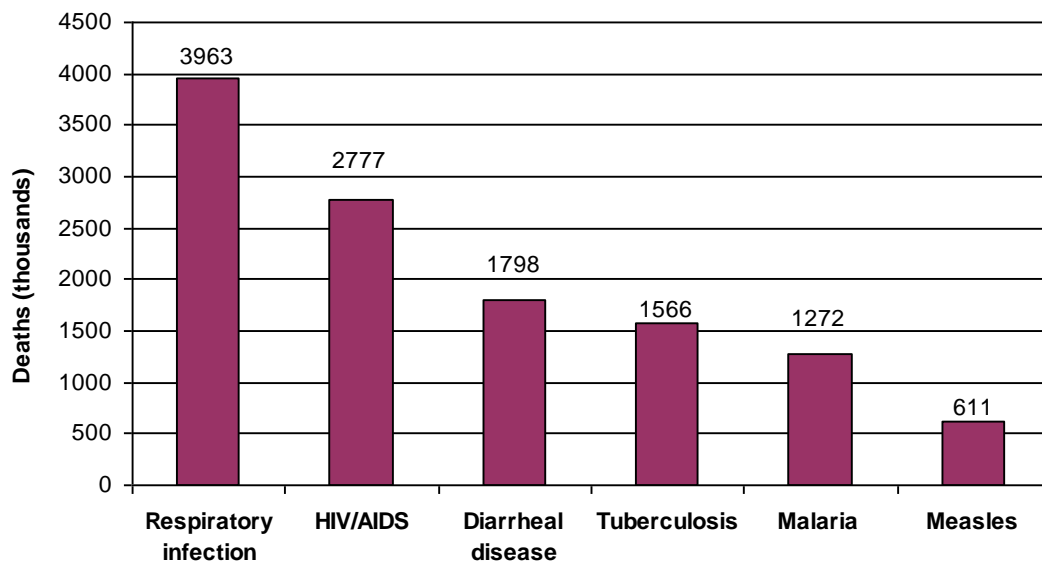
(WHO, 2004)

For every child that dies, countless others suffer from poor health and lost educational opportunities leading to poverty in adulthood. Every episode of diarrhea reduces their calorie and nutrient uptake, setting back growth and development. The UNDP (2006) estimates that parasitic infections retards the learning potential for more than 150 million children and water-related illness causes the loss of 443 million school days each year.

Having safe drinking water is essential in breaking the cycle of disadvantage and poverty by improving health, ability go to school, and strength to work. The WHO estimates that 94% of diarrheal cases are preventable through modifications to the environment, including interventions to increase the availability of clean water, and to improve sanitation and hygiene (Prüss-Üstün and Corvalan, 2006).

In addition, Fewtrell et al. (2005) conducted a systematic review and concluded that diarrheal episodes are reduced by 25% through improving water supply (e.g. increasing access to more water can enable better hygiene), 32% by improving sanitation, 45% through hand washing, and 39% via household water treatment and safe storage.

A more recent Cochrane review of controlled trials confirmed the key role that POU quality interventions at the household level could play in reducing diarrhea episodes. The authors reported a reduction in diarrheal disease by roughly half, on average, with some studies resulting in disease reductions of 70% or more (Clasen et al, 2006).

"There is increasing recognition that simple household-based approaches to ensuring drinking water safety should be incorporated into country strategies to reduce waterborne disease."
(WHO, 2007)

Figure 1.2.2: Preventing Diarrhea

Annual number of deaths of children under five years 2002 (thousands)
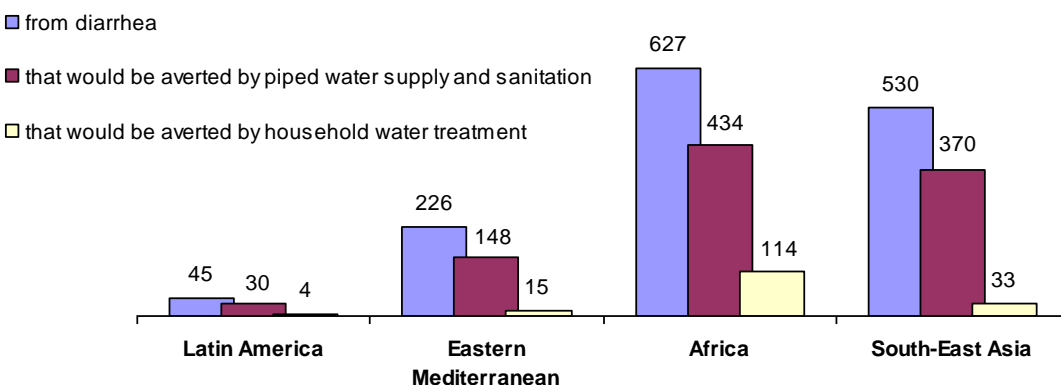
(Adapted from WHO, 2004)

1.3 Reaching the Vulnerable

Many of these people are among the most vulnerable and those hardest to reach: families living in remote rural areas and urban slums, families displaced by war and famine, and families living in the poverty-disease trap, for whom improved drinking water could offer a way out.

For millions of poor households, daily water use can vary temporally and seasonally, due to changes in water quality and availability. Low pressure and irregularity of supply in a piped network mean that households in urban slums seek a back up source – such as a shallow well. In rural villages, people might draw water from a protected well or standpipe for part of the year but then be forced to fetch water from a river during the dry season. The use of water sources constantly adjusts to take into account factors ranging from water quality, proximity, price and reliability (UNDP, 2006).

Household water treatment allows people to use a wide array of water sources which may be more convenient and accessible, even though they are of poor quality, such as rivers, ponds, streams and canals. Treating water in the home allows people to adapt to the temporal and seasonal variations in their water supply. In some cases, HWTS may be the only option for remote and isolated homes to have safe water.

Even if water is drawn from an improved source, it may be subject to fecal contamination during collection, storage, and use in the home. Contamination of water between source and point-of-use is widespread and often significant, particularly in urban areas that have safe water sources to begin with (Wright et al., 2004). A WHO 2007 assessment found that in one country more

than half of the household samples showed post-source contamination. The research implies that treating and storing drinking water in the home just before it is consumed will improve its quality. Water treatment also needs to be accompanied by safe storage.

To reach the vulnerable, drinking water provision must meet the criteria for the poor, namely being simple, acceptable, affordable and sustainable – all of which household water treatment is able to do.

A variety of simple household treatment technologies and methods are available. Many have been tested and successfully implemented in a variety of settings and for a diverse range of populations. Many of these technologies are convenient and easy to use, minimizing the need for significant behaviour change in people's daily routines and habits.

Field studies show that taste and other aesthetic properties of water are important factors for its acceptability (WHO, 2007). Every person, regardless of being poor or wealthy, wants their water to look, taste and smell good. And in this regard, household water treatment provides a range of options for people to immediately and consistently improve the aesthetics of their water, while at the same time making it safe to drink.

Affordabilityhas a significant influence on the use of water and selection of water sources. Households with the lowest levels of access to safe water supply frequently pay more for their water than do those connected to a piped water system. The high cost of water may force households to use alternative sources of water of poorer quality that pose a greater risk to their health (WHO, 2005). Treating water at home can therefore be a low cost option for these households to provide safe drinking water, even if they are using contaminated sources.

In addition to these cost savings, there are health costs that can be averted by both individuals and governments from household water treatment. Direct cost offsets more than cover the costs of implementing most household water treatment interventions. This means that governments, who are chiefly incurring such costs, would reduce their overall outlays by investing in household water treatment rather than in the treatment of cases of diarrheal disease (Clasen and Haller, 2008).

> At the global level, a WHO report suggests that household water interventions can lead to a benefit of up to US$60 for every US$1 invested (Hutton and Haller, 2004).

Reaching the vulnerable, however, implies much more than developing simple and affordable HWTS products. These interventions are most effective in preventing disease only if they are used correctly and consistently. Identifying and implementing successful approaches to increase the uptake of HWTS on a sustainable basis is essential for this intervention to achieve widespread and long-term success (WHO, 2007).

1.4 Contributing to the Millennium Development Goals

MDG 7, Target 10, calls for reducing by half the proportion of people without sustainable access to safe drinking water by 2015. Reaching this target implies tackling both the quantity (access) and quality (safety) dimensions of drinking water. Progress towards meeting the target is tracked by the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP).
The WHO/UNICEF JMP estimates that globally 884 million people do not use improved sources of drinking water. However, the percentage of people worldwide who have access to an improved water supply has risen from 77% in 1990 to 87% in 2008, an increase of 1.8 billion people. All regions of the world have succeeded in reducing the proportion of the population using unimproved sources for drinking water. At the current rate of progress, the world is expected to exceed the MDG safe drinking water target. Even so, 672 million people will still lack access to improved drinking water sources in 2015, especially in rural areas (WHO/UNICEF JMP, 2010).

Figure 1.4: Worldwide Drinking Water Coverage, 2006
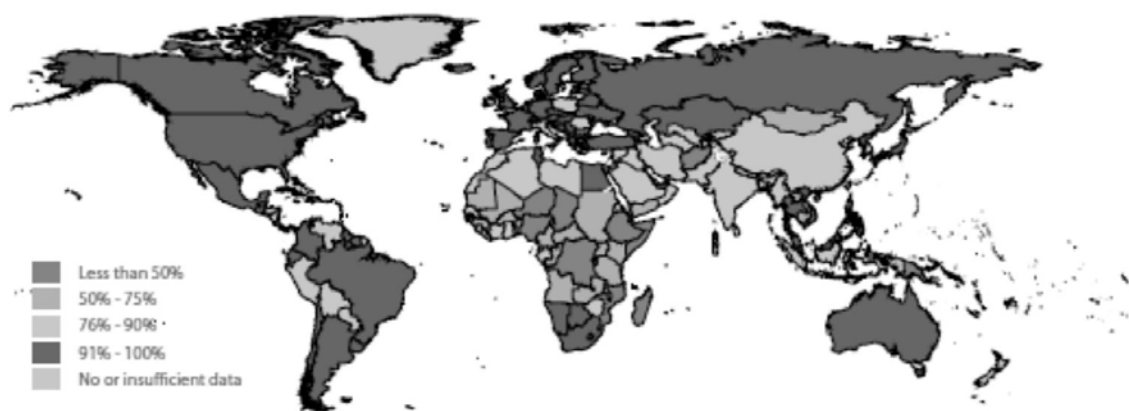
(WHO/UNICEF JMP, 2008)

It is important to distinguish between "improved" and "safe" drinking water. Safe water does not have any detectable fecal contamination in any 100 ml sample and meets the WHO Guidelines for Drinking Water Quality (2006). Improved water, on the other hand, is defined by WHO/UNICEF JMP (2010) as a drinking water source that by nature of its construction adequately protects the source from outside contamination, in particular fecal matter. Examples of improved water sources are listed in the following table.

It is assumed that certain sources are safer than others, but **not all improved sources in actual fact provide drinking water that is safe.** Many people who have access to improved water are still, in fact, drinking contaminated water (WHO, 2007). This contamination can occur at the source or within a piped distribution system. Even unhygienic handling of water during transport or within the home can contaminate previously safe water.

Table 1.4.1: What Are Improved Drinking Water Sources?

Improved Sources	Unimproved Sources
• Piped water into dwelling, yard or plot • Public tap or standpipe • Tubewell or borehole • Protected dug well • Protected spring • Rainwater collection	• Unprotected dug well • Unprotected spring • Vendor-provided water • Tanker truck water • Surface water (e.g. river, stream, dam, lake, pond, canal) • Bottled water[1]

[1] Bottled water is a source of improved drinking water only when another improved source is also used for cooking and personal hygiene; where this information is not available, bottled water is classified on a case by case basis.
[2] Shared or public facilities are not considered to be improved.   (WHO/UNICEF, 2010)

The MDG target for safe water is indicated by the proportion of households reporting the use of "improved" water supplies. The statistics about the number of people who drink unsafe water in the world today, and consequently the progress in achieving the MDG targets, are approximate. The WHO/UNICEF JMP household surveys and censuses do not provide specific information on the quality of water. Assessing drinking water quality through national health and demographic surveys is considered to be too costly and time consuming to be practical. The WHO/UNICEF JMP relies, instead on proxy indicators such as "improved" water sources to indicate water quality.

It is also worth noting that the household surveys and censuses on which the JMP relies also measure "use" and not "access". The proportion of the population that uses an improved drinking water source is a proxy indicator for access to improved drinking water. Access involves many additional criteria other than use, such as time taken or distance to collect water. Some argue that the time needed to collect water should be considered when determining whether a source is "improved" or not because it is a factor in use (WHO/UNICEF, 2008).

Household-level interventions can make an immediate contribution to the safety component of this target, and would significantly contribute to meeting the MDGs in situations where access to water supplies is secure, but household water quality is not assured (WHO, 2007).

The two main household surveys used by the JMP now include questions on household water treatment. The purpose of the questions is to know whether drinking water is treated within the household and, if so, what type of treatment is used. The questions provide an indication of the drinking water quality used in the household. Results from recent surveys conducted in 35 countries show that a variety of household treatment methods are used. Additional evidence can be obtained and a trend analysis carried out as more surveys become available over time (WHO/UNICEF, 2008).

As shown in the following table, safe drinking water is a complex issue that is interlinked to achieving other targets set under the Millennium Development Goals, ranging from the reduction of extreme poverty to gender equality to health and education. A lack of progress in achieving the safe drinking water target will hold back improvements across the board.

