Status of Household Water Treatment and Safe Storage in 45 Countries and a Case Study in Northern India

By

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ABSTRACT

This thesis examines the present of the status of household drinking water treatment and safe storage (HWTS) technologies across the world, and in one location Lucknow, India. The data for the global status of HWTS was collected by contacting the Water, Sanitation and Hygiene (WASH) groups of 45 UNICEF country offices. The second aspect of this thesis analyzes the user perceptions and behaviors relative to HWTS and quality of water at the point of consumption, post HWTS treatment in the field. This was executed by conducting 240 sanitary surveys and 276 water quality tests in Lucknow, India.

The results of the study reveal that there is a lack of technical expertise in understanding and implementing these systems in the 45 UNICEF countries contacted and in the author's field site in Lucknow, India. Moreover, it was observed in India that safe storage was not being promoted properly by the NGO with which the author worked.

It was also observed that HWTS technologies are still relatively expensive because of which they are beyond the reach of the poor. Moreover, lack of education among the masses makes scale-up more challenging.

However, going by the interest shown by both the UNICEF country offices and the survey respondents in Lucknow, it is only a matter of time and concerted effort, before we start to see substantial scale-up of HWTS.

Keywords: Status, Scale-up, HWTS, UNICEF, Lucknow

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LIST OF ABBREVIATIONS

ACF	Action contre la Faim
ACTED	Agency for Technical Cooperation and Development
ADPP	Ajuda de Desenvolvimento de Povo para Povo
ADRA	Adventist Development and Relief Agency
AED	Academy for Educational Development
AEMO	Association de l'éducation En Milieu Ouvert
AGWP	Aqua Guard Water Purification
AWD	Accute Watery Diarrhoea
AWP	Annual Works Plan
BCC	Behavior Change Communication
BCIG	5-bromo-4-chloro-3 indolyl-beta D Glucuronide
CAMEP	Centrale Autonome Métropolitaine d'Eau Potable
CBO	Community Based Organization
CDA	Community Development Association
CDC	Center for Disease Control and Prevention
CERD	Center for Educational Research+ Development
CESVI	Cooperazione e Sviluppo
CFU	Coliform Forming Units
CLD	Comités locaux de Développement
COFORWA	Compagnons Fontaniers du Rwanda
COUHES	Committee on the Use of Humans as Experimental Subjects
CREPA	Centre Régional pour l'Eau Potable et l'Assainissement à faible coût
CS	Colloidal Silver
CWF	Ceramic Water Filter
DEIS	Direction Epidemoilogie et de l'information Sanitaire
DST	Defined Substrate Technology
ENPHO	Environment and Public Health Organization
GRET	Groupe de Recherche et d'Echanges Technologiques
GUMCO	Golden Utility Management Company
HVs	Health Volunteers
HWT	Household Water Treatment
HWTS	Household Water Treatment and Safe Storage
IDE	International Development Enterprise
IDP	Internally Displaced Person
IEC	Information Education and Communication
IFRC	International Federation of Red Cross and Red Crescent Societies

IMC	International Medical Corps
INE	Instituto Nacional de Estadísticas
INFOM	Instituto de Fomento Municipal
IRC	International Rescue Committee
IRD	International Relief and Development
JICA	Japan International Cooperation Agency
JMP	Joint Monitoring Programme
KAP	Knowledge Attitude and Practice
KWAHO	Kenya Water for Health Organization
LED	Light-Emitting Diode
MAP	Medical Assistance Programs
MARD	Ministry of Agriculture and Rural Development
MDG	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
MININFRA	Ministry of Infrastucture Rwanda
MLD	Million Liters a Day
MOH	Ministry of Health
MPN	Most Probable Number
MOPH	Ministry of Public Health
MRRD	Ministry of Rehabilitation and Rural Development
MSF	Medecins Sans Frontieres
MTF	Multiple Tube Fermentation
MUG	4-methyl-umbelliferone-beta-glucuronidase
NGO	Non Governmental Organization
NRSP	National Rural Support Program
ONEAD	Office National des Eaux de Djibouti
ONPG	ortho-nitro-phenol-beta D-Galactopyranoside
PCA	Project Cooperation Association
PCRWR	Pakistan Council for Research in Water Resources
PML	Portable Microbiology Laboratory
PSAWEN	Puntland State Agency for Water and Natural Resources
PSI	Population Services International
RDIC	Resource Development International Cambodia
RO	Reverse Osmosis
SHHS	Sudan Household Health Survey
SHILCON	Shilaale Ecological and Rehabilitation Concern
SHIPO	Southern Highlands Participatory Organisation
SNEP	Service National d'Eau Potable
SODIS	Solar Disinfection
SORSO	Somali Relief Society
SRS	Southern Red Sea

TC	Technical Committee
TDS	Total Dissolved Solids
TEDHA	Tropical and Environmental Diseases and Health Associates
UF	Ultra Filtration
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
UV	Ultra Violet
VRB	Violet Red Bile
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
YCSD	Young Child Survival and Development

CHAPTER 1: INTRODUCTION

1.1 Background

Water is the key ingredient for survival of all life forms on this planet. Hence, quite naturally human settlements old or new chose to settle close to a source of fresh water. That explains why big cities like New York, New Delhi, London, Paris all lie on the banks of a river. In earlier times, settlements would often drain their wastewaters into the rivers or streams, where natural processes would decompose complex harmful waste matter into safer compounds. However, as time has progressed, our populations have increased many fold although the available fresh water supplies have remained constant. Hence, there is an ever-increasing pressure on fresh water supplies, both from the standpoint of drinking water sources and also from the standpoint of water supplies being a natural cleansing agent for raw sewage. Plausibly, mega-cities around the developed world have built water and wastewater treatment plants in order to meet their water needs while maintaining the quality of fresh water resource.

It is important to recognize the fact that unsafe drinking water, along with poor sanitation and hygiene, are the main contributors to an estimated 4 billion cases of diarrheal disease annually, causing 1.5 million deaths, most among children under the age of 5 years (JMP, 2008). Microbiological contamination of water causes many waterborne diseases like typhoid, or hepatitis, in other cases contaminated water may also be the source of water-based diseases such as the guinea worm. To address this, the Millennium Development Goals set by the United Nations seek to halve the proportion of people without adequate water and sanitation facilities by the year 2015 (MDG, 2000).

A piped supply as described by Cairncross et al. (2006) is the presumed ideal solution to our drinking water problems, since a tapped connection is able to eliminate contamination occurring from the 'public domain' (occurring due to the unsafe sources and due to improper filling and transportation of water) as well as from the 'domestic domain' (occurring within the household owing to issues of handling, storage and use). The developed world has been able to provide most of its inhabitants with a safe and secure piped source of water supply. Still, about 884 million people across the world lack access to improved water supplies while many more rely on other improved supplies such as boreholes, improved dug wells, springs and harvested rainwater (JMP, 2008).

Even though governments across the world work with international aid agencies and NGOs to help achieve this target, one must acknowledge that infrastructural costs associated with developing such a system are too steep to be met by many developing countries. Moreover, a piped system may encourage excessive use of fresh water, a resource that is already fairly depleted in many developing countries, by utilizing too much water for activities such as gardening and toilet flushing. Owing to the reasons mentioned above, it seems nearly impossible to provide everybody with access to a safe and secure piped water system, particularly for people living in rural areas, where 84% of the total population lacking access to water lives (JMP, 2008). Hence, there is a need to search for alternative, low-cost implementable solutions to manage water and wastewater more effectively in the developing world.