Table 1.4.2: Safe Water and the Millennium Development Goals

Millennium Development Goal	Importance of Safe Drinking Water
Goal 1 Eradicate extreme poverty and hunger	• The absence of clean water is a major cause of poverty and malnutrition • Diseases and productivity losses linked to water and sanitation in developing countries amount to 2% of GDP • The poorest households pay as much as 10 times more for water as wealthy households
Goal 2 Achieve universal primary education	• Collecting water and carrying it over long distances keeps millions of girls out of school, consigning them to a future of illiteracy and restricted choice • Water-related diseases such as diarrhea and parasitic infections cost 443 million school days each year and diminish learning potential • The absence of adequate sanitation and water in schools is a major reason that girls drop out • Parasitic infection transmitted through water and poor sanitation retards learning potential for more than 150 million children
Goal 3 Promote gender equality and empower women	• Women bear the brunt of responsibility for collecting water which is a major source of time poverty • The time women spend caring for children made ill by waterborne diseases diminishes their opportunity to engage in productive work
Goal 4 Reduce child mortality	• Unsafe water accounts for the vast majority of the 1.8 million child deaths each year from diarrhea, making it the second largest cause of child mortality • Access to clean water can reduce the risk of a child dying by as much as 50%
Goal 5 Improve maternal health	• Provision of water reduces the incidence of diseases and afflictions—such as anaemia, vitamin deficiency and trachoma—that undermine maternal health and contribute to maternal mortality
Goal 6 Combat HIV/ AIDS, malaria and other diseases	• Inadequate access to water restricts opportunities for hygiene and exposes people with HIV/AIDS to increased risks of infection • HIV-infected mothers require clean water to make formula milk

(Adapted from UNDP, 2006)

1.5 Summary of Key Messages

- Household water treatment and safe storage (HWTS) is an essential component of a global strategy to provide safe water to the 884 million people who currently live without it and the millions more who suffer from contamination of their improved water sources.

- Research and implementation experience suggests that HWTS:

  o Dramatically improves microbiological water quality

  o Significantly reduces diarrheal disease

  o Is among the most effective of water, sanitation and health interventions

  o Is highly cost-effective

  o Can be quickly implemented and taken up by vulnerable populations

- The Millennium Development Goals (MDGs) commits to reduce by half the proportion of people without sustainable access to safe drinking water by 2015. While progress is being made, current trends will still leave hundreds of millions without access to improved water sources by the target date.

- There is a difference between "improved" and "safe" drinking water. Not all improved sources in actual fact provide drinking water that is safe. Many people who have access to improved water are still, in fact, drinking contaminated water.

- Providing safe, reliable, piped-in water to every household is an essential goal. However, the resources needed to construct, operate and maintain a community water supply system are not always available. HWTS can provide the health benefits of safe drinking water while progress is being made in improving water supply infrastructure.

- HWTS should be targeted to the most vulnerable populations, including those with:

  o Underdeveloped or impaired immune systems – children under five, the elderly, people living with HIV/AIDS

  o High exposure to contaminated water – families living in remote rural areas and urban slums or those displaced by war and famine

- HWTS is highly cost effective compared to conventional water supply interventions. In addition to cost savings, there are health costs that can be avoided by both individuals and governments through the use of HWTS. When health care savings are included, governments could reduce their overall expenditures by investing in HWTS rather than treating diarrheal disease.

- To realize the full potential of HWTS, it is essential that technologies perform well and are affordable. As well, they need to reach the most vulnerable populations at scale (coverage) and these populations need to use HWTS correctly and consistently over the long-term (adoption).

2 Water Contamination and HWTS Options

The first priority is to ensure that drinking water is free of pathogens that cause disease, even though there are several chemical and physical contaminants that may also be harmful to humans. Household water treatment is primarily focused on removing pathogens– the biggest public health threat.

Using the multi-barrier approach in the home is the best way to reduce the risk of drinking unsafe water. Each step in the process, from source protection, to water treatment and safe storage, helps reduce health risks incrementally. Both community and household systems follow the same basic water treatment process: sedimentation, filtration and disinfection.

More often than not, people focus on a particular HWTS option rather than considering the water treatment process as a whole. While individual technologies can incrementally improve drinking water quality, the multi-barrier approach is essential in providing the best water quality possible.

Many people simply want to be told the "best" technology for household water treatment. Unfortunately, there is no easy formula that will answer this question since there are many factors to consider, including treatment effectiveness, appropriateness, acceptability, affordability and implementation requirements. Each of these criteria for selection is described further in this Section.

To select the most appropriate HWTS option, implementers need to know about water quality, as well as how different HWTS options work and their effectiveness against different contaminants. This Section presents the different biological, chemical and physical contaminants commonly found in unsafe water. As well, detailed fact sheets that summarize field experience and research evidence on the operation and treatment efficiency of various HWTS options are provided in Appendix B.

2.1 How Much Water Do People Need?

There are basic things that we all need water for: drinking, personal hygiene, cooking, laundry and cleaning. There is no rule about how much water is enough for each person. On average, people need to drink between 2 to 4.5 litres of water a day just to survive; the higher number being for people who do manual work in hot climates.Women who are breast feeding and doing even moderate physical activity should have about 5.5 litres of drinking water each day, and may even require up to 7.5 litres if they are working in hot climates (WHO, 2003).

In total, every person should have at least 20 litres of safe water each day to meet their basic needs for drinking and personal hygiene. Below this level people are constrained in their ability to maintain their physical wellbeing and the dignity that comes with being clean. 20 litres is the minimum requirement for respecting the human right to water – and a minimum target for governments. Factoring in bathing and laundry needs would raise the personal threshold to about 50 litres a day (UNDP, 2006).

The 884 million or so people in the world who live more than 1 kilometre from a water source often use less than 5 litres a day of unsafe water (UNDP, 2006).

Every person should have at least 20 litres of water each day to meet their basic needs.

2.2 What is Safe Drinking Water?

As water moves through the water cycle, it naturally picks up many things along its path. Water quality will naturally change from place to place, with the seasons, and with the kinds of rocks and soil which it moves through.

Water can also be polluted by human activities, such as open defecation, inadequate wastewater management, dumping garbage, poor agricultural practices (e.g. use of fertilizers or pesticides near water sources), and chemical spills at industrial sites. In developing countries, 75% of all industrial waste and up to 95% of sewage is discharged into surface waters without any treatment (Carty, 1991).

Even though water may be clear, it does not necessarily mean that it is safe for us to drink. It is important to judge the safety of water by taking the following three qualities into consideration:

1. **Biological** – bacteria, viruses, protozoa, and worms

2. **Chemical** – minerals, metals and chemicals

3. **Physical** – temperature, colour, smell, taste and turbidity

Different household water treatment technologies remove different types of contaminants. Understanding the local water quality and contaminants will influence the selection of appropriate household water treatment options. The focus of household water treatment is on removing biological pathogens. However some household water treatment options can also remove chemicals and improve physical qualities of drinking water.

Microbiology versus Epidemiology

Microbiology – The study of organisms that are too small to be seen with the naked eye, such as bacteria, viruses and protozoa.

Epidemiology – The study of the causes, distribution, and control of disease in populations. It focuses on groups rather than individuals. Epidemiology developed out of the search for causes of human disease in the 19th century. One of its main purposes is to identify populations at high risk for a given disease, so that the cause may be identified and preventive measures can be taken. Epidemiologists use their understanding of microbiology when they are studying diseases.

2.2.1 Biological Quality

Water naturally contains many living things. Most are harmless or even beneficial, but others can cause illness. Living things that cause disease are also known as **pathogens**. They are sometimes called other names, such as microorganisms, microbes or bugs, depending on the local language and country.

There are four different categories of pathogens: **bacteria, viruses, protozoa and helminths**. Their microbiology and epidemiology will be discussed in the following sections.

Table 2.2.1: Water-Related Diseases

Type	How People Get Sick	Possible Diseases	How to Prevent Illness
Water-borne	Drinking water with pathogens	Diarrhea, cholera, typhoid, shigellosis, hepatitis A and E	Improve drinking water quality by removing or killing pathogens.
Water-washed	Pathogens touch the skin or eye	Trachoma, scabies	Provide enough water needed for basic hygiene. Improve basic hygiene practices.
Water-based	Pathogens go through the skin	Schistosomiasis, guinea worm	Do not bath or swim in water that is known to be contaminated. Improve water quality by removing or killing source of pathogens.
Water-insect vector	Pathogens are passed on by insects that breed or live in water, such as mosquitos	Malaria, dengue, yellow fever, filariasis, river blindness, sleeping sickness	Prevent insects from breeding in water. Use pesticides to control insects. Prevent insects from biting by using bed nets and wearing long clothes.

2.2.1.1 Pathogenic Bacteria

Bacteria are very small single-celled organisms that are present everywhere and are the most common living things found in human and animal feces. Drinking water that contains feces is the main cause of water-related diseases.

The most common water-related diseases caused by pathogenic bacteria have **diarrhea** as a major symptom, including **cholera, shigellosis** (also known as bacillary dysentery) and **typhoid**. About 1.8 million people die every year from diarrheal diseases, about 90% are children under the age of five (WHO/UNICEF, 2008).

Cholera is no longer an issue in countries that have basic water, hygiene and sanitation standards. However, it is still a problem where access to safe drinking water and adequate sanitation practices are limited. Almost every developing country in the world has cholera outbreaks or the threat of a cholera epidemic (WHO, 2007).

Typhoid is also common in places that do not have safe drinking water and proper sanitation. There are an estimated 17 million cases of typhoid worldwide resulting in 600,000 deaths (WHO, 2007).

2.2.1.2 Pathogenic Viruses

Viruses are the smallest of microorganisms. Viruses are unable to reproduce by themselves and must use another living thing to make more viruses. It is difficult and expensive to study viruses so less is known about them than other pathogens.

Some pathogenic viruses that are found in water can cause **hepatitis A** and **hepatitis E**. Hepatitis A is common throughout the developing world with 1.5 million people getting sick every year (WHO, 2004).

There are other viruses that are passed on by certain mosquitoes, which breed or live in water. For example, they can spread viral diseases such as **Dengue Fever**, **Japanese Encephalitis** and **West Nile Fever**. Most of these diseases occur in tropical places where there is standing water for mosquitoes to breed.

Water cannot spread the human immunodeficiency virus (HIV) and other viruses that cause the common cold. Water does not provide the environment needed for these viruses to survive.

2.2.1.3 Pathogenic Protozoa

Protozoa are larger than bacteria and viruses. Some protozoa are parasites that need a living host to survive. They weaken the host by using up their food and energy, damage internal organs, or cause immune reactions.

Amoeba, cryptosporidium and giardia are some of the pathogenic protozoa that are found in water, mainly in tropical countries. Amoebic dysentery is the most common illness and it affects around 500 million people each year.

Some protozoa like cryptosporidium are able to form cysts which let them stay alive without a host and survive in harsh environments. The protozoa cysts become active once the environmental conditions are optimal for their development.

Malaria is another protozoa that is passed on by mosquitoes. About 1.3 million people die each year of malaria, 90% are children under the age of five. There are 396 million cases of malaria every year, most of them happening in sub-Saharan Africa (WHO, 2004).

2.2.1.4 Pathogenic Helminths

Helminths are worms. Pathogenic helminths are generally passed through human and animal feces. Some spend part of their life in hosts that live in water before being passed on to people through the skin. For others, the infection route is by ingestion or by vectors such as mosquitoes.Many can live for several years in our bodies. The WHO estimates that 133 million people suffer from worms and about 9,400 people die each year (WHO, 2000).

Common types of pathogenic helminths that cause illness in developing countries are **round worms**, **pin worms**, **hook worms** and **guinea worms**. **Schistosomiasis**, also known as bilharzia, is caused by the trematode flatworm. This disease affects about 200 million people worldwide and it causes severe symptoms. Schistosomiasis is often associated with large water resource projects, such as the construction of dams and irrigation canals, which provide an ideal breeding ground for the worm.

2.2.1.5 Infective Dose

The minimum number of pathogens needed to make somebody sick is called the infective dose. The presence of a pathogen in water does not always mean that it will make someone sick. The infective dose is different depending on the type of pathogen. Generally, bacteria have a higher infective dose than viruses, protozoa and worms. This means that with some bacteria, larger numbers need to be ingested to cause illness relative to other pathogens.

Infants, young children, the sick and elderly generally have a lower infective dose than an average adult. This means that they are most at risk and more likely to die from water related diseases. Over 90% of deaths from diarrheal diseases in developing countries occur in children under 5 years old (WHO, 2007).

Table 2.2.2: Dose of Microorganisms Needed to Produce Infection in Humans ID50[1]

Disease	Pathogen	Type of Pathogen	Disease-Producing Dose
Shigellosis	*Shigella spp.*	Bacteria	10 – 1,000
Typhoid fever	*Salmonella typhi*	Bacteria	100,000
Cholera	*Vibrio cholerae*	Bacteria	100,000,000

(Adapted from Ryan et al., 2003)

2.2.1.6 Indicator Organisms

Testing for every pathogen in water would be time consuming, complicated and expensive. Alternatively, the presence or absence of certain bacterial indicator organisms is used to determine the safety of the water, especially since there are no routine testing techniques available for viruses, protozoa and helminths. Bacterial indicator tests have been found to be cheaper, easier to perform and yield faster results, compared to direct pathogen testing.

There is no universal indicator to ensure that water is pathogen free, but there are several types of indicators, each with certain characteristics. Coliform bacteria are most commonly used as indicators because they exist in high numbers making them easier to detect in a water sample.

The WHO Guidelines for Drinking Water Quality (2006) recommend using *Escherichia coli* (also commonly known as *E. coli*) as the indicator organism of choice for fecal contamination. Thermotolerant coliforms (TTC) can be used as an alternative to the test for *E. coli* in many circumstances. According to the WHO Guidelines, water intended for human consumption should contain no indicator organisms. See Section 3.4 for further information about the WHO Guidelines for Drinking Water Quality.

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[1]Infective dose is the dose necessary to cause disease in 50% of the exposed individuals, hence ID50. These numbers should be viewed with caution and cannot be directly used to assess risk since they are often extrapolated from epidemiologic investigations, best estimates based on a limited data base from outbreaks, worst case estimates, or other complex variables (US FDA).

2.2.2 Chemical Quality

Water may also contain chemicals which can be helpful or harmful to our health. There are different ways that chemicals get into drinking water. Some are found naturally in ground water, such as arsenic, fluoride, sulphur, calcium and magnesium. Human activities such as agriculture, industry and our daily lives can also add chemicals such as nitrogen, phosphorous and pesticides to water. Many countries are experiencing a rise in industrial activity with no strict compliance to environmental rules and regulations. As a result, water sources are increasingly becoming contaminated with industrial chemical waste.

There are many chemicals that may be in drinking water, but only a few make people sick right away. There are only a few chemicals that can lead to health problems after a single exposure, except through massive accidental contamination of a drinking water supply (WHO, 2006). The main problems are the chemicals that cause illness after drinking contaminated water over a long time.

Even though there are many chemicals that may occur in drinking water, only a few cause health effects on a large-scale. Arsenic and fluoride are usually the chemicals that are most concerning. Other chemicals, such as nitrates and nitrites may also be an issue in certain situations (WHO, 2006).

HWT technologies are generally targeted towards improving the microbiological quality and may not be able to remove all chemical contaminants from drinking water. Therefore, water quality testing carried out at the water source can help to identify an effective and appropriate HWT technology for a particular area.

While microbiological contamination is the largest public health threat, chemical contamination can be a major health concern in some cases. Water can be chemically contaminated through natural causes (e.g. arsenic, fluoride) or through human activity (e.g. nitrate, heavy metals, pesticides).

(UNICEF, 2008)

2.2.2.1 Arsenic

Arsenic can naturally occur in ground water and some surface water. It is one of the greatest chemical problems in developing countries. The WHO considers arsenic to be a high priority for screening in drinking water sources (WHO, 2006).

High levels of arsenic can be found naturally in water from deep wells in over 30 countries, including India, Nepal, Bangladesh, Indonesia, Cambodia, Vietnam, Lao PDR, Mexico, Nicaragua, El Salvador and Brazil. In south Asia alone, it is estimated that 60 to 100 million people are affected by unsafe levels of arsenic in their drinking water. Bangladesh is the most severely affected country, where 35 to 60 million of its 130 million people are exposed to arsenic-contaminated water. It is possible that arsenic may be found in other locations as more extensive testing is done.

Arsenic is poisonous, so if people drink water or eat food contaminated with arsenic for several years, they develop chronic health problems called arsenicosis. According to the UNDP (2006), the projected human costs over the next 50 years include 300,000 deaths from arsenic associated cancer and 2.5 million cases of arsenic poisoning.

There is currently no effective cure for arsenic poisoning, however the health effects may be reversed in the early stages by removing the exposure to arsenic. The only prevention is to drink water that has arsenic levels within the safe limit. There are different HWT technologies that are able to remove arsenic from drinking water to safe levels.

More information about arsenic is provided in **Appendix A: Chemical Contaminants in Drinking Water Fact Sheets**.

2.2.2.2 Fluoride

Fluoride is also a naturally occurring chemical that may be found in groundwater and some surface water.

High levels of fluoride can be found naturally in many areas of the world including, Africa, the Eastern Mediterranean and southern Asia. One of the best known high fluoride areas extends from Turkey through Iraq, Iran, Afghanistan, India, northern Thailand and China. It is possible that fluoride may be found in other locations as more extensive testing is done.

Small amounts of fluoride are generally good for people's teeth. But at higher amounts over time, it can damage people's teeth by changing colour and pitting. Eventually, fluoride can build up in people's bones and cause crippling skeletal damage. Infants and young children are most at risk from high amounts of fluoride since their bodies are still growing and developing.

There is currently no effective cure for fluoride poisoning. The only prevention is to drink water that has safe levels of fluoride. There are emerging household water treatment technologies that are able to remove fluoride from drinking water. More research is needed to find a simple, affordable and locally available technology that can be easily used by households.

More information about fluoride is provided in **Appendix A: Chemical Contaminants in Drinking Water Fact Sheets**.

2.2.2.3 Nitrate and Nitrite

Nitrate and nitrite are naturally occurring chemicals in the environment. Nitrate is commonly used in fertilizers and for agriculture and nitrite is used as food preservatives, especially in processed meat.

Nitrate in ground water and surface water is normally low but can reach high levels if there is leaching or runoff from agricultural fertilizers or contamination from human and animal feces (WHO, 2006). High nitrate levels are often associated with higher levels of microbiological contamination since the nitrates may have come from feces.

High levels of nitrate and nitrite in drinking water can cause methaemoglobinaemia, commonly called blue baby syndrome. This occurs in infants that are bottle fed with formula prepared with drinking water. It causes them to have difficulty breathing and their skin turns blue from a lack of oxygen. It is a serious illness that can sometimes lead to death.

More information about nitrate and nitrite is provided in **Appendix A: Chemical Contaminants in Drinking Water Fact Sheets**.

2.2.2.4 Iron

Iron can be naturally found in groundwater and some surface water (such as creeks, rivers and some shallow dug wells). There are areas of the world that have naturally high amounts of iron in their groundwater. Iron can also be found in drinking water that is passed through rusty steel or cast iron pipes.

Drinking water with high concentrations of iron will not make people sick. Iron, however, can turn water a red-orange colour and it may cause people to not use it and choose another, possibly contaminated, water source instead.

Iron is a nuisance – high levels can cause an objectionable colour and taste and can stain cooked food, water pipes and laundry. As well, some types of bacteria feed on iron and leave slimy red deposits that can clog water pipes.

More information about iron is provided in **Appendix A: Chemical Contaminants in Drinking Water Fact Sheets**.

2.2.2.5 Manganese

Manganese can be naturally found in groundwater and surface water, and it usually occurs with iron. However, human activities may also be responsible for manganese contamination in water in some areas.

People need small amounts of manganese to keep healthy and food is the major source for people. However, too little or too much manganese can cause adverse health effects.

Manganese causes similar issues as iron. High concentrations can turn water a black colour and it may cause people to not use it and choose another, possibly contaminated, water source instead. It also causes an objectionable taste, stains water pipes and laundry, and also forms coatings on water pipes. As well, some types of bacteria feed on manganese and leave black-brown deposits that can also clog pipes.

More information about manganese is provided in **Appendix A: Chemical Contaminants in Drinking Water Fact Sheets**.

2.2.2.6 Total Dissolved Solids

Total dissolved solids (TDS) are made up of inorganic salts (mainly sodium chloride, calcium, magnesium, and potassium) and small amounts of organic matter that are dissolved in water. TDS in drinking water comes from natural sources, sewage, urban runoff and industrial wastewater. There are areas of the world that have naturally high amounts of TDS in their drinking water.

Water with very high or low levels of TDS is often called "hard" or "soft" water, respectively. Hard water received this name because it requires more soap to get a good lather and makes the water "hard" to work with. Soap is less effective with hard water due to its reaction to the magnesium and calcium; leading to high use of soap for laundry and bathing. As well, hard water can leave a residue and cause scale to build up on cooking pots and water pipes. People

generally prefer the taste of hard water due to the dissolved minerals, however very high concentrations of TDS can cause a bitter or salty taste.

Soft water is usually preferred for laundry, bathing and cooking. However, water with extremely low TDS concentrations (e.g. rainwater) may be unacceptable because of its flat taste.

More information about total dissolved solids is provided in **Appendix A: Chemical Contaminants in Drinking Water Fact Sheets**.

2.2.3 Physical Quality

The physical characteristics of drinking water are usually things that can be measured with our senses: turbidity, colour, taste, smell and temperature. In general, drinking water is judged to have good physical qualities if it is clear, tastes good, has no smell and is cool.

2.2.3.1 Turbidity

Turbid water looks cloudy, dirty or muddy. Turbidity is caused by sand, silt and clay; and suspended precipitates of iron that are floating in the water. Drinking turbid water will not make people sick by itself. However, viruses, parasites and some bacteria can sometimes attach themselves to the suspended particles in water. This means that turbid water usually has more pathogens so drinking it increases the chances of becoming sick.

It is also important to remember that clear water does not necessarily mean that it is free of pathogens and safe to drink.

High turbidity levels reduce the efficiency of some household water treatment technologies such as chlorination, solar disinfection (SODIS) and ultraviolet disinfection. Sand in water can also wear out pipes, valves and pumps ahead of their time.

2.2.3.2 Colour

Coloured water will not usually make people sick. Although, it may cause people to not use the coloured water and choose another, possibly contaminated, water source instead.

The following explain some of the different colours that may be found in water:

- Vegetation such as leaves, bark and peat can cause dark brown or yellow colour

- Sand, silt and clay usually cause brown or red colour

- Iron can cause orange or brown colour that can stain laundry and plumbing fixtures and gives water a bad taste

- Manganese can turn water black and cause the same problems as iron

- Algae can make water look bright green or blue-green and some forms produce toxins which can be harmful

- Bacteria growth can also turn water black. These bacteria can also cause illness.

2.2.3.3 Taste and Smell

Most people like to drink water that tastes and smells good. A bad taste or smell may indicate some sort of contamination, especially when a change happens quickly. In most cases, an unpleasant taste or smell will not make people sick. However, it is next to impossible to convince people that water is safe to drink if it tastes or smells bad.

The following explain the cause of different tastes and smells that may occur in water:

- Algae and some bacteria may cause an unpleasant taste and smell

- High level of sulphate (SO_4) may cause a bitter or medicinal taste

- Some bacteria can convert sulfate (SO_4) to form hydrogen sulphide (H_2S) which has a rotten egg smell

- Iron can combine with tea, coffee and other beverages, to produce a harsh, unacceptable taste

- Chlorine has a distinct taste and may be present in treated water

- Rain water has less taste than ground water or surface water

2.2.3.4 Temperature

Most people like to drink cool water instead of warm water. The desirable temperature is between 4^oC to 10^oC (39-50°F); people generally do not like to drink water that has a temperature above 25^oC (77°F). Some bacteria can grow in warm water and may cause the water to taste, smell and look bad over time.

2.2.4 Drinking Water Quality Guidelines and Standards

What is the Difference between Guidelines and Standards?

Standard – A mandatory limit that <u>must</u> not be exceeded; standards often indicate a legal duty or obligation.

Guideline – A recommended limit that <u>should</u> not be exceeded; guidelines are not intended to be standards of practice, or indicate a legal duty or obligation, but in certain circumstances they could assist in evaluation and improvement.

The WHO writes the **Guidelines for Drinking Water Quality** (2006) to help make sure that people are drinking safe water around the world.

The WHO Guidelines explain that safe drinking water will not make people sick at any time throughout their life, including when they are young, old or sick. Safe drinking water should be good to use for all of our personal needs, including drinking, cooking, and washing.

The WHO Guidelines cover microbiological, chemical and physical qualities. However, it is stressed that microbiological quality is the most important since this is biggest cause of illness and death around the world.

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.

(WHO, 2006)

The implementation of the WHO Guidelines for Drinking Water Quality varies among countries. There is no single approach that is used worldwide. The Guidelines are recommendations to work towards and they are not mandatory limits.

Countries can take the WHO Guidelines into consideration along with the local environmental, social, economic and cultural conditions. This may lead to countries developing their own national standards that are quite different from the WHO Guidelines. For example, in 2007 Nepal developed national drinking water standards where total coliform should be zero at least 95% of the time.

The following table summarizes the WHO Guidelines for Drinking Water Quality.

Table 2.2.4: Summary of WHO Guidelines for Drinking Water Quality

Parameter	Guideline Value
Aluminum	No health based value is proposed
Ammonia	No health based value is proposed
Antimony	0.02 mg/L
Arsenic	0.01 mg/L
Barium	0.7 mg/L
Boron	0.5 mg/L
Cadmium	0.003 mg/L
Calcium	No health based value is proposed
Chloride	No health based value is proposed
Chlorine	5 mg/L
Chromium	0.05 mg/L
Copper	2.0 mg/L
Cyanide	0.07 mg/L
Fecal contamination	0 *E. coli* or thermotolerant coliforms in any 100 ml sample
Fluoride	1.5 mg/L (Recommended to have 0.5 - 1.0 mg/L for artificial fluoridation of drinking water)
Iron	No health based value is proposed
Lead	0.01 mg/L
Manganese	0.4 mg/L
Mercury	0.006 mg/L (for inorganic mercury)
Molybdenum	0.07 mg/L
Nickel	0.07 mg/L
Nitrate	50 mg/L
Nitrite	3 mg/L (short-term exposure) 0.2 mg/L (long-term exposure)
pH	No health based value is proposed
Potassium	No health based value is proposed
Silver	No health based value is proposed
Sodium	No health based value is proposed
Total dissolved solids (TDS)	No health based value is proposed
Uranium	0.015 mg/L
Zinc	No health based value is proposed

(WHO, 2006)

2.3 The Multi-Barrier Approach

Household water treatment is primarily focused on removing pathogens from drinking water – the biggest water quality issue around the world. While improving the microbiological quality, there are some technologies that may also be able to remove certain chemicals as a secondary benefit, such as arsenic and iron.