1.2 Household Water Treatment and Safe Storage and the Network

Drinking water must be microbiologically safe, free from toxic or harmful chemicals or substances, and comparatively free of physical compounds that affect the aesthetics of water, including turbidity, color, and taste-producing substances. While most efficient water treatment plants are able to achieve and provide these standards to their users, it is hard to meet such standards in cases where the piped supply is unavailable or where the piped network is contaminated. Household Water Treatment and Safe Storage (HWTS) systems were developed to provide a first or extra barrier of protection to ensure safe drinking water quality. They have gained increasing recognition as well as been implemented in the developing world for as many as 15 years[1]. The idea is simple- to treat water at the point of use, preferably using effective but low-cost treatment technologies that could be developed using locally available raw materials. Ever since, HWTS technologies such as flocculation, filtration, chlorination and solar disinfection (SODIS) have been instrumental in treating water at the point of use (Sobsey, 2002). There is significant evidence to suggest that these systems have been successful in improving the drinking water quality and preventing diarrheal disease (Fewtrell, 2005) but there also has been conflicting evidence from double-blinded studies that question HWTS efficacy (Schmidt, 2008).

Given the potential of HWTS to improve the health of vulnerable populations through improved point-of-use water management, about 20 organizations from the public, private, academic and the non-profit sector came together in February 2003 to form the International Network, to promote Household Water Treatment and Safe storage (The “Network”), hosted by WHO. The Network today has more than 120 organizations that include representatives of UN agencies, bilateral development agencies, international non-governmental organizations, research institutions, international professional associations, the private sector and industry associations. The main objectives of this public-private partnership is to provide a forum for its members where they can share information, discuss and promote collective, multi-lateral and individual action. By creating a common mission and strategic plan among participating stakeholders, the Network model encourages communication, cooperation and coordinated action while optimizing flexibility, participation and creativity.

Even though the Network and other initiatives to scale up HWTS have been a part of international development efforts since 2003, the desired results have not yet been achieved. The challenges to scale-up are many, such as constraints on distribution, user acceptance, and effective use of products, price-economics, training-methods, sustainability, inadequate maintenance, monitoring and evaluation, among others.

[1] Several HWTS, specifically boiling, cloth filtration and ceramic filtration have a longer history, which will be touched on in Chapter 2.

1.3 Scope of Current Work

The current study has three objectives.

1. Collection and organization of a database on the status of the HWTS implementation and scale-up programs based on the information obtained from UNICEF country offices. For this purpose, the authors traveled to New York City to undertake an internship at the UNICEF headquarters, New York during January 2009. The results of this work can be found in Chapter 3.

2. To determine the user perceptions and behaviors relative to HWTS and to test the quality of water at the point of consumption, post HWTS treatment. For this purpose, the author traveled to the city of Lucknow, in India during summer 2009. There he conducted 240 sanitary surveys in conjunction with 276 water quality tests.

3. To compare the newly developed microbial water quality testing kit, 'The EC-Kit' (developed by Prof. Robert Metcalf of California State University- Sacramento and enhanced, branded and developed into a product by Susan Murcott at MIT), to one of the Standard Methods - Multiple Tube Fermentation (MTF). The results and discussions related to this effort can be found in Chapter 7 and 8 respectively.

1.4 Internship at UNICEF, Headquarters, New York, USA

For the month of January 2009, the author was stationed at the UNICEF headquarters in New York, USA together with Xuan You[2], in order to conduct the first part of this thesis research. Here he worked under the guidance of Mr. Oluwafemi B.C.Odediran, who is the Senior Advisor-Programmes for the WASH cluster at UNICEF. Using the internal network between the headquarters and the UNICEF country offices, the author and Ms.You contacted 71 country offices of UNICEF. Out of the 71 offices contacted, all 60 priority country offices and 11 that were not priority countries were contacted. Out of the 71 that were contacted, 45 responded.

The author, under the guidance of Susan Murcott and Mr. Oluwafemi B.C.Odediran, developed the survey instrument that was used to carry out this database creation project. The survey instrument had questions for the Water, Sanitation and Hygiene (WASH) group of the UNICEF country office, pertaining to the demographics, water supply and status of HWTS of that country.

[2] Xuan You worked as a research assistantship under Susan Murcott during 2008-2009. She holds a Master of Water Resource Engineering and Management from the University of Stuttgart, and has since returned to China to work for Gale International.

1.5 UNICEF's WASH Program

The overall objective of UNICEF in the area of water, sanitation and hygiene (WASH) has been to contribute to the realization of child's rights to survival and development by supporting national programs to increase access to, and to help promote use of, safe water, basic sanitation and an improved hygiene. UNICEF's role is to step in and get involved with a country's WASH program, when it is asked to do so by the government of the country in question.

The main objectives of any WASH program that UNICEF gets involved with are:

- To halve, by 2015, the proportion of people without access to safe drinking water and basic sanitation (MDG Target 10)
- To ensure that all schools have adequate water and sanitation facilities, and that each institution plays an important role in providing hygiene education to the children.

To achieve these objectives, UNICEF has tailored three packages of support, namely

1) *In priority countries:* There are 60 priority countries defined by UNICEF. The classification is based on high child mortalities and low water and sanitation coverage in these countries. The program in these countries is designed to lead to the achievement of both the aforementioned main objectives.

2) *In emergencies:* This support is provided in case of any emergency, based on the need of the country or where urgent WASH interventions are required to prevent the death and suffering of children, and to protect their rights.

3) *In all countries:* UNICEF works in 201 countries total. In each of these countries UNICEF's WASH team provides support to the government when it called in for help.

1.6 Field Studies in Lucknow, INDIA

The author's field site was the Indian state Uttar Pradesh's capital city, Lucknow. The fieldwork lasted for three months over the summer (June to August) of 2009. The author was hosted by PATH- INDIA, a Non-Government Organization (NGO) whose primary objective is to promote public-health welfare. PATH-INDIA office headquarters is in Delhi, but it has a presence in some of the southern states of India, and also in the north Indian states of Uttar Pradesh and Bihar. PATH's *Safe Water Project* is funded by the Gates Foundation and looks to scale up HWTS across both rural and urban India and beyond. PATH conducts research on existing technologies to treat and store water in homes. These technologies include filters, chemical and ultraviolet treatments and heat disinfection. They also research the availability of these products, what they cost and the consumer willingness to pay for them (Path, 2009). However, an important aspect of this project is that it is at a fairly early stage of its development in India and the organization itself is still figuring out the best technologies and commercial partners to promote in order to bring to scale the various HWTS at the project locations. The author elected to carry out his field research on HWTS in Lucknow over other project sites because in the southern part of India he would have faced a language barrier while conducting field studies. Amongst the north Indian project sites, Lucknow was chosen over other options like Pratapgarh, owing to logistical issues.

The project in Lucknow was such that, the PATH office in Delhi had arranged for the author to work out of the Academy for Educational Development (AED)[3] office in Lucknow. The AED office in turn introduced the author to the workers of Pratinidhi, an NGO working on water projects funded by AED and PATH. The author covered about ten locations in and around Lucknow where he conducted surveys and water quality tests.

The following section gives a brief background on the demographics of Lucknow, its water supply and the partnering ground-level NGO.

1.7 Field Background Information on Lucknow

Lucknow is the administrative and the business capital city of India's largest state, Uttar Pradesh, and has a land area of 2528 square kilometers (Maps of India, 2009). Located in the fertile Indo-Gangtic plain, the state is best known for its agricultural produce. Unlike most other parts of Uttar Pradesh, Lucknow is a cosmopolitan city with a population of about 3.6 million people.