Using the multi-barrier approach is the best way to reduce the risk of drinking unsafe water.

Each step in the process, from source protection, to water treatment and safe storage, helps reduce health risks incrementally. The concept of the multi-barrier approach is also addressed as part of water safety plans, the principles of which can be applied at both community and household levels. The WHO provides additional information about water safety plans on their website.

Both conventional and household systems follow the same basic water treatment process: sedimentation, filtration and disinfection. The main difference is the scale of the systems that are used by individuals and communities.

More often than not, people focus on a particular technology that is directed towards one step rather than considering the whole water treatment process. While individual technologies can incrementally improve drinking water quality, the entire process is essential in providing the best water quality possible.

Figure 2.3: The Multi-Barrier Approach to Safe Water

Household Water Treatment

Source Protection	Sedimentation	Filtration	Disinfection	Safe Storage
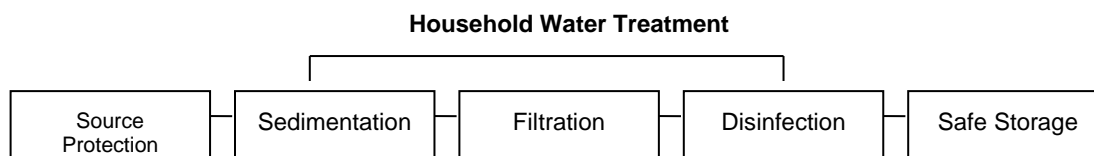
- Sedimentation removes larger particles and often > 50% of pathogens

- Filtration removes smaller particles and often > 90% of pathogens

- Disinfection removes, deactivates or kills any remaining pathogens

2.3.1 Water Source Protection

There are many ways in which pollution may threaten drinking water quality at the source, or point of collection. These risks include the following:

- Poor site selection

- Poor protection of the water source against pollution

- Poor structure design or construction

- Deterioration or damage to structures

- Lack of hygiene and sanitation knowledge and practice in the community

Protecting the water source reduces or eliminates these risks and can lead to improved water quality and health. Actions that can be taken at the community level can include some of the following:

- Regularly cleaning the area around the water source

- Moving latrines away from and downstream of water sources

- Building fences to prevent animals from getting into open water sources

- Lining wells to prevent surface water from contaminating the ground water

- Building proper drainage for wastewater around taps and wells

- Stabilizing springs against erosion and protection from surface run-off contamination

- Ensuring watershed use is non-polluting

Further information is provided in the **Fact Sheet: Source Protection** found in **Appendix B**.

2.3.2 Sedimentation

Sedimentation is a physical treatment process used to reduce the turbidity of the water. This could be as simple as letting the particles in the water settle for some time in a small container such as a bucket or pail.

The sedimentation process can be quickened by adding special chemicals or native plants, also known as **coagulants**, to the water. Coagulants help the sand, silt and clay join together and form larger clumps, making it easier for them to settle to the bottom of the container.

The common chemical coagulants used are aluminium sulphate (alum), polyaluminium chloride (also known as PAC or liquid alum), alum potash and iron salts (ferric sulphate or ferric chloride).

Native plants are also traditionally used in some countries, depending on the local availability, to help with sedimentation. For example, prickly pear cactus and moringa seeds have been used to help sediment water.

Further information on different sedimentation options is provided in the **Fact Sheets** found in **Appendix B.**

2.3.3 Filtration

Filtration is commonly used after sedimentation to further reduce turbidity and remove pathogens. Filtration is a physical process which involves passing water through filter media. Some filters are also designed to grow a biological layer that consumes pathogens and improves the removal efficiency.

Sand and ceramic are the most common filter media, although cloth and membranes can also be used. There are various types of filters that are used by households around the world, including:

- Straining through a cloth

- Biosand filter

- Ceramic pot filter

- Ceramic candle filter

- Membrane filters

Further information on the different filtration options is provided in the **Fact Sheets** found in **Appendix B.**

2.3.4 Disinfection

The last step in household water treatment is to remove or kill any remaining pathogens through **disinfection**. The most common methods used by households around the world to disinfect their drinking water are:

- Chlorine disinfection

- Solar disinfection (SODIS)

- Solar pasteurization

- Ultraviolet (UV) disinfection

- Boiling

When water has high levels of turbidity, pathogens "hide" behind the suspended particles and are difficult to kill using chemical, SODIS and UV disinfection. Reducing turbidity by sedimentation (see Step 2) and filtration (see Step 3) will improve the effectiveness of these disinfection methods.

Distillation is another method of using the sun's energy to treat drinking water. It is the process of evaporating water into vapour, and then capturing and cooling the vapour so it condenses back into a liquid. Any contaminants in the water are left behind when the water is evaporated.

Further information on the different disinfection options and distillation is provided in the **Fact Sheets** found in **Appendix B.**

2.3.5 Safe Water Storage

Households do a lot of work to collect, transport and treat their drinking water. Even after the water is treated, it should be handled and stored properly to keep it safe. If it is not stored safely, the treated water quality could become worse than the source water and may cause illness.

Recontamination of safe drinking water is a significant issue. The risk of diarrhea due to water contamination during household storage, first noted in the 1960s, has since been repeatedly observed by others (Mintz et al., 2001).

Distributing and using safe storage containers has shown substantial reductions in diarrheal disease (Roberts et al., 2001). Safe storage means keeping treated water away from sources of contamination, and using a clean and covered container. It also means drawing water from the container in a way that won't recontaminate the water and cause sickness. The container should prevent hands, cups and dippers from touching the water.

There are many designs for water containers around the world. A safe water storage container should be:

- With a strong and tightly-sealing lid or cover

- With a tap or narrow opening at the outlet

- With a stable base so it does not tip over

- Durable and strong

- Not transparent or see-through

- Easy to clean

A good safe storage container should also have instructions on how to properly use and maintain it.

Other safe water handling practices include:

- Using a container for collecting and storing only untreated water

- Using a separate container for storing only treated water

- Frequently cleaning out the storage container with soap or chlorine

- Storing treated water off the ground in a shaded place in the home

- Storing treated water away from small children and animals

- Pouring treated water from the container instead of scooping the water out of it

- Using the water as soon as possible after it is treated, preferably on the same day

Sometimes it is difficult for rural and poor households to find or buy good storage containers. The most important things are to make sure that they are covered and only used to store treated water.

Further information is provided in the **Fact Sheet: Safe Storage and Handling** found in **Appendix B**.

2.4 Technology Selection

Decision making and technology selection can take place at many levels, ranging from central government to independent program implementers to the individual households.

There is no one right way to make decisions and they are often made pragmatically based on the information and resources available. Decision making can be a formal process undertaken by the stakeholders or be done informally and subconsciously by individuals. .

2.4.1 What is the Best Technology?

Many people simply want to be told the "best" technology for household water treatment. Unfortunately, there is no easy formula that will answer this question since there are many factors to consider.

First of all, it is important to remember that household water treatment is a process (i.e. sedimentation, filtration and disinfection), not just a single technology. It is not easy to know which combination of technologies is the most appropriate. Many measures have the potential to seriously reduce diarrheal disease, each with its advantages and limitations depending on the local circumstances. Different technologies have varying suitability in each local situation.

The "best process" ought to be driven by a number of factors, including treatment effectiveness based on the source water quality and local contaminants, appropriateness, affordability, and acceptability for sustainable use by poor households.

Since the household water treatment process is dependent on so many different factors, there can be no standard solution. However, decision making tools are available to help identify the HWTS process that is best suited for the local context. Several decision making tools have been provided in **Appendix C** to compare different HWTS options against criteria which are important to the stakeholders.

The tools are participatory activities which encourage the involvement of different stakeholders in a group process. Participants can actively contribute to decision making, rather than passively receiving information from outside experts, who may not have an understanding of the local context and issues.

Participatory activities are designed to build self-esteem and a sense of responsibility for one's decisions. Experience shows that when everyone contributes to the decision making process, people feel more ownership of the problem and develop more appropriate solutions for their situation. Participatory decision making can empower communities to implement their own HWTS improvements.

2.4.2 Criteria Influencing Technology Choice

There are five main criteria that should take into consideration when deciding which household water treatment technologies are most suitable:

1. **Effectiveness** – How well does the technology perform?

2. **Appropriateness** – How well does the technology fit into people's daily lives?

3. **Acceptability** – What will people think of the technology?

4. **Cost** – What are the costs for the household?

5. **Implementation** – What is required to get the technology into people's homes?

Each of these criteria is described in the following sections. Other criteria which are important to the stakeholders can also be added.

2.4.2.1 Effectiveness

Effectiveness is the ability of the technology to provide sufficient water quality and quantity. There should be enough safe drinking water for a household to meet their basic needs. Criteria that show the technology's effectiveness include the following:

Water Quality

- Which microbiological, physical and chemical contaminants can be removed by the technologyand how much?

Water Quantity

- How much water can be provided every day?

- Is it sufficient to meet the household's daily needs?

Local Water Source

- Will the technology be able to treat the specific microbiological, physical and chemical contaminants of the local water source?

- Will it treat water from different sources to the same level?

2.4.2.2 Appropriateness

Some technologies will be more suitable than others depending on the needs and conditions of the community. Answering the following criteria can help to match a technology with a particular community:

Local Availability

- Can the technology be manufactured in or near the community using local materials and labour?

- Does the technology need imported spare parts or consumables?

- Is it possible to buy spare parts or consumables locally?

- Is the supply chain reliable?

Time

- How long does it take for a household to treat enough water to meet their daily needs?

- Does it significantly add to the household's labour burden?

Operation and Maintenance

- What are the household's responsibilities to operate and maintain the technology?

- Is it easy and convenient for women and children to use the technology?

Lifespan

- How long will the technology last before it needs to be fixed or replaced?

2.4.2.3 Acceptability

People's opinion about the technology will affect its widespread adoption and consistent use. It is difficult for many people to accept a new technology until they personally experience the benefits. People's acceptance of a technology is affected by the following criteria:

Taste, Smell and Colour

- How will the treated water look, taste and smell?

Needs and Motivations

- What benefits will the technology give to people?

- Will it provide convenience, health improvement, social status, time or money savings?

2.4.2.4 Cost

Most HWTS options are not free. The following costs need to be considered:

Capital Costs

- Initial purchase of a durable product

- Transportation

On-Going Costs

- Continuing purchase of consumable products

- Operation and maintenance

- Potential repair and replacement parts

Willingness to Pay and Affordability

- Can households afford the full cost of the technology?

- Are households willing to pay for capital costs?

- Are households willing to pay for on-going operation and maintenance costs?

- How is technology subjected to household income fluctuations?

- Do durable or consumable items need to be subsidized?

Implementation Costs

- Cost to run the program (e.g. staff, office space, etc.)

- Cost to raise awareness in the community

- Cost to educate people about how to use the technology

- Cost to provide on-going support for households

Successful cost recovery is an important part of the program sustainability. Implementers need to consider how the costs can be recovered - whether from households, donors, government or others. It is important to figure out who is financially responsible for which costs, and over what period of time.

2.4.2.5 Implementation

There are several factors to consider about how the technology is implemented:

- How is the technology manufactured and distributed to the households?

- Are local manufacturing and repair skills and spare parts available? If not, can these be made available?

- How fast can the technology be implemented?

- What training will the household require to properly use the technology?

- Who will help a household if they have a problem or question?

- What monitoring is required for the technology?

- What additional support is needed?

- Do households perceive the technology to be of benefit to them?

- How well can the technology be integrated into current government programs?

2.5 Summary of Key Messages

- The first priority is to ensure that drinking water is free of pathogens that cause disease. Household water treatment is primarily focused on removing pathogens– the largest public health threat. Some household water treatment options can also remove chemicals and improve physical qualities of drinking water.

- There are four different categories of pathogens: bacteria, viruses, protozoa and helminths. Different household water treatment technologies have varying levels of effectiveness in removing, inactivating or killing the different types of pathogens.

- Many chemicals may be found in drinking water, however only a few cause health effects on a large-scale, such as arsenic and fluoride. Water quality testing of the source can help to identify mitigation and treatment options for particular chemicals.

- The implementation of the WHO Guidelines for Drinking Water Quality varies among countries. There is no single approach that is used worldwide. The Guidelines are recommendations to work towards and they are not mandatory limits.

- Safe water and improved water do not mean the same thing. Improved water is a source that by nature of its construction adequately protects it from outside contamination, in particular fecal matter. It is assumed that certain sources are safer than others, but not all improved sources in actual fact provide safe drinking water.

- Using the multi-barrier approach is the best way to reduce the risk of drinking unsafe water. Each step in the process, from source protection, to water treatment and safe storage, helps reduce health risks incrementally. Water safety plans use the concept of the multi-barrier approach, the principles of which can be applied at both community and household levels.

- Both community and household systems follow the same basic water treatment process: sedimentation, filtration and disinfection.

- People often focus on a particular HWTS option rather than considering the water treatment process as a whole.

- There is no "best" technology for HWTS. There are many criteria to consider for the local context, including treatment effectiveness for the water source, appropriateness, acceptability, affordability and implementation requirements.

- There is no one right way to make decisions about HWTS selection. They are often made pragmatically based on the information and resources available.

3 Implementation of HWTS

The objective of this Section is to illustrate the diversity of HWTS implementation and explain the components shared by successful programs. Understanding what it takes to implement a HWTS program will help governments promote and support best practices in their country.

A review of the implementation programs worldwide shows that **there is no standard approach for getting HWTS into people's home**. There are a wide variety of organizations using different HWT options and a diverse range of programs, from emergency response to long term development. While there is no one standard implementation model, many of the programs do address the following key components, which make them more likely to succeed:

1. Creating demand for HWTS
2. Supplying the required HWTS products and services to meet the demand
3. Monitoring and continuous improvement of program implementation

The organization's ability to plan and implement these components is determined by their **human capacity (people)** and **financing (money).** Successful programs understand and integrate these supporting components into their planning and implementation.

Figure 3: Framework for HWTS Implementation
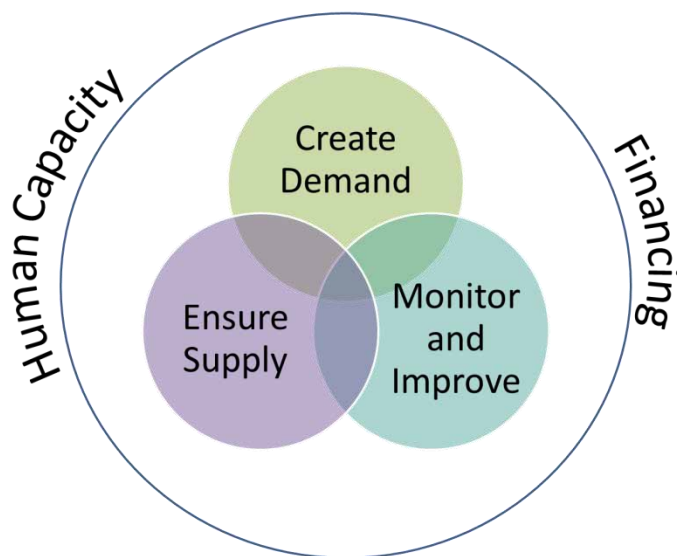
The following sections discuss each of these framework elements in more detail. Case studies are also used to illustrate the diversity of implementers and their approaches.

Implementation… is the process of creating and following a plan to execute a HWTS program. It also includes monitoring day to day activities and evaluating the results of the program.

3.1 Creating Demand

Creating demand requires awareness and education to convince households of the need and benefits of HWTS so that it is desired and sought after. Demand exists when people need and want HWTS and have the opportunity and ability to bring it into their homes. It is critical that households actually want and value HWTS; this ensures it will be used over the long term.

Ultimately all implementation programs want to make a change – an increase in the number of people who have safe drinking water. For anything to change, one has to start acting differently, such as treating water in their home. The challenge of changing people's behaviour, and subsequently creating demand for HWTS, is significant for implementers – requiring time, sustained investment, and a range of strategies.

Many successful implementers use the following steps to create demand for HWTS:

Plan	1. Identify an appropriate target population.
	2. Select a suitable and feasible HWTS option
Initiate and Pilot	3. Increase awareness of HWTS as a solution for safe water and educate people on the relationship between water and health.
	4. Use demonstration projects to convince people of the benefits of HWTS.
	5. Engage government agencies to give credibility to HWTS.
Sustain and Expand	6. Provide positive reinforcement to households so they continue using HWTS.

Each step is discussed in more detail in the following sections.

The piloting phase is especially important. Before scaling up, many organizations gain significant benefit from first implementing a small pilot project to establish their processes, learn from experience, get household feedback, ensure quality of service, and demonstrate results and their capability to potential funders.

3.1.1 Identify the Target Population

Implementers should identify a target population during their program planning. They can often find initial success by working with households that are more likely to adopt HWTS, and working within their organizational capacity.

It is easier to start implementation in an area where people already have self-identified a need and motivation to adopt healthier behaviours. Implementers can also strategically focus on people who are most vulnerable from unsafe water, including those who:

• Have low immune systems, such as children under the age of five, the sick (including people living with HIV/AIDS), and the elderly

• Suffer from diarrheal diseases and other illnesses which can be prevented through water, hygiene and sanitation programs

- Use surface water and shallow wells which are more likely to be contaminated by pathogens
- Live in areas susceptible to flooding, in areas of poor hygiene and sanitation, and in places experiencing conflict or other emergencies

3.1.2 Select HWTS Options

The majority of organizations select only one HWTS option within the multi-barrier approach to implement. This is frequently due to their limited resources and capacity to provide more than one option to households.

Implementers often make their decision using the criteria presented in Section 2:

1. **Effectiveness** – How well does the technology perform?

2. **Appropriateness** – How well does the technology fit into people's daily lives?

3. **Acceptability** – What will people think of the technology?

4. **Cost** – What are the costs for the household?

5. **Implementation** – What is required to get the technology into people's homes?

It is believed that demand can be increased by providing more HWTS options; allowing household to choose from a range of products at a number of price points (WSP, 2002; UNICEF, 2008; Clasen, 2009). Generally, the greater involvement households have in selecting their HWTS, the greater their understanding and motivation for using it.

People can, however, be easily overwhelmed if there are too many choices. Difficulty in making a decision may lead to people not taking any action at all and continuing to drink unsafe water. Households often need someone to help them make a decision by suggesting a good place to start. Some implementers help people decide what is most appropriate for their situation through education and training and proposing a small selection of options.

3.1.3 Increase Awareness and Knowledge

Implementers need to increase awareness and knowledge to motivate people to take action against their poor water conditions. Promotion activities are used to create awareness and encourage people to learn more about the solutions for getting safe drinking water. Education increases their knowledge on the relationship between water and health and the available HWTS options. Both are needed to motivate individuals to act differently and integrate HWTS into their daily routine. Promotion and education efforts must be designed specifically for the target population.

Figure 3.1.3 Increasing Awareness and Knowledge
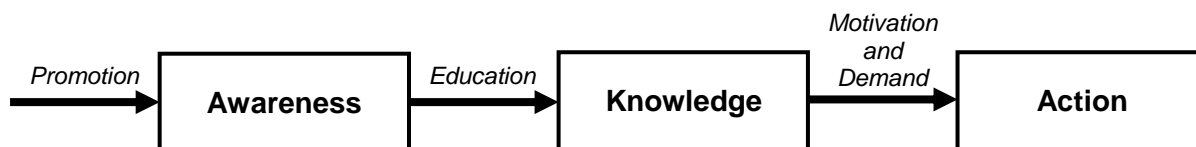
3.1.3.1 Promotion to Create Awareness

Promotional activities are generally targeted at a wide range of individuals, with the understanding that those most interested will step forward. It lends itself to using of mass media communication channels such as television, radio, newspaper, billboards, street dramas, etc. Mass media campaigns usually focus on a few key messages for the general public, such as:

- "Dirty water can make you sick."

- "Clean water makes you healthy."

- "You can treat dirty water at home to get clean water."

Mass media can be very timely (e.g. raising awareness about cholera just before the rainy season) and can reach a large audience with limited human resources. However, mass media should be quickly followed by **education** to further motivate people to take action. Mass media alone is less effective for long-term change because it provides only one way communication. As well, it may only reach select audiences, such as wealthy households, who may be the only ones owning a television or radio (Namsaat, 2001).

3.1.3.2 Education to Increase Knowledge

People need to be educated on three things in order to begin treating water in their home:

1. Why use HWTS

2. What to do to get HWTS

3. How to use HWTS

Community health promoters are critical to successful implementation by helping households learn about the need for safe water and HWTS. They are local people who are trusted and respected, giving credibility to HWTS, such as nurses, teachers, women's leaders, community leaders, and elders.

Education as a First Approach to Safe Water – Ceramic Filters, Thirst-Aid, Myanmar

Thirst-Aid's goal is to make knowledge of household water treatment as common as how to cook rice or fry an egg. They use education and knowledge to inspire the drive for safe water to come from within the community before introducing HWTS.

The organization creates demand by using education and knowledge as investment capital. Their approach is based on the assumption that educated people do not willingly drink contaminated water – much less give it to their children.

Thirst-Aid provides the currency for community buy-in by issuing *Certificates of Knowledge* upon successful completion of their educational program. These certificates serve as legal tender that can be later used for the purchase of HWTS.

(Bradner, C., Personal communication, July 2010)

Studies show that people are more likely to treat water if they understand the relationship between water and health and have some knowledge of safe water practices (Kraemer and Mosler, 2010; Brown et al., 2007). However many, many people around the world do not understand the relationship between water and health.

Traditional norms, and beliefs that diarrhea is not a disease or that it is caused by supernatural powers, are often mentioned by implementers as reasons for the lack of demand. Other implementers have found that people believe that since they have been drinking the water for a long time, they have immunity and do not need to treat it (Heri and Mosler, 2008; Graf et al., 2008; Clasen, 2009).

Choosing the most appropriate key messages and communication channels are essential for appealing to the beliefs and motivations of the target audience. For example, community health promoters may arrange for house-to-house visits and meetings with women's groups to reach mothers, while street theatre may be more effective in reaching fathers and youth.

Some argue that person to person communication is too resource intensive and not scalable and should therefore be limited to areas where the reach of mass media is unavailable (Parker, 2009). However, many implementers report that group meetings and household visits done by community health promoters is the most successful strategy to educate people and support them to adopt HWTS. Acceptance, adoption and long term use is more likely and, in addition, it helps create a "word-of-mouth education" beyond the investment of the project – resulting in further potential scale-up.

Using Appropriate Communication Channels – Chlorine, Afghanistan

In Afghanistan, men primarily learn about safe water though mass media channels such as television and radio. Women, however, generally learned about PSI's chlorine products through friends, neighbours, and other person-to-person interactions. Given that men often control a family's finances and that women usually prepare the household's water, targeting both genders was critical for program success.

(POUZN Project, 2007)

3.1.4 Use Demonstration Projects

Seeing is believing. A demonstration project allows people to see and experience the benefits of HWTS for themselves. Doing a small demonstration project at the beginning of a program is a good strategy for implementers. This helps to generate interest and create demand before the program is scaled up.

Seeing is Believing

Implementers have reported that when people observe the benefits their neighbours have with HWTS, they want the same thing forthemselves.

A study done by Moser et al. (2005) showed that the more people that someone has seen using SODIS, the higher the percentage of SODIS use.

Clean Water for Haiti initially placed biosand filters in schools, health centres, churches and in the homes of community leaders to demonstrate the technology. People were able to see for themselves that the filtered water was better, and that there were improvements in people's health. The success of their demonstration helped convince people to adopt filters. To date over 10,000 households have biosand filter installed and demand outstrips the organization's ability to supply (Dow Baker et al., 2008).

The best locations to set up a demonstration are generally public and community institutions, such as schools and health clinics. These locations highlight leadership from those in authority and gives credibility to the program. It is also a way for implementers to gain access to some of the most vulnerable populations – young children and the sick.

In a school situation, the effectiveness of HWTS can be demonstrated and teachers can also receive training in safe drinking water, hygiene and HWTS to share with their students. Once youth have knowledge about the importance of safe drinking water and the solutions available, they pass the messages onto their parents and encourage action at home.

Similarly, demonstrations in health clinics can be coupled with education for health workers, who pass the information on to their patients and clients. Outreach through clinics directly reaches the children under five years of age who experience the highest rates of illness and death from diarrhea, and mothers who are concerned about their family's health and looking for solutions.

HWTS options are usually given to schools and clinics at no cost. Letters of agreement or contracts have been used successfully to ensure that they agree and comply to the proper operation and maintenance of the HWTS products. Some programs also provide free HWTS for teachers and health workers to use at home.

Educating Communities through Schools and Health Clinics – Chlorine, Kenya

CARE-Kenya implemented a school-based safe water and hygiene intervention in rural schools. Schools were provided with safe water storage containers, WaterGuard (chlorine), and hand washing stations. The program was evaluated to assess its impact on students' knowledge and on parents' adoption of safe water and hygiene practices in the home. The approach showed promise for passing on messages from student to parent to promote water and hygiene interventions at home (O'Reilly et al., 2006; O'Reilly et al., 2008).

In another study, nurses in a maternal and child health clinic were trained in chlorination using WaterGuard and proper hand washing. They were asked to communicate this information to their clients. Interviews immediately following the training were conducted with the health clinic clients - 76% reported being taught both chlorination and hand washing during their clinic visit (Parker et al., 2006).

3.1.5 Engage Government Agencies

Acknowledgement and support from government is required to help increase demand over time. Endorsements from government agencies give credibility to HWTS and implementers.

Implementers should be proactive and take steps to engage all levels of government – local, regional and national. HWTS can cross a range of sectors (such as health, water and sanitation, rural development, and education), so officials from each of these areas should be involved. Engaging government officials can be done by educating them about the benefits of HWTS and showing how it can leverage their own efforts in providing services (Clasen, 2009).