[3] http://www.aed.org/

Figure 1.1: Map of Uttar Pradesh showing Lucknow in the center and its position relative to India (Source: mapsofindia.com)

The primary source of water for the city is groundwater accessed via hand pumps or tube wells. In some localities, groundwater accessed via mechanized boreholes pump water up to water towers that act as the primary source for drinking water. Excessive utilization of groundwater coupled with limited wastewater treatment and disposal facilities has created a situation where the available groundwater supplies are highly contaminated. In fact, even the piped network (wherever it is available) is open to pollution from the surrounding areas, making the supply unclean and unfit for consumption.

The following table lists some key facts about Lucknow.

Indicator	Lucknow
Total Population	3,647,000
Urban Population	64%
Rural Population	36%
% Access to an improved water source	47%
% Access to improved sanitation	61%
Total piped connections[4]	300,000
Total Fresh Water Supply[5]	200 Million Liters a Day (MLD) (from Gomti River)
Total Groundwater Supply[6]	250 MLD (Government operated tubewells)[7]
Literacy Rate	77% (Men) 61%(Women)
Infant Mortality	79 per 1000 live births

Table 1.1:Facts about Lucknow (Source: http://nrhmmis.nic.in/ui/reports/dlhsiii/dlhs08_release_1.htm#TC)

[4] This data was received via conversation with officials from UP Jal Nigam (the water supply agency) in Lucknow.

[5] Ibid

[6] Ibid

[7] The number indicates only the authorized government connections and not private boreholes, which are very common throughout the city, but very hard to account for. Hence total groundwater consumption is much higher than what is indicated by the numbers above.

CHAPTER 2: LITERATURE REVIEW

HWTS technologies have not provided all the expected health benefits, nor have they been scaled up to their true potential. To understand this challenge in greater depth, this chapter looks at some of the previous literature in this field of study.

Murcott (2006) makes an interesting point about innovation and diffusion in the domain of HWTS technologies. By means of an S-shaped diffusion curve, she illustrates the idealized scaling up process.

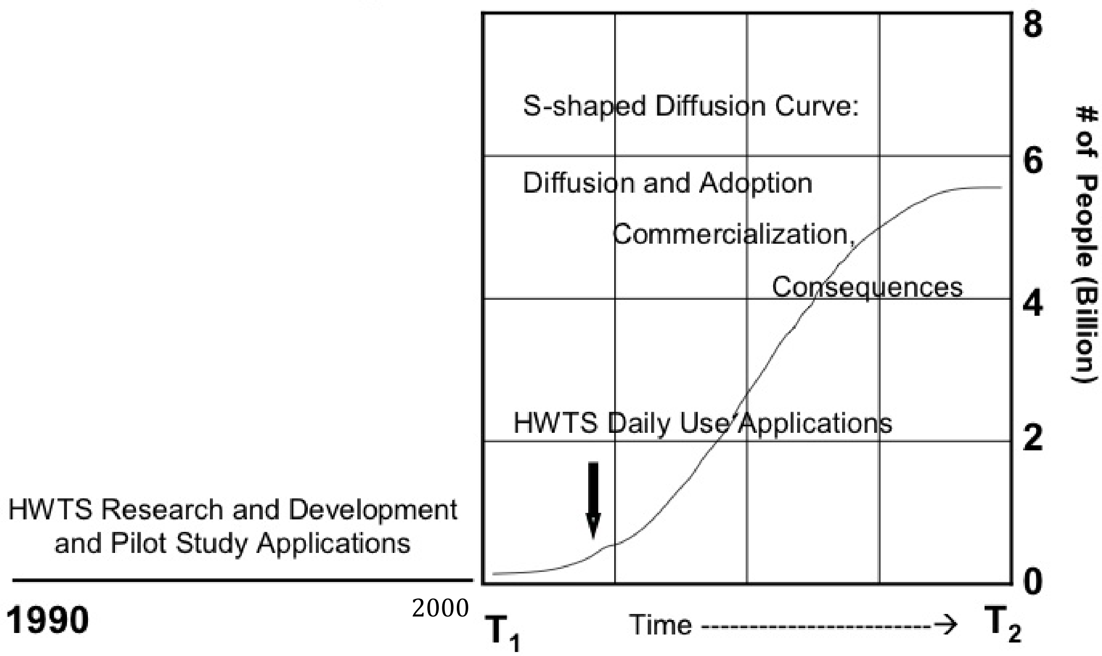

Figure 2.1: S-shaped diffusion curve used to explain HWTS innovation and scale-up (Source: Murcott, 2006)

Isolated research, development and innovation in the field of HWTS went on in many countries in the early 1990s. However, at time T_1 on the graph, which is signified by the early 2000s, is when diffusion began to take off. In her hypothesis, Murcott explains that if HWTS diffusion were to follow the general diffusion curve, it would take until time T_2 to achieve successful widespread scale up. Making the case for HWTS, she cites Everett Roger's work *"Diffusion of Innovations"*(2003), which includes a case study comparing cell-phone diffusion in USA to the diffusion of HWTS technologies. Drawing the comparison, she explains that as with cell-phones in the first decade of their diffusion, the markets were slow to respond. However in the second decade, over 1.1 billion units were sold.

However, unlike cell phones, HWTS systems are more than just a utility item, making them harder to market and sell, moreso when a significant portion of the target population is uneducated and falls below the poverty line. Hence, innovating, marketing, financing, manufacturing, installation, operation and maintenance of these systems become more challenging than for a number of other technologies.

2.1 The Innovation Phase

According to Lukacs (2003), a good HWTS technology is one that caters to the maximum number of needs of the user. For instance, the technology should be effective on a large array of pathogens, should perform regardless of water fluctuations, operate well within a relatively broad range of temperature and pH values, should be adaptable to local conditions, be easy to handle and should be affordable.

If we look at all the listed requirements of the system, it can be tied down to the fact that while developing a HWTS technology, one needs to focus on the user.

2.2 Marketing and Finance

Marketing and pricing a technology are two of the most important aspects of any scale-up activity. In case of HWTS systems, since the target population does not have the purchasing power, this becomes a big challenge. As Murcott (2007) and Clasen (2009 a) highlight, social marketing, partnerships, favorable policy and micro-financing would help make scale-up more efficient and self-sustaining.

2.3 Manufacturing

Given the financial constraints, it becomes problematic to try and market HWTS products that are too expensive. HWTS systems should preferably be developed with locally available material, by training and using the locally available human resources for maximum benefits. In this way price can be kept low and local jobs can be created. Although, Murcott (2006) is quick to point out, it is very important not to overlook the quality component of the manufacturing process in order to have better results both in performance and scale-up.

2.4 Installation

Manufacturing HWTS systems gives both the manufacturer and the user mutual benefits. It is possible that the manufacturer can manufacture all parts and leave the assembly and installation for the user to do. This could cut the manufacturer’s cost of production. On the other hand, the user can be trained about assembling the HWTS. This would make the user more confident about using his/her HWTS system.

2.5 Operations and Maintenance

Essentials for ensuring good operation are that the documents describing the operation be written in the local language, these documents should be illustrated with adequate images, as well, to enable users who are uneducated to understand them. The system should comply with all specifications that it claims and should perform well in varied climatic and physical conditions.

As far as maintenance is concerned, the systems should be easy to clean and maintain. They should be developed that anyone, young or old, may be able to execute the maintenance procedure. The documentation for maintenance too should be provided in the local language, with adequate illustrations. Spare parts should be made available locally and these locations should be advertised properly.

2.6 HWTS Implementation

Household-based water treatment technologies may be introduced to a population by four categories of implementers:

(i) Public sector,
(ii) Non Governmental Organizations (NGOs),
(iii) NGO/private sector hybrid (social marketers or social entrepreneurs),
(iv) Private sector.

These actors, in turn, may pursue one of three basic approaches to the diffusion of the invention:

(i) Providing it free of charge (or for nominal consideration) as a public good,
(ii) Providing it at a subsidized price with partial cost recovery; and
(iii) Selling it on a commercial basis at a price designed to cover its full manufacturing and sales cost, together with a profit.

The permutation one sticks with would however differ owing to the demographic, geographic and economic conditions of a place. The technology adopted at each place may also differ owing to the availability of certain raw materials required to build the treatment system or owing to the behavioral aspects of uptake of a particular technology. This can even be perceived as a failure on the part of technology developers, who haven't been able to develop a robust technology, which would cater to all the prescribed needs. Hence, any proposed design should be technically stable, i.e, it should provide sufficient quantity of water at a healthy standard, it should be easy to use and maintain, it should be robust and durable. Faced with limited time and money, competing priorities, and an uncertain risk of the consequences of non-compliance, householders easily backslide, secure in the knowledge that they themselves probably grew up on untreated water. Moreover, HWTS implementation is faced with yet another challenge that is deeply ingrained in each society. They call for a behavioral change on the part of the user, which is hard to promote and achieve. The only way to overcome this problem is by involving and partnering with the user community at all levels of the project. Along with this, the overall framework needs to be financially viable. This means that the consumer should get the most out of his/her product and the recurring costs should be minimal for the product to be a success. The knowledge about efficient/successful models of distribution and implementation needs to be made available in the public domain so as to maximize its successful scale-up. One should strive to achieve a price mechanism such that it becomes a self-sustaining industry.

2.7 Measuring the Success of the Installed HWTS system

The easiest way to measure the success or failure of a system is by measuring the impact of a particular technology in the field i.e. to measure the coverage of a particular HWTS technology. This is difficult to do. Coverage is usually measured at a small scale, i.e. at the community level or the district level.

Metrics that may be used to determine coverage of HWTS across products are:

(i) Number of days with safe water,
(ii) Number of liters treated
(iii) Number of users.

It is toughest to measure the first one, since there is limited data available and it is harder to quantify (Howard 2003). The number of liters treated is probably the easiest method to compare amongst various products. However, this metric would also differ from case to case, owing to the different types of systems and their differing volumes and rates.

One of the most robust metrics is the number of users. This provides a numerator from which to calculate coverage. Unfortunately, few implementers of HWTS directly track and report the number of users of their interventions. Most use number of units sold or placed in service as their metric. For durable products, such as filters, this usually means assumptions that everyone in the household uses the product and a calculation based on average household size using each unit. For consumables, the number of users is usually based on assumptions about amounts of water treated per day and the overall capacity of the bottle, tablet or sachet at a given level of dosing (i.e. the first metric on the list above).

In 2008 UNICEF initiated the formation of an Indicators Task Force as an advisory team. The objective of this Task Force was to define a set of no more than 10 indicators that UNICEF could use to measure progress in the implementation and scale up of HWTS. The team put together the following list of indicators:

Percentage of households correctly storing treated water

Percentage of households correctly treating their drinking water using some HWTS technology

1.
2. Percentage of households consistently treating drinking water with HWTS
3. Percentage of respondents that agree that their drinking water needs to be treated
4. Percentage of respondents that think others approve treating drinking water at home
5. Percentage of respondents that feel confident they can improve the quality of their drinking water.
6. Percentage of households with a negative test for *E.coli* in drinking water
7. Percentage of households with positive chlorine residual in drinking water treated with a chlorine product.
8. Percentage of households who know at least one location where they can obtain a HWTS product.

2.8 Known Studies on the Status of HWTS systems

Whereas advocates for particular HWTS have kept records on the dissemination and scale-up of individual HWTS systems, there have been at least 3 members of the Network who have done research into the status of HWTS globally, across multiple systems. Below we review these efforts.

2.8.1 Murcott (2006)

Mucott (2006) presents information on the status of implementation and scale up of eight different HWTS technologies, using global maps based on a survey of member organizations of the Network. The results for this have been summarized in Table 2.1.

Technology	**Number of Countries**
Boiling	8
Household Chlorination	29
SODIS	33
Ceramic candle filters	20
Ceramic pot filters	9
Ceramic filters (All types)	26
Bio-sand Filters	25
Coagulation	19
Total beneficiaries in 53 countries = 6 Million	

Table 2.1: Summary of Murcott's survey of Network organizations

2.8.2 Allgood (2008)

Greg Allgood, in a presentation at the HWTS Network Ethiopia Country Conference presented information on the status of implementation and scale-up of five different HWTS technologies:

i. Ceramic Filters

ii. Bio-sand filters

iii. SODIS

iv. Coagulation/Disinfection (PUR)

v. Safe Water System

Allgood, like Murcott, derived his data from contact with implementing organizations within the Network.

The results from this research have been summarized in Table 2.2.

Technology	Number of units sold/ number of units produced	Hardware (capital and maintenance)	Software Requirements	Challenges to Scale-up	Scale up Methodology
Ceramic Filters	2.5 million ceramic filter elements produced and sold each year	USD 8.00 to 21.00 for a complete system lasting 1 to 3 years; USD 2.00 to USD 6.00 for replacing the candle element	Education and training on maintenance and cleaning	– Ensure consistent quality – Low flow rates limits use with turbid waters – Recontamination	– Develop method to address front-end cost – Targeted distribution to address low turnover and fragility
Bio-sand Filters	Estimated 138,000 produced to date in 27 countries (CAWST)	About USD 20.00 (plastic) or USD 65.00 (concrete)	Education and training of entrepreneurs and public health workers	• Estimated investment in equipment: USD 200 per single steel mold for concrete filters. • USD 200,000 for injection mold for mass- produced plastic bio-sand filters.	–
SODIS	Used in 27 countries by over 2 million people	Very low	Requires training, guidance, and monitoring to bring about behavior change	–	Demonstration projects may go to scale through local government support in combination with external aid agencies
PUR	• PUR currently used in 13 countries with ongoing marketing/distribution efforts and in more than 30 countries for emergency relief • 75 million sachets of PUR in 4 years	USD 0.05-0.10 per sachet to treat 10 liters	Requires education and training	–	Social Marketing/Distribution at full cost recovery and Community Mobilization via network of NGOs
Safe Water System	Social Marketing/Distribution at full cost recovery and Community Mobilization via network of NGOs	USD 0.20 to USD 1.00 for 1.5 month supply	Requires extensive education and training	–	Social Marketing with combined with community mobilization

Table 2.2: Summary of the findings of the Allgood (2008) study

The Allgood study clearly identifies the problems to scale-up of 5 core technologies. On the other hand it also provides successful methodologies that have helped scale-up HWTS technologies. However, the most interesting aspect of this study is that it identifies education and training as an important software requirement for bringing these technologies to scale.

2.8.3: Tom Clasen

This section summarizes Clasen's work on the status on HWTS.

Clasen (2008) presented his results on the status of HWTS in 54 countries based on the data from the Joint Monitoring Program.