In Nepal, the government is very active in HWTS promotion. They coordinate the development of HWTS promotion materials and messaging with implementing organizations. The government of Lao PDR also works closely with implementers to promote various HWTS options, including boiling, chlorine, SODIS, and the biosand filter. They also provide training through their government extension system and are involved in the joint production of education materials with implementers (SODIS, 2010).

A number of country governments (including Haiti, Tanzania, Viet Nam, Cambodia, Indonesia, Nepal and the Philippines) have also drafted HWTS guidelines to encourage implementation and endorse product quality.

The Success of Boiling

Boiling is the predominant method of HWT with 21% of low- and middle-income households reporting the practice. Boiling is almost universal in Mongolia (95.1%), Vietnam (91%) and Indonesia (90.6%), and also quite high in Timor-Leste (73.4%), Cambodia (60.1%), and Laos (62.7%). In some countries, the success of boiling is due to government recommending it as part of their overall health or hygiene campaigns. As well, many governments have trained health and community workers to promote the practice in villages and communities.

(Clasen, 2009; Rosa and Clasen, 2010)

3.1.6 Provide Positive Reinforcement

Positive reinforcement is critical after HWTS has been first introduced in the home.People need encouragement and support as they learn to incorporate HWTS into their daily routines. They often have questions or need reminding on how to properly use and maintain their HWTS product.

One of the greatest challenges for implementers is to follow up with households in a timely manner to monitor and reinforce the use of HWTS. Many implementers have successfully used community health promoters to reinforce key messages and practices. Community health promoters visit with households and organize group activities to help people treat their water, provide troubleshooting, and answer questions.

Need for Continuous Reinforcement – SODIS, Bolivia

A study of SODIS in Bolivia observed that altering existing habits and developing new ones is a difficult and long process. It recommended regular monitoring and follow-up with new users over a long period of time to support and reinforce using SODIS

(Moser et al., 2005).

3.2 Supplying Required Products and Services

Households need both the HWTS product and support services to ensure its proper and consistent use over the long term. This requires significantly more effort on the service component or "software" than has traditionally been the case in the water and sanitation sector.

Implementers must work towards supplying both high quality products and services to create demand and then meet that demand. Many organizations choose to do a small pilot project to establish their processes, learn from experience and ensure quality control of product and service before scaling up their program.

While there are successful stories of large scale supply of HWT products, many organizations rely on localized supply. Supply chains which use locally available resources, supply routes, fabrication and people (for labour, education and follow up) are often successfully used as they can:

• Create local knowledge skills which empower beneficiaries to meet their own needs

• Aid demand creation and sustainable supply

• Allow more gradual expansion, since implementation can be limited to a predefined area

• Reach areas which are difficult to access via existing commercial means

3.2.1 Products

Affordability and availability are the two key considerations to ensure the supply of household water treatment and safe storage products. Safe water storage containers are critical products that also need to be supplied to households.

HWTS options can be divided into consumable and durable products, each requiring different implementation strategies to make them affordable and available.

Consumable products, such as alum or chlorine, need to be replenished on a regular and continuing basis (e.g. weekly or monthly). As such, they have recurrent costs, but generally no capital costs.

Durable products are an occasional or one-time purchase (e.g. ceramic filter elements need to be replaced every 1-2 years, biosand filters can potentially last a lifetime). They have a relatively higher capital cost than consumable products, butminimal recurrent costs.

Table 3.2.1 Comparison of Consumable and Durable HWTS Products

Consumable Products	Durable Products
• Need to be constantly replenished • Has little to no capital costs, however has regular, recurrent costs • Should be self-sustaining without subsidies • Implementation is similar to commercial products • Lends to private sector implementation	• One-time or infrequent purchase • Has relatively high capital costs, but minimal recurrent costs • Initial capital costs may be subsidized • Implementation is similar to community development or infrastructure programs • Lends to NGO and government implementation

3.2.1.1 Affordability

Many programs target poor populations because they often derive the most benefit from HWTS. Consequently, both the initial capital cost and the on-going recurrent costs need to be affordable to the poor, especially those who live on US$1-2 a day.

It is generally agreed and widely accepted that for programs to be sustainable, recurrent costs should be affordable and not subsidized. Households need to be able to afford the full cost of purchasing consumable products on a continuous and long-term basis. In the case of durable products, people should be able to pay for the minimal recurrent costs associated with replacement parts and the on-going operation and maintenance.

Subsidies for the capital cost of durable products may be required to make it affordable to the poor. The high up-front purchase cost of durable products, like a biosand filter, often makes it impossible for the poorest of households to afford. Similar to other infrastructure projects, some form of cost sharing is usually required.

The majority of implementers recommend that households should contribute to the initial purchase of durable products in some way. Experience has shown that people place more value on their HWTS product and use it over the long term when they have invested at some level. Free distribution is not recommended.

Several different types of schemes have emerged to enable the poor to contribute to the capital costs. Householders often contribute in kind, by providing voluntary labour for construction or transport, or by providing local materials. Household may also be offered the option of paying smaller amounts in installments, rather than having to pay the full cost all at once.

Microfinance institutions can also have a useful role in financing the capital cost of durable HWTS products. Pilot microfinance projects in India have reported nearly 100 percent repayment on loans by lower income populations for purchase of filters that are usually only affordable to middle-income households. Safe water saves money from reduced illness and increased productivity, making it easier to repay loans over time. Even with this success, current access to small loans for non-income generating products (such as HWTS) is limited. It will be important for implementers who wish to use microfinancing to educate these institutions on the benefits of HWTS (IFC, 2009).

Household Investment in HWTS – Biosand Filters, Cambodia

Biosand filters are subsidized by Clear in Cambodia to support those who are unable to purchase them at full cost. Households pay a nominal amount and contribute labour to help construct and transport their filters home. As such, people have made a personal investment and Clear has experienced a high adoption rate with over 67,000 biosand filters implemented in the country.

(Heng, K. Personal communication, July 2010.)

3.2.1.2 Availability

A supply chain is needed to ensure that HWTS products are available to respond to the demand. As part of the supply chain, implementers need to consider how the product is going to be manufactured, packaged, distributed and priced (cost recovery and financing is discussed further in Section 4). The complexity of the supply chain depends on many factors, including:

- Type of HWTS product (i.e. durable or consumable)
- Availability of local materials and labour
- Strength of the private sector
- Transportation
- Shelf life
- Quality assurance
- Scale and capacity of the program

Consumable products require an uninterrupted and long-term supply chain. Product shelf life and quality assurance are critical factors to consider when manufacturing and distributing consumable products. For example, consumable products which have a short shelf life, like chlorine solution, are best made by local manufacturers and distributed through small networks. Whereas, products with a long shelf life, such as Aquatabs® or Pur®, lend themselves to international manufacturing and global distribution.

Durable HWTS products are usually more appropriate for local manufacture. Both biosand filters and ceramic filters can be built using locally available materials. They have established production processes which allow them to be built to consistent standards in diverse communities with lower costs than importing them. Also, these products are difficult to transport over long distances, due to the weight or fragility, so it is better to manufacture them as close to the end users as possible.

A variety of roles are needed to implement a supply chain. Manufacturing and distribution may be carried out within one organization or across multiple organizations. The implementing organization first needs to decide which parts of the supply chain they are going to manage themselves and which can be handled by another organization or the private sector. We will consider manufacturing and distribution separately in the following sections.

(a) Manufacturing

Implementers who do the manufacturing and distribution themselves have more control over the product's quality as they control the entire process from beginning to the introduction to the household. It may however require them to have special skills and training, and an increased financial and human resource base.

Implementers who do their own manufacturing need to decide if they want to have centralized or decentralized production. For example, RDI in Cambodia and FilterPure in Haiti use a centralized factory to construct ceramic filters and then distributes them across the country. Alternatively, Clear Cambodia uses a decentralized model to build biosand filters. They have travelling teams that transport the filter molds and tools to a temporary work site in the village. The team spends several weeks there until the demand has been satisfied before moving onto the next village.

If the implementer decides to purchase HWTS products from another organization or the private sector, then the decision is one of whether to use local or imported products from national or international companies. While there are successful stories of large scale, imported supply, many organizations rely on a local supply of HWTS products.

Supply chains which use locally available resources, supply routes, fabrication and people (for labour, education and follow up) are often used since they can:

- Build local knowledge and skills which empowers beneficiaries to meet their own needs

- Create jobs and support the local economy

- Allow for more gradual scale up, since implementation can be limited to a predefined area

- Reach areas which are difficult to access via existing commercial means

Leveraging the resources of the local entrepreneurs or other organizations has many benefits. However, some implementers have found that working with local entrepreneurs was difficult and time consuming in the early stages of implementation. But in the end they report that it is essential for program sustainability and cost-effectiveness.

Reputable regional and international manufacturers, such as Medentech, Proctor & Gamble and Hindustan Unilever Limited, have the advantage of high quality control standards and product manufacturing consistency. However, HWTS products that depend on international supply chains may be subject to importation taxes and storage and handling fees, potentially resulting in delays and expenses.

Even with outsourcing to the private sector, experience has shown that implementers may still need to be involved in the product development, sourcing of raw material suppliers, product registration, product testing, and ensuring quality control (POUZN Project, 2007; Ngai, 2010).

(b) Distribution

There are also many strategies used by implementing organizations for distributing HWTS products. Depending on the strength of the private sector, some implementers choose to distribute their product through traditional commercial outlets, such as retail shops and pharmacies. Others also use non-traditional outlets to sell HWTS products, such as through community volunteers and mobile sales teams. In some programs, households must purchase their HWTS product directly from the factory or implementing organization.

Partnerships in Manufacturing and Distribution – Chlorine, AmanTitra, Indonesia

AmanTirta, Safe Water Systems (SWS), a five-year project funded by USAID, aimed to ensure widespread access in Indonesia to an affordable chlorine solution (Air RahMat) for low income families with children less than five years old. Led by Johns Hopkins University, in partnership with the Ministry of Health, CARE International Indonesia, PT Tanshia Consumer Products and Ultra Salur, the project used a public-private partnership (PPP) model to create the first fully sustainable commercial model for SWS.

The PPP combined commercial manufacturing and distribution of Air RahMat by PT Tanshia, with community participation and media promotion to create demand. The project negotiated and supported extensive distribution of Air Rahmat through traditional channels (e.g. stores and kiosks), as well as non-traditional retail outlets (e.g. community based organizations, microcredit organizations, community volunteers).

(Johns Hopkins University, 2009)

3.2.2 Services

Implementers need to set up a system to support households with the proper and consistent use of HWTS over the long term. Households need a contact point for follow up service, purchase of replacement parts, and queries.

> *"Ceramic water filters are not a passive resource; they require ongoing management and maintenance by users. Therefore, like computers, after sales support is essential for on-going and appropriate use of ceramic water filters."*
>
> (Hagan et al, 2009)

Organizations need to identify the level of service required and how it will be financed as part of the program to ensure that it is actually done. Delivering long-term services, even after the implementation program may have ended, generally involves using community health promoters, local institutions (e.g. health clinics) and government agencies.

For consumable products that are sold commercially, the private sector has incentive to provide follow-up support to households, ensuring that they are satisfied and will purchase the product again. However, businesses which sell durable products that are a one-time purchase and much less likely to be replaced, have little incentive to provide support to households since it will cut into their profit margins.

3.3 Monitoring and Continuous Improvement

Monitoring is essential for on-going improvement of implementation programs. It helps to create a feedback loop within a program. It is particularly important for making improvements to the program as well as measuring the impact and success of a program, especially if an organization wants to scale up their activities.

The key to successful monitoring is to keep it simple and within the means of the organization. The tendency for many implementers is to collect too much data which is overwhelming and often not of practical use. It is ideal to use a small set of indicators that can be collected without becoming an additional burden to the program.

The extent of monitoring will vary depending on the implementer's capacity and nature of their activities. There is no specific formula for implementers to follow, however programs often monitor the following elements:

- Management

- Product quality

- Distribution systems

- Household education

- Performance and use of the HWTS option

- Impact

Good monitoring systems share the following characteristics:

- Has a clearly defined purpose

- Collects specific information on a small but well-defined set of indicators

- Fully integrated into the program activities

- Simple and within the means of the organization

- Analyzed on a regular schedule to determine lessons learned

- Focused on factors within complete control of the program

- Results in program modifications and improvements, based on lessons learnt and information collected

3.3.1 What Should be Monitored

There are two broad categories of monitoring that can be used during implementation: process monitoring and impact monitoring.

Process monitoring looks at the processes that contribute to the functioning of the program. This includes production, quality control, distribution systems, financial control, use of materials, and program management. Process monitoring helps implementers to answer the question "Are we doing things right?" Depending on the implementation approach, there are many different process indicators that could be used to monitor the program. A few indicators to consider include:

- Number of products manufactured

- Number of products distributed

- Cost per product

- Number of people trained (e.g. promoters, technicians, staff)

- Number of education material distributed

- Number of household visits conducted

Impact monitoring looks at the impact the program has on the target population and can look at the following: number of people with improved water as a result of HWTS implementation; proper and consistent use of HWTS; effectiveness of HWTS; adequacy of promotion and education efforts; and usefulness of training and education material. Impact monitoring helps implementers to answer the question "Are we doing the right things?" A few impact indicators to consider include:

- Percentage of products meeting basic operating parameters

- Percentage of products still in use after a given time period

- Percentage of products being used correctly after a given time period

- User perception of the product's benefits and limitations

- Number of people with access to safe water

- Number of people experiencing health benefits, such as reduced diarrhea

3.3.2 Who Should be Involved

Process monitoring is usually internal to an organization and carried out by staff through record keeping, spot checks and regular reviews and appraisals.