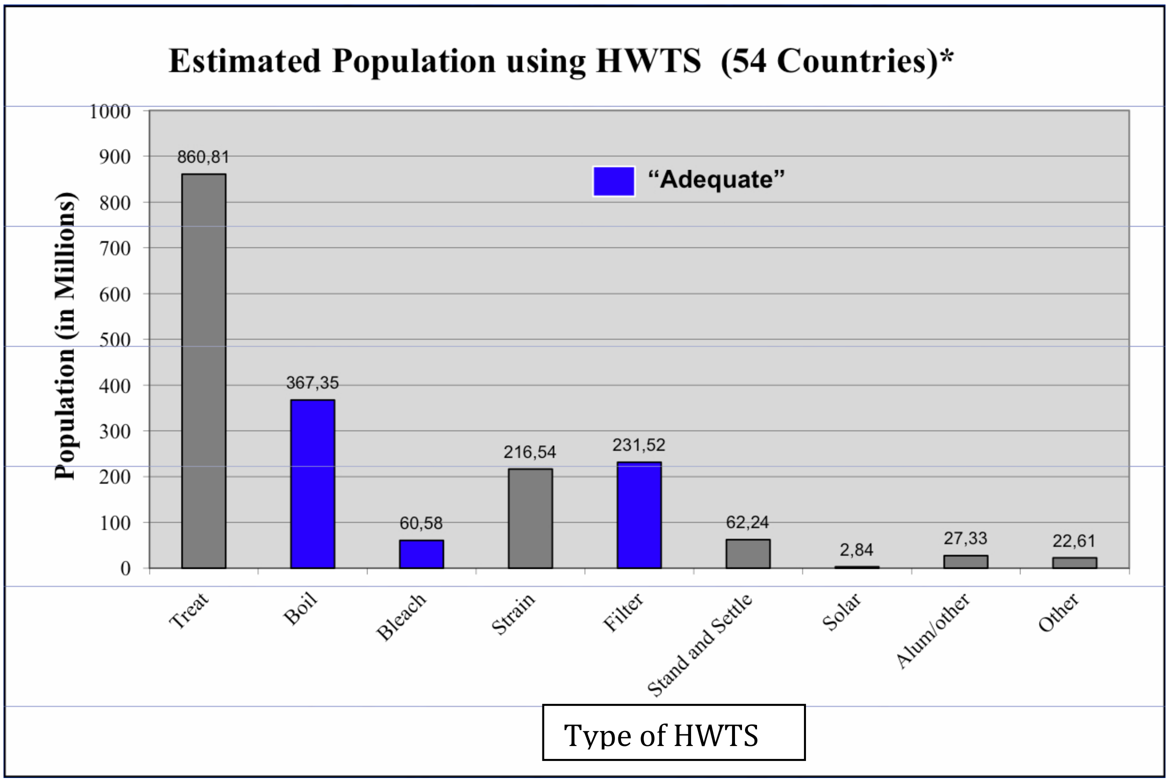

Figure 2.2: Users of different HWTS- Global Estimate (JMP data from 54 Countries) (Source: Clasen, 2008)

The above graph depicts that about 861 million people in 54 countries are using some HWTS technology or the other, of which 367 million use boiling. This data has further been disaggregated into 'adequate' and 'inadequate' treatment technologies. This distinction has been provided by the JMP and is explained in greater detail in Annex I.

In another study, Clasen (2009 a) presents the extent of coverage of some HWTS technologies around the world. The author presents these results using two graphs, one showing the increasing coverage in terms of number of users per year (between 2005 and 2007) and the second showing the increasing coverage based on the number of liters of drinking water treated per year (between 2005 and 2007). Figures 2.3 and 2.4 are presented below.

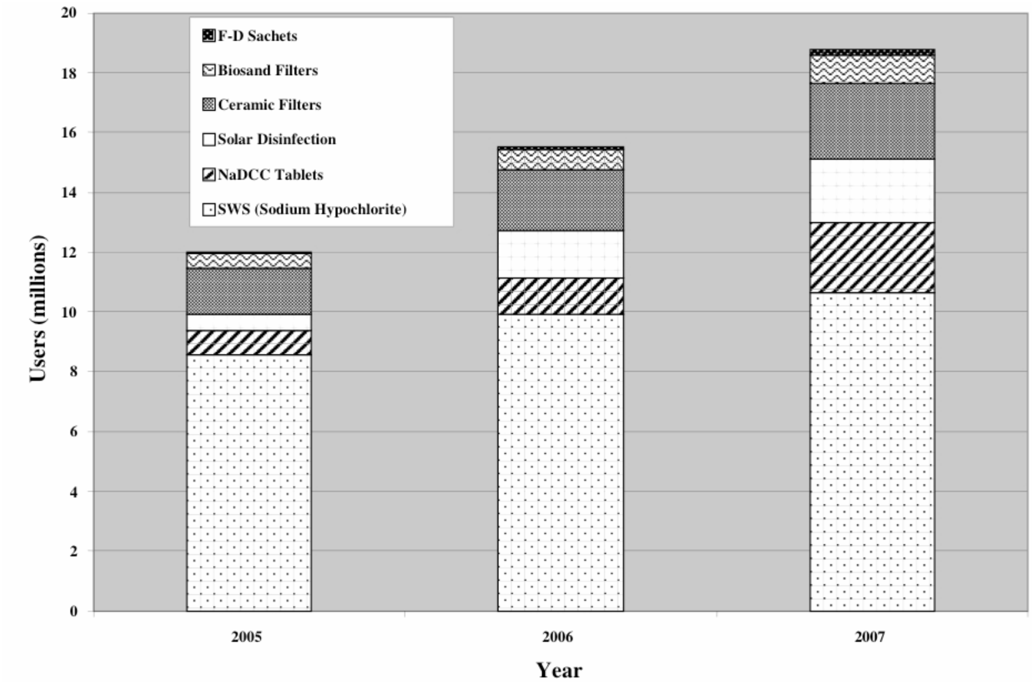

Figure 2.3: Combined estimate of increased number of users of selected HWTS products between 2005 and 2007 (Source: Clasen, 2009 a)