Impact monitoring is usually initially done by the implementer and then should be transitioned to an activity done by the local community to ensure that it continues beyond the length of the program. Community health promoters are an excellent mechanism to monitor behaviour change and encourage proper and consistent use of HWTS. In most instances, local government is also better placed than implementers to ensure long-term monitoring and support.

In addition, project evaluations are a form of impact monitoring, and normally include a review of the process monitoring to ensure that it is sufficient and being done correctly and consistently. These are often done by people who are not involved in the process monitoring to reduce the potential for overlooking problems.

Project evaluations are also a form of impact assessment. Evaluations normally include a review of the process and impact monitoring indicators as well as a more in depth look into the long term impact of the program. This is to ensure that the program is being done correctly and consistently. Evaluations are often done by people who are not involved in monitoring to reduce the potential for overlooking problems.

3.4 Human Capacities Required for Implementation

Developing individual people's knowledge and skills is part of building the overall organizational capacity required for implementation. A capacity building process with competency validation can be used to increase both individual and organizational capacity. The ultimate objective of HWTS programs should be to build the capability of local populations to meet their own needs.

A variety of roles are needed to implement HWTS programs. The following roles may be carried out within one organization, or more commonly across multiple organizations:

- **Program Implementers:** Individual or organization who plans and implements a HWTS program.

- **Community Health Promoters:** Raise awareness and educate households about the need for safe water and HWTS solutions.

- **Product Manufacturers:** Construct and distribute the HWTS product.

- **Trainers:** Provide training and consulting to support implementers.

- **Other Stakeholders:** Donors, government, universities and education institutions

Figure 3.4: Roles Required for HWTS Program Implementation
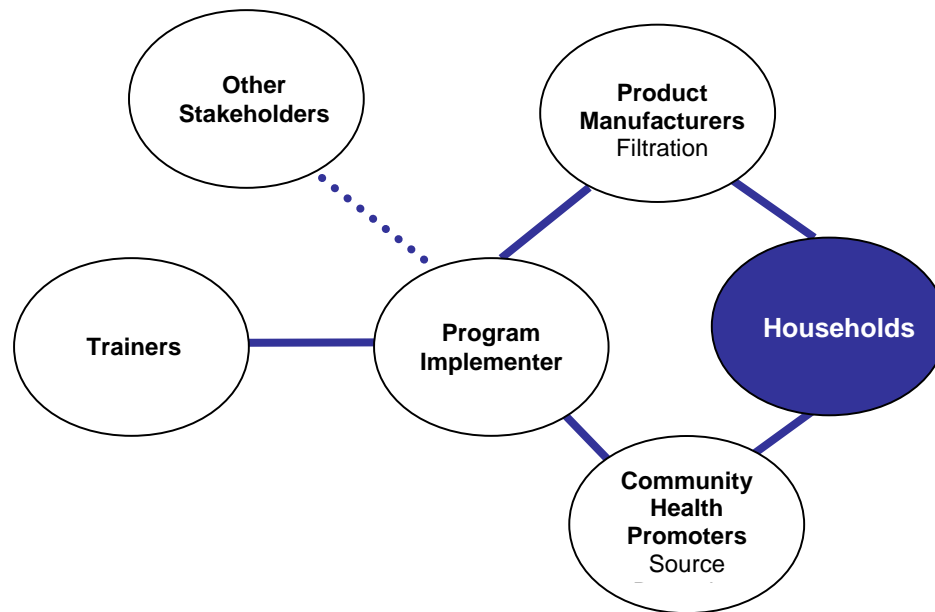
Smooth transfer of knowledge from one role to another is vital and occurs best when:

- All stakeholders contribute to defining the program goals and objectives
- All stakeholders agree on and understand their roles and responsibilities
- The needs of each stakeholder are understood by others (e.g. information, resources and support)
- Communication channels remain continually open
- Formal and informal systems and tools are in place to aid knowledge transfer
- Communication and knowledge transfer occurs in both directions
- Plans and tools are available for building competency and capacity

3.4.1 Program Implementers

There is no standard type of program implementer. A review of HWTS programs globally highlights the diversity of implementers, profiled in the following table. However, successful implementers do share common characteristics such as excellent planning, management, organizational and communication skills.

Table 3.4.1: Characteristics of Implementing Organizations

Type of Organization	Characteristics
Indigenous NGOs	• Initiated and managed in-country by local people • Have strong relationships with the target population • Builds local ownership and capacity to solve own problems • Often have simpler processes to implement projects • Can react quickly to lessons learned and make changes • May need external support with technical expertise and institutional capacity building • May depend on external funding support
International and Multinational NGOs	• From developed countries who initiate programs, often in partnership with an in-country organization • Range from small international to large, multinational organizations • Often have good access to funding • Have enormous technical expertise and often well connected to the latest research • Knowledge and capacity often remains with foreign experts, needs to be transferred to the local community • Much of the experiences and lessons learned may be lost once the program is completed
UN agencies	• UNICEF is the main agency implementing programs and supporting governments with HWTS in various countries • WHO and UNHABITAT are promoting HWTS with governments and supporting training • Often have good access to funding • Have enormous technical expertise and often well connected to the latest research • Bureaucracy may limit implementation and delay planned activities
Government	• May be local, regional or national levels responsible for health, rural development, water or environment • Lends political will to change • Gives credibility to HWTS and leads to higher acceptance by households • Can support implementation by incorporating HWTS in public health and education programs, may also be a source of funding • Bureaucracy may limit formal cooperation with other organizations and delay implementation of planned activities

Type of Organization	Characteristics
Private sector	• May be local entrepreneurs or national and international companies • Has the expertise, incentive and resources to manufacture, distribute and promote HWTS products • In many cases, able to provide long-term financial and institutional sustainability to HWTS programs • Market-driven, full cost-recovery models used by private sector are not likely to reach the poorest of the poor

3.4.2 Community Health Promoters

Community health promoters are essential for the successful implementation of any HWTS program. Their main role is to facilitate the learning process and help others improve their water, hygiene and sanitation practices through community activities and household visits.

Community health promoters usually report to the implementer. They can either be paid or act as volunteers, and may spend their whole day or only a few hours a week on the job. Depending on the organization, there may be additional responsibilities that are assigned, such as performing monitoring activities.

Almost anyone with the following capacities can become a community health promoter:

• Is trusted and respected by the community

• Speaks the local language

• Understands the local culture

• Communicates effectively and listens to others

• Demonstrates good water, hygiene and sanitation practices within their household

• Is committed to addressing water, hygiene and sanitation needs in their community

Community health promoters don't necessarily have to be experts in water, hygiene and sanitation. This is knowledge that they can learn through training. It is more important for them to have the capacity to learn new skills and communicate.

3.4.3 Trainers

Training and consulting support is often required to build human capacity for the different implementation roles. On-the-ground assistance can be a significant factor that contributes to successful programs. For many people, training helps build their knowledge and skills, and gain confidence, to meet the numerous challenges which must be overcome on a regular basis.

"*Interaction with high level experts from different organizations can be difficult as we feel we are lacking in knowledge and expertise to be able to talk at the same level, despite the fact that we have constructed and installed many filters which are operating properly and supplying people with safe water. We need additional professional training and support,*" reports Koshish, a biosand filter implementer in Pakistan.

(Dow Baker et al., 2008)

Any training needs to be practical and help address the real challenges that implementers face. Often implementers focus on technology training and on theory, which is usually not enough. Depending on their human capacity, organizations shouldalso learn how to plan, implement and monitor their programs.

External training organizations can provide professional training, consulting services, and networking to implementers through highly skilled advisors and volunteers. Experienced in-country organizations can also act as local trainers and are capable of training other community organizations in the various roles required to implement HWTS programs.

Technical Training and Education Organizations

CAWST, the Centre for Affordable Water and Sanitation Technology, based in Canada, provides technical training and consulting services on HWTS to implementing organizations around the world. CAWST starts with education and training to build local capacity. They deliver training that is customized for the different implementation roles. After training, CAWST provides on-going support to help organizations with program development, overcome barriers to implementation, and make connections with other implementers.

The Swiss Federal Institute of Aquatic Science and Technology (Eawag), based in Switzerland, provides technical assistance, support and education programs to NGOs and governments in developing countries. They focus on the worldwide promotion and implementation of SODIS programs.

3.4.4 Other Stakeholders

It is important for implementers to work with and create effective relationships with other stakeholders. There are different types of stakeholders that play a role at various times, including donors, government, universities and education institutes.

- **Donors**include local and international individuals, community organizations, foundations, and government agencies. Implementing organizations need long-term, consistent funding to ensure that their activities can be executed without disruption. Implementers have a role to play in educating donors who may not be familiar with HWTS and implementation best practices. It is helpful for donors to understand why and what they are funding when they are reviewing and approving proposals, providing advice, and conducting program evaluations.

- **Governments**have the mandate for providing safe water and can benefit from HWTS implementation programs. Some governments have drafted national HWTS guidelines. Support and endorsement from the government gives credibility to HWTS and implementers. Governments may be a source of funding and can provide in-kind resources to support implementers, such as workspace or transportation.

- **Universities and education institutes** provideresearch which can build the case for HWTS as an intervention worthy of support by policy makers and donors (Clasen, 2009). Universities and other institutes can conduct research on technology development and program implementation. Universities can also help implementers conduct program evaluations.

3.4.5 Use a Capacity Building and Competency Validation Process

A **competency** is a knowledge, skill or attitude that is a standardized requirement for somebody to properly perform a specific job or role. A list of competencies can be created by implementers for each role within their organization, such as trainer, product manufacturer or community health promoter.

Validation is the process of checking people's knowledge, skills and attitudes to confirm that they are competent in their role. Validators can be from within the implementing organization or from external training organizations.
Implementers may use a capacity building and competency validation process for several reasons:

- Provides an opportunity and framework by which individuals and organizations can improve their knowledge, skills and attitude with respect to a specific process or task

- Brings credibility to the organization by giving justifiable confidence in their capacity to provide high quality products and service

- Allows the implementer to pursue opportunities for financing or funding since they can demonstrate the quality of their products and services

- Distinguishes those who are trained to provide a good quality product and service from those who do not

Implementers need to ensure that time and resources are available to support individuals in improving existing capacities and developing new ones. A needs assessment can be conducted to help organizations identify gaps in people's competencies and create a plan to address the gaps and build their capacity. The length of time required for the capacity building and competency validation process is individual specific and depends on the baseline of the individual's knowledge and skills.

There is no standard way to build capacity. Often people participate in trainings, and later by apprenticing with qualified staff or external experts to gradually take on more responsibility as they build their confidence, knowledge and skills. Building capacity and competencies takes more than just a one-time training event. It is important to provide on-going coaching and mentoring to provide feedback and support as people develop and practice their new skills.

Example Competencies for Community Health Promoters

A Community Health Promoter should be able to:

- Describe their role as a Community Health Promoter

- Identify local water and sanitation issues in the community

- Describe water-related disease transmission routes

- Describe the multi-barrier approach to safe water

- Demonstrate active listening and effective questioning skills

- Demonstrate how to facilitate participatory learning activities

- Demonstrate how to properly use and maintain various HWTS options

- Demonstrate how to effectively conduct a household visit

3.5 Program Financing

Implementers need consistent and long-term funding to ensure that all of their program activities are executed without disruption. Adequate financing is essential to ensure that implementation efforts are sustained and that they can be scaled up. Given the numbers of independent organizations operating at different levels, the success of scaling up HWTS will rely on providing varying amounts of funding to numerous implementers, including the often neglected smaller organizations.

The costs of implementation are highly program specific. At a minimum, the following costs should be considered:

- Program planning and administration

- Promotion and education activities

- Product manufacturing and distribution

- Monitoring for improvement
- Evaluation

Implementers often need a combination of funding sources to cover their expenses. It is important to figure out who is financially responsible for each cost, and over what time period. Financing also depends on the organization's legal structure (e.g. for profit, NGO status) and its implementation strategy (e.g. subsidized products, retail sales). Potential funding sources may include:

- Local and international donors

- Implementing organization

- Earned revenue from households

- Government partnerships

The key for implementers to obtain funding is to know who to ask for support, to clearly state the reasons why this financial support is needed, and to explain how it will lead to more effective HWTS programs. Typically, funding begins with small costs to start a demonstration project, with larger amounts made available based on the results and plans.

While there are no fixed models for financing there are several lessons that have been learned through HWT implementation, including:

- Raising awareness, education and capacity building for HWTS are almost always a public sector activity, and are highly subsidized

- Users need to pay for their own long term operation and maintenance whereas initial capital costs can (and in some cases should) be subsidized

- Durable products often need to be subsidized to enable access by the poorest

- Households need to invest in HWTS at some level, whether in kind or small financial contributions

These lessons will be discussed further in the following sections.

3.5.1 Program Planning and Administration

Program planning and administration need adequate attention and funding to increase the chance of implementation success. Those who fail to plan, plan to fail.

Many implementers underestimate the time and financial resources required to make comprehensive plans, and thus fail to seek or allocate sufficient resources to planning activities. As a consequence, many essential elements of planning are bypassed, and the overall program design becomes fragmented. The different components (e.g. creating demand, supplying products and services, and monitoring) are not thoroughly considered, and coordination and communications with stakeholders are weak. The end results are often ineffective or unsuccessful HWTS implementation.