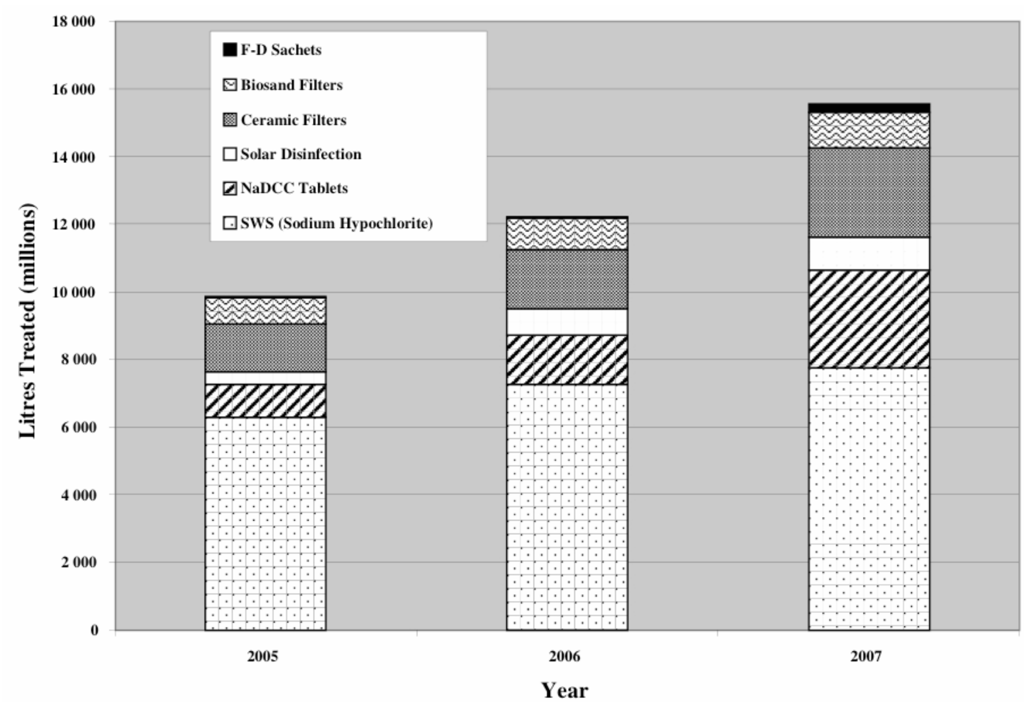

Figure 2.4: Combined estimate of increased number of liters treated by selected HWTS products between 2005 and 2007 (Source: Clasen, 2009 a)

In contrast to the data in Figure 2.2 the source of data for Figures 2.3 and 2.4 was the HWTS Network member organizations, private manufacturers and implementers. The results of the two graphs are encouraging, but Clasen clearly identifies that the data does not represent uptake in the sense of sustained use, instead it represents coverage. He also provides evidence on long-term use, which suggests that many of the users to whom these interventions successfully reach do not continue to use these technologies, or sometimes they are not used in a manner that provides them with optimal protection. He suggests that while large numbers of households buy the product, very few become continuing users. In other cases, households use products only when they perceive the risk to be greatest. As a concluding remark, he adds that one should not assume that the populations represented by this coverage estimate are the most vulnerable to waterborne diseases.

More recently, Clasen (2009 b) presented a graph (Figure 2.5) that updates the status of HWTS based on coverage of each technology. Like Figure 2.2, the source if the data for this graph is the Joint Monitoring Programme. From this research one can conclude that the percentage of people boiling water before drinking is very high and that the percentage of users of HWTS generally is substantial number in many regions of the world, more than what previously might have been imagined.

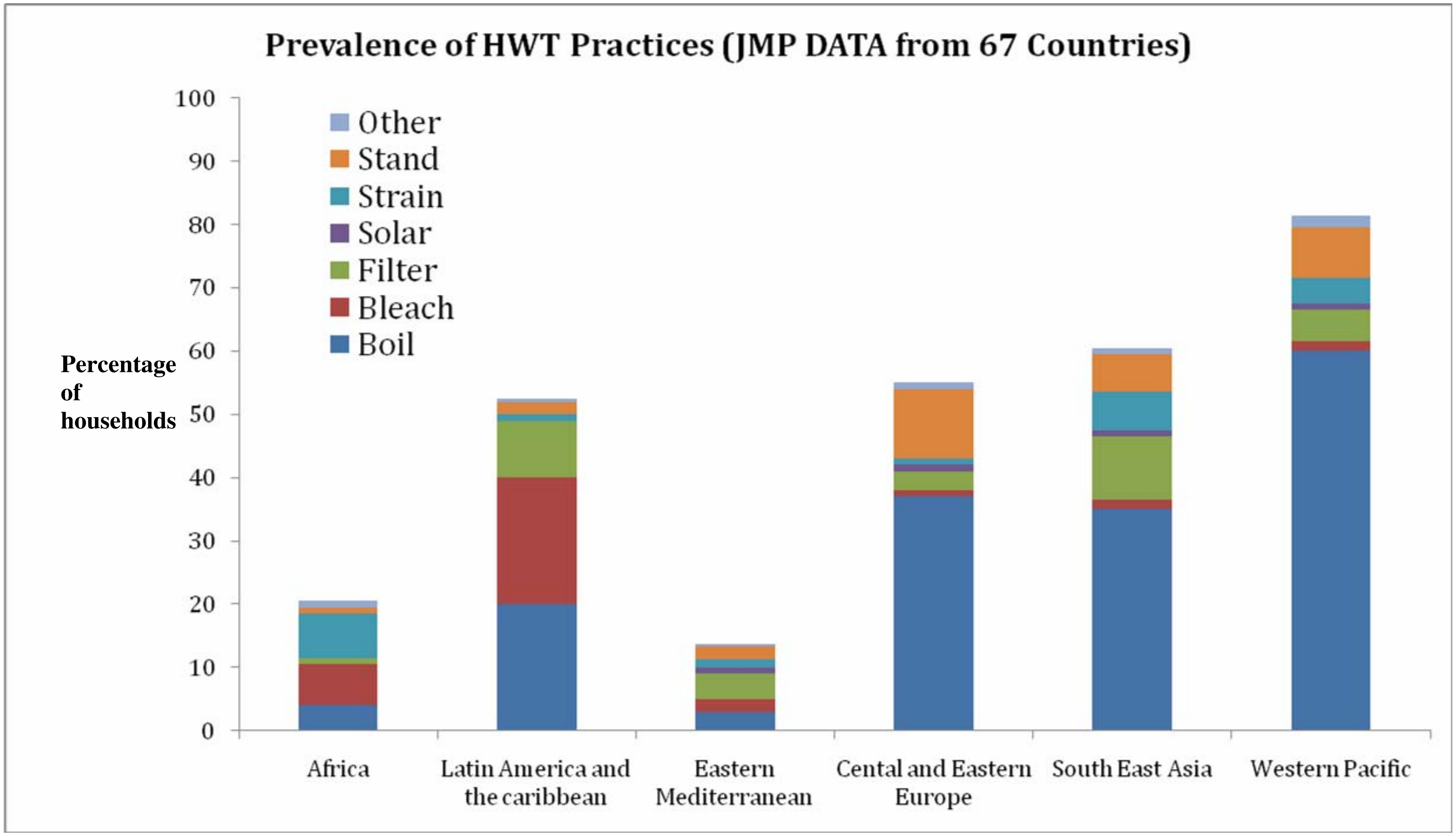

Figure 2.5:Graph representing JMP data for 67 countries (Clasen 2009 b)