Funding for program planning and administration is commonly provided by donors or from within the implementing organization. The level of funding is dependent on many factors, such as the organization's internal financial and institutional capacity, the knowledge and commitment to HWTS among donors, and the perceived reputation of the implementing organization.

3.5.2 Promotion and Education Activities

In many cases, implementers have found the cost of promotion and education activities (i.e. software) to be far greater than the cost of manufacturing the HWTS product (i.e. hardware).

As discussed previously, creating demand through behaviour change is a long and demanding process. To create real and lasting change in the perception and practice of HWTS, it is important to have a long-term investment of human and financial resources required for promotion and then followed up with education.

Raising awareness, education and capacity building for HWTS are almost always a public sector activity, and highly subsidized. These expenses are often covered through donor funding and government partnerships to generate widespread acceptance and adoption of HWTS. For example, the social marketing strategy used by PSI is designed to recover the cost of product manufacture and distribution, but not the promotion costs which are covered by donor funding from USAID.

3.5.3 Product Manufacturing and Distribution

For most of the HWTS options, there are capital and recurrent costs associated with manufacturing, distribution, operation, and maintenance. Consumable products need to be replenished on a regular basis and therefore have on-going recurrent costs; they generally have no capital costs. Durable products havecapital costs and minimal recurrent costs.

The relationship between what the households are expected to pay and the actual production and distribution costs can be divided into the following four categories:

- **Fully subsidized as a public good:** Households receive the HWTS product without paying any money.

- **Subsidized with partial cost recovery:** Households pay for a portion of the HWTS product cost.

- **Full cost recovery:** Households pay for the full cost of the HWTS product.

- **Full cost recovery with profit:** Households pay for the full cost of the HWTS product plus an additional cost allowing it to be sold on a commercial basis.

It is generally agreed and widely accepted that for programs to be sustainable, households should pay the full cost of consumable products and recurrent costs.

However, some form of cost sharing is usually required to make the capital cost of durable products accessible to the poor. Durable products are often partially subsidized so that households contribute a small portion of the product cost, whether it is monetary or in-kind. It is important to consider both the ability and the willingness of the households to pay. Implementers have also set different prices for the technology depending on the wealth of the household in the community. This way, richer households pay more and cross-subsidize the costs for poorer families. Research has shown that the poor will pay, but payment needs to be flexible to their situation.

Implementers must engage donors to provide the necessary funding to cover the product subsidies given to households.

Moving from Subsidies to Full Cost Recovery – Ceramic Filters, Cambodia

International Development Enterprises Cambodia (IDE) and Resource Development International-Cambodia (RDI) have been manufacturing and distributing ceramic pot filters in Cambodia since 2001 and 2003, respectively. Their production is evolving from subsidized NGO-based implementation to market-based, full cost recovery programs. The ceramic filters are accessible to all but the very poorest households.

IDE has four regional distributors covering 131 retailers in 19 provinces, operating on a full cost recovery basis. They ended subsidized distribution of filters in 2005. IDE sells about 22,000 filters each year at full cost (US$7.50-US$9.50) – about half to NGO partners and the other half through retailers.

RDI is able to sell about 23,000 filters a year at full cost (US$8.00) through direct sales to users, local contract vendors, and sales to NGOs and government agencies. A relatively small number of filters are also distributed at subsidized cost to villages in an NGO-led program. The subsidies are targeted to the poorest households, as determined by a means assessment, and the costs vary from US$1 -7.

(Brown et al., 2007)

3.5.4 Monitoring and Evaluation

Monitoring and follow up visits are essential to support people as they learn to incorporate HWTS into their daily routines. This helps to ensure its proper and consistent use over the long-term.

The cost of monitoring and follow up is not limited to household visits. Other expenses such as water quality testing, technical troubleshooting, reinforcement education and training, as well as program evaluation are important and should be considered as well.

There are a range of options to fund monitoring and evaluation activities. In some cases, donors support monitoring during the program period and an evaluation at the end of the fuding period, after which the funding must come from other sources. Local government institutions and/or community health promoters are often encouraged to conduct monitoring and follow up well beyond the program period so the costs are essentially shifted over to their agencies or organizations. In other cases, the cost of monitoring and follow up is incorporated into the overall product cost to be recovered at the time of sale. Occasionally, some implementers may charge a service fee to households for monitoring, troubleshooting, and technical repair services.

3.6 Implementation Case Studies

A review of HWTS programs highlights the diversity of implementers and the wide range of strategies they use to create their own unique approaches to implementation.

Even within the same country, there is an assortment of implementers, situational contexts, and strategies. This level of complexity makes it difficult to simplify implementation into typical approaches. However, social and commercial marketing are two approaches which are emerging and being used by a variety of implementers.

Implementation case studies are provided in **Appendix D** to illustrate the variety of approaches that are used by different types of organizations. In particular, the case studies highlight the strategies used by the implementer to address the following:

- Creating demand for HWTS

- Supplying HWTS products and services

- Monitoring and continuous improvement

- Building human capacity

- Program financing

3.7 Summary of Key Messages

- There is no standard approach for getting HWTS into people's homes. There are a variety of organizations implementing different HWTS options in different ways. This level of complexity makes it difficult to simplify implementation into typical approaches.

- Implementers should address three key components to make them more likely to succeed:

  1. Creating demand for HWTS

  2. Supplying the required HWTS products and services to meet the demand

  3. Monitoring and continuous improvement of program implementation

- The organization's ability to plan and implement the key components is determined by their human capacity (people) and financing (money).

- Awareness and education are needed to create demand and convince households of the need and benefits of HWTS. The following steps can be used to create demand:

  1. Identify an appropriate target population.

  2. Select appropriate and feasible HWTS options.

  3. Increase awareness of HWTS as a solution for getting safe water, and educate people on the relationship between water and health.

  4. Use demonstration projects to convince people of the benefits of HWTS.

  5. Engage government agencies to give credibility to HWTS.

  6. Provide positive reinforcement to households so they continue using HWTS.

- Households need both the product and support services to ensure the proper and consistent use of HWTS over the long term.

- HWTS options can be divided into consumable and durable products. Consumable products require an uninterrupted and long-term supply chain, and their recurrent costs should not be subsidized. For durable products, the capital cost may require partial subsidies to make it affordable.

- The key to successful monitoring is to keep it simple and within the means of the organization.

- Developing individual people's knowledge and skills is part of building the overall organizational capacity required for implementation. A competency building and validation process can be used to increase both individual and organizational capacity.

- A variety of roles are needed to implement HWTS programs, including Program Implementers, Community Health Promoters, Trainers and other Stakeholders.

- Implementers need consistent and long-term funding to ensure their program activities are executed without disruption. Costs are highly program specific and implementers often need a combination of funding sources to cover their expenses.

4 Additional Resources

Akvopedia
www.akvo.org/wiki/index.php/Main_Page

Akvopedia is an open water and sanitation resource that anyone can edit. The goal of Akvopedia is to improve water and sanitation projects through knowledge exchange on smart and affordable technical solutions and effective approaches. The Water Portal contains explanations on various household water treatment technologies.

Centers for Disease Control and Prevention (CDC)
Website: www.cdc.gov/safewater

CDC promotes the Safe Water System (SWS) – a water quality intervention that employs simple, robust, and inexpensive technologies appropriate for the developing world. The objective is to make water safe through disinfection and safe storage at the point of use. CDC provides various publications including the Safe Water System Handbook and fact sheets on their programs and various household water treatment options.

CAWST, the Centre for Affordable Water and Sanitation Technology
Website: www.cawst.org

CAWST is a Canadian non-profit organization focused on the principle that clean water changes lives. CAWST believes that the place to start is to teach people the knowledge and skills they need to have safe water in their homes. CAWST transfers knowledge and skills to organizations and individuals in developing countries through education, training and consulting services. One of CAWST's core strategies is to make water knowledge common knowledge. This is achieved, in part, by developing and freely distributing education materials with intent of increasing its availability to those who need it the most. CAWST provides free open content training manuals, posters, learning activities, and HWTS fact sheets. These materials are provided to workshop participants, interested organizations upon request, and are available online.

International Network to Promote HWTS
Website: www.who.int/household_water/network/en/index.html

The Network was set up to accelerate health gains to those without reliable access to safe drinking water. It was established by the World Health Organization and is aimed at promoting HWTS. The network format optimizes flexibility, participation and creativity to support coordinated action. Membership in the Network is open to all interested stakeholders that agree with the Network mission and guiding principles and who are willing to commit themselves to working toward achieving the objectives of the Network. The World Health Organization provides the Secretariat for the Network.

International Water and Sanitation Centre (IRC)
Website: www.irc.nl

IRC bridges the knowledge gap and joint learning with partners for improved, low-cost water supply, sanitation and hygiene in developing countries. IRC offers public access to a bank of information and interactive tools. In addition to more than 100 documents on water and sanitation, they provide the Source Water and Sanitation News Service, the Source Bulletin, a digital library, InterWater Thesaurus, and a question and answer service.

Johns Hopkins Bloomberg School of Public Health, Center for Communication Programs
Website: www.jhuccp.org/

CCP advances the science and art of strategic communication to improve health and save lives. They are a recognized leader in the field of health communication, with extensive technical expertise and program experience in social and behaviour change communication. Researchers have published documents on social, cultural and behavioral correlates on household water treatment.

London School of Hygiene and Tropical Medicine (LSHTM)
Website: www.lshtm.ac.uk

The LSHTM's mission is to contribute to the improvement of health worldwide through the pursuit of excellence in research, postgraduate teaching and advanced training in national and international public health and tropical medicine, and through informing policy and practice in these areas. LSHTM conducts extensive academic research on household water treatment and safe storage in developing countries.

Massachusetts Institute of Technology (MIT)
Website: http://web.mit.edu/watsan/tech_hwts.html

This MIT website offers information on HWTS and technologies, global water mapping, International HWTS Network, methods for water quality field testing, and open content courses on Water and Sanitation Infrastructure in Developing Countries.

Oxfam
Website: www.oxfam.org.uk/resources/learning/humanitarian/watsan.html

Oxfam is a humanitarian organization that acts as a catalyst for overcoming poverty. To achieve the greatest impact, they work on three fronts: saving lives by responding swiftly to provide aid, support and protection during emergencies; developing programs and solutions that empower people to work their way out of poverty; and campaigning to achieve lasting change. Oxfam has developed emergency manuals and guidelines, as well as technical briefing notes on public health engineering topics, including household water treatment and storage.

Swiss Agency for Development and Cooperation (SDC)
Website: www.poverty.ch/safe-water.html

SDC's 2008 document "Marketing Safe Water Systems" provides unique insights – from the varied perspectives of users, disseminators, producers and retailers – into the marketing challenges of point-of-use treatment devices. It discusses the 5 Ps of marketing: Product, Price, Place, Promotion and People. As well, the document puts forward a mix of marketing and social marketing strategies which can raise the dissemination of household water treatment systems to the levels required for achieving the Millennium Development Goals.

United Nations Children's Fund (UNICEF)
Website: www.unicef.org/wes/
         www.unicef.org/wes/files/Scaling_up_HWTS_Jan_25th_with_comments.pdf

UNICEF works in more than 90 countries around the world to improve water supplies and sanitation facilities in schools and communities, and to promote safe hygiene practices. In emergencies, UNICEF provides urgent relief to communities and nations threatened by disrupted water supplies and disease. Their 2008 publication "Promotion of Household Water Treatment and Safe Storage in UNICEF WASH Programmes" summarizes some of the leading approaches for treating water in the home, provides evidence of their effectiveness and cost effectiveness in development and emergency settings and it outlines how the promotion of HWTS can be incorporated with UNICEF programs.

United States Agency for International Development (USAID)
Website: www.ehproject.org/

The Hygiene Improvement Project (HIP) was a 6-year USAID-funded program (2004-2010) that sought to reduce diarrheal diseases and improve child survival through the promotion of three key hygiene practices: hand washing with soap, safe feces disposal, and safe storage and treatment of household drinking water. The website remains available to share the resources developed by HIP, but will no longer be updated.

United States Agency for International Development (USAID)
Website: www.ehproject.org

USAID is the largest bi-lateral donor supporting HWTS. On their website, they have resources and materials developed by their implementers, as well as a comprehensive bibliography on point of use water disinfection at: www.ehproject.org/ehkm/pou_bib2.html. There is also a link to a Google group on household water treatment.

Water and Sanitation Program (WSP)
Website: www.wsp.org

WSP is a multi-donor partnership administered by the World Bank. The goal is to help the poor gain sustained access to improved water supply and sanitation services (WSS). WSP works directly with client governments at the local and national level in 25 countries through regional offices in Africa, East and South Asia, Latin America and the Caribbean, and in, Washington D.C. WSP focuses on five topics: Financing the Sector, Rural Water Supply and Sanitation, Strategic Communications, Sanitation and Hygiene, Urban Water Supply and Sanitation. WSP offers the Access Newsletter and news updates to subscribers.

World Health Organization (WHO)
Website: www.who.int/household_water/en/

WHO works on aspects of water, sanitation and hygiene where the health burden is high, where interventions could make a major difference and where the present state of knowledge is poor. WHO has produced several documents related to HWTS that are available online. As well, the WHO manages a water, sanitation and health listserve to subscribers.

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