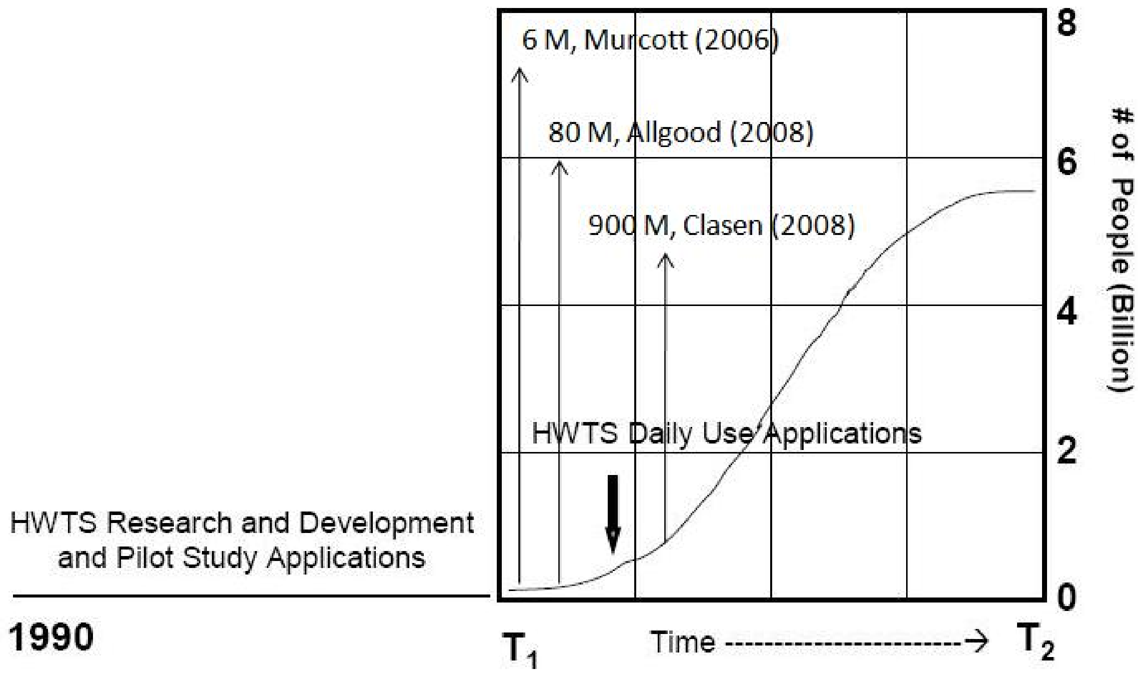

Figure 2.6: S-shaped diffusion curve representing coverage, presented by the three studies.

Based on these research efforts, it can be suggested that the coverage of HWTS systems is definitely increasing along the S-shaped diffusion curve.

2.9 Overview of Technologies

A multitude of HWTS technologies are mentioned in this thesis. Those HWTS technologies described by the UNICEF survey national office respondents (Chapter 3) are written up in brief descriptions of each individual technology below. In the second part of the thesis that includes the field work in Lucknow, India, those Indian manufactured HWTS are separately written in Fact Sheets (Chapter 4).

2.9.1 Boiling

Boiling is the oldest means of disinfecting water at the household level (Sobsey 2002). If practiced efficiently, it is known to kill or deactivate all classes of waterborne pathogens, including bacterial spores and protozoan cysts that have shown resistance to chemical disinfection and viruses that are too small to be mechanically removed by microfiltration (Block 2001). Feachem et.al (1983) showed that heating water to 55° C can kill or inactivate most waterborne bacteria and viruses. However the WHO recommends heating water until it reaches boiling point.[1]

Even though, boiling seems to be successful in some countries, it has not been adopted with the same ease worldwide. A number of factors play into this, as follows,

1. *Cost of Fuel*
   The populations being targeted for the uptake of boiling are often ones that live in the rural areas in developing countries, in urban slums or are populations in emergency situations. For such people, the cost of fuel to heat water can be a heavy one to incur. Unlike other technologies, this is one that can't be distributed at a subsidized rate or for free by the agencies and governments.

2. *Health Hazard*
   Most people living in poverty have space constraints in their homes. The fuel is usually burnt indoors in poorly ventilated rooms, owing to which the indoor air quality is poor. Other than this, people frequently do not store their water in the same vessel that they boil it in, which can contribute to recontamination.

3. *Issues Related to Uptake of Technology*
   Quite often, even though the people have the facilities to boil the water, they refrain from doing so. Surveys suggest that this can be attributed to the lack of knowledge, that its too much work (owing to the time involved in heating the water), the fact that some people may not like hot water, especially in hot climates or even the fact that the taste of the water changes significantly.

[1] http://www.hip.watsan.net/page/2848

2.9.2 Solar Disinfection (SODIS)

Solar disinfection or SODIS[2], is a simple method to improve the quality of drinking water by using sunlight to inactivate pathogens. It involves filling transparent plastic bottles with water and exposing them to full sunlight for five to six or more hours. The water gets disinfected by a combination of UV-A radiation and increased water temperature. This process may be combined with solar reflectors or solar cookers to further increase water temperature. SODIS has been extensively developed by the Swiss Federal Institute for Environmental Science and Technology to prevent diarrhea in developing countries.

This process has been proven to be effective in the reduction of viruses, bacteria, and protozoa in water. Also, it is an inexpensive process since the only cost to the user is the plastic bottles. However, this process does not change the chemical water quality, is not effective in turbid waters and requires pre-treatment of turbid waters via as filtration or flocculation. SODIS is most appropriate in areas where there is availability of bottles and community motivation and training for users on how to correctly and consistently use SODIS for treating household drinking water. It has been implemented by over 2 million people in 33 developing countries for their daily drinking water treatment (Murcott, 2006).

2.9.3 Bio-sand filters

Bio-sand filters[3] are modification of slow sand filters as intermittent household scale systems. These filters consist of layers of sand and gravel through which filtration of water takes place. They do not require any chemical pre-treatment of water. Microorganisms in water get absorbed onto the fine sand particles and develop into a highly active food chain, called the Biological Layer or *Schmutzdeke*. This biological layer traps and feeds on the microorganisms and contaminants in the water. Water is poured into a diffuser on top of the filters and travels slowly through the sand bed and several layers of coarse sand and gravel, and collects in a pipe at the base of the filter.

These filters are easy to use and maintain. However, they require regular cleaning in order to avoid clogging. Biosand filters are effective in the removal of pathogens, moderate levels of turbidity and also, odor and color. These filters have a high flow rate and can be constructed of local materials. However, they are not effective in highly turbid waters, and may also require some post- disinfection since they are not very effective in the removal of viruses.

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[2] http://www.sodis.ch

[3] http://www.biosandfilter.org/biosandfilter/index.php/item/229

2.9.4 Products

1. HTH Chlorine Solution

High-test Hypochlorite (HTH)[3] chlorine solution is used for disinfecting water. It is sold in the market as dry chlorine, and has a typical chlorine concentration of 65% to 70%. HTH is manufactured and sold as powder or granules by Arch Chemicals, Inc[4]. These granules are easy to use and do not require complex metering equipment. When used for disinfection purposes, HTH granules or powder is dissolved in water to produce a clear chlorine solution. Other than its application as a HWTS technology, it is also used in several industries including breweries, dairy plants, meat processing, poultry plants, pulp and paper industries, sugar refineries, tanneries, vineyards, restaurants, and orchards.

2. Certeza

Certeza is the brand name of a dilute solution of sodium hypochlorite, which is used for household water treatment. It is known to purify water regardless of its source (USAID, 2008). It is manufactured and sold by Population Services International (PSI) in Angola[5], though it is also marketed in several other countries around the world. It has been made readily available in Angola in conjunction with the Angolan Ministry of Health and Sanitation, at household level for the low-income group at an affordable price. This product has facilitated the prevention of cholera through increased awareness and a focus on improved hygiene. USAID supported an active social-marketing campaign that sold 472,000 bottles of Certeza in Mozambique in 2008. This program enabled communities in remote, rural and peri-urban slum areas to access and consume clean drinking water (USAID, 2008).

3. Abate® Water treatment

Abate® is a micro-granule insecticide used primarily in public health programs for disease vector control. It is a potent larvacide, and is used for control of several disease-causing insects including mosquitoes. World Health Organization (WHO) approves it for use in drinking water. It is a low toxicity organophosphate, which poses no risk to humans, birds, fish, and effectively controls mosquito larvae at relatively low doses. Abate® is a cost effective way of controlling mosquito larvae, since mosquitoes are prevented not only from spreading disease, but also from breeding to create new generations of disease-carrying insects. It can be applied in portable water containers, water tanks, ceramic water jars, and stagnant waters. Abate is manufactured and sold as granules by an Australian chemical company, BASF[6].

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[3] http://www.hth.co.uk/glossary.shtml#h

[4] http://www.archchemicals.com/Fed/

[5] http://ipsnews.net/news.asp?idnews=42841

[6] http://www.basf.com/group/corporate/en/

4. Chlorfloc

Chlorfloc[7] is a flocculating product used for removing turbidity and for sanitizing water. Chlor-Floc tablets contain flocculating agents (e.g., aluminum sulfate) to clarify the water and sodium dichloroisocyanurate, a form of chlorine to provide disinfection. These tablets are easy to use, non-hazardous, easily transported, and disinfect water within minutes. . This product has been used during flood disasters in Africa, South America and Southeast Asia, and by several military institutions worldwide. US Army and SA Defence Forces have been using the product for the past 15 years. Independent studies have also been conducted by OXFAM, who recommend the product for safe drinking water in emergency situations.

6. Sur'Eau

This is a point-of-use disinfectant made of sodium hypochlorite solution. It is locally produced and marketed in Madagascar by Population Services International (PSI), in conjunction with USAID, in order to improve household water quality and decrease diarrheal disease. It is used widely in Rwanda and Madagascar, and has become one of the most popular methods used to purify water. The community mobilization for the promotion of Sur'Eau[8] is managed is in those countries by CARE, under their MAHAVITA programme. PSI and CARE, in cooperation with CDC, recently changed the Sur'Eau product to a smaller bottle with more concentrated solution to facilitate transport and adoption in rural and remote areas. The new bottle has been well-received by rural populations in Madagascar.

7. WaterGuard

WaterGuard[9] is a solution of sodium hypochlorite, which is used for household water treatment. It is locally produced, marketed, and distributed in Kenya by Population Services International (PSI). Several other organizations are also working to increase adoption of WaterGuard at the household level. The Kenya Ministry of Health supports the use of WaterGuard, and has collaborated with CARE/Kenya and CDC to promote WaterGuard and safe storage containers in hospitals.

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[7] http://www.preparedness.com/watpurtab.html

http://www.selectech.co.za/index.php?page=products&category=6&product=CFW

[8] http://pdf.usaid.gov/pdf_docs/PDABY045.pdf,
http://www.cdc.gov/safewater/where_pages/where_Madagascar.htm

[9] **Source:** Preventing Diarrheal in Developing Countries: The CDC/PSI Project in Kenya, January 2009

8. Watermaker

Watermaker[10] is a chorine-based solution used for household water purification. It is a combined flocculent and disinfectant, available as a powder in sachets. This product is ideal for emergency situations where water can be very turbid and where there is no ability or capacity to treat water using other methods. Watermaker sachets are non-hazardous, easy to use, can be transported easily, and disinfects water within minutes. WaterMaker sachets have been made available at household level in Mozambique and these sachets are generally donations received from abroad.

9. PUR® Sachets

PUR Sachets[11] contain a powder used as a flocculent and disinfectant applied at the household level. The sachets contain powdered ferric sulphate (a flocculant) and calcium hypochlorite (a disinfectant). This product was developed by Proctor & Gamble Company (P&G), in conjunction with the Centers for Disease Control and Prevention. It was designed to replicate the processes used in a water treatment plant, incorporating the multiple barrier approach of removal of particles followed by disinfection. It is centrally produced in Pakistan, and sold to NGOs worldwide. PUR has been made available in 30 countries with numerous partners using a variety of strategies (Table 2.2).

PUR sachets have been proven to remove a vast majority of bacteria, viruses, and protozoa, even in highly turbid waters. It has also been documented to reduce diarrheal disease from 16% to greater than 90% incidence in five randomized, controlled health intervention studies. In addition, PUR removes heavy metals, such as arsenic, and chemical contaminants, such as some pesticides, from water. However, the use of PUR involves a multi-step process requiring demonstrations for new users and a time commitment for water treatment from the users, because the water must stand for 30 minutes after treatment before it is ready to use.

[10] http://bushproof.biosandfilter.org/index.php?id=162
Mozambique: Floods and Cyclone, Emergency Appeal No. MDRMZ002 *(Glide no. FL-2006-000198-MOZ),* 20 July 2007

[11] Source: Household water treatment options in developing countries: Flocculent/Disinfectant Powder, January 2008, USAID, CDC

CHAPTER 3: UNICEF COUNTRY LEVEL HWTS SURVEYS: RESULTS

3.1 Overview

This chapter provides the UNICEF country level HWTS survey results. The way this data was obtained was that UNICEF country offices of all 60-priority countries and 30 other UNICEF country offices were sent a questionnaire comprised of a set of targeted questions pertaining to the particular country's HWTS program. (A clearer description of the support programmes UNICEF has available for its member countries is given in Annex II). The author, who was given feedback by Susan Murcott and Mr. Oluwafemi B.C.Odediran, designed the survey instrument based on the list of indicators set forth by the indicator task force. The survey asks questions on accessibility of improved water supplies and the availability of HWTS technologies in a particular country. The survey instrument is unique since it is designed to collect information on the number of implementers in a country, moreover it gives each country office the flexibility to present their opinion on the challenges they face in scaling-up HWTS, and what support they think they need from the UNICEF headquarters to overcome these challenges. A copy of this survey instrument is presented in the next section.

Out of the 71 country offices we contacted, 45 responded. The pie chart below shows this result.

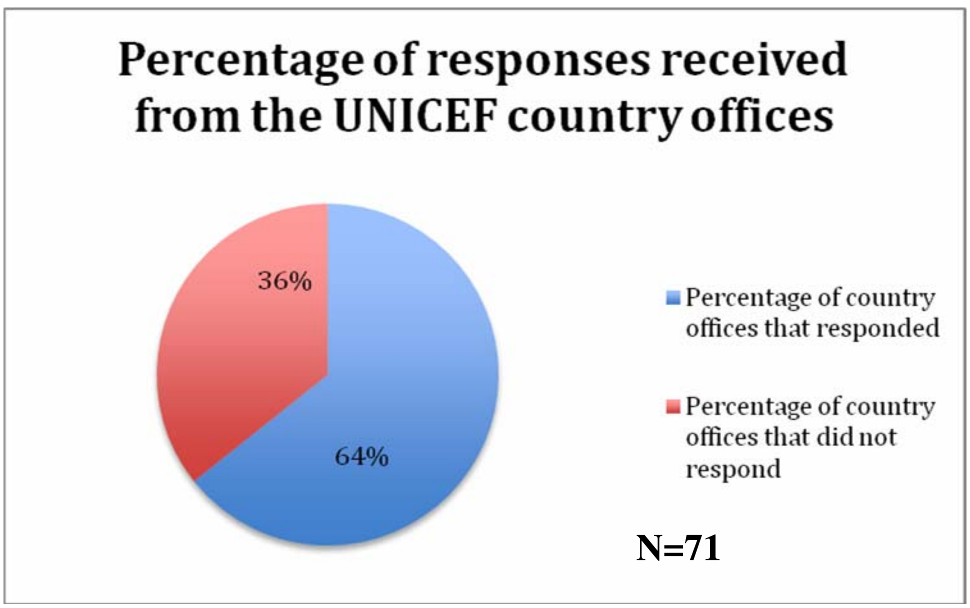

Figure 3.1: Pie-chart representing percentage of respondents to the UNICEF country level HWTS surveys

Results of the 45 respondent UNICEF country offices are summarized in this section. A table listing the available HWTS technologies in these 45 countries can be found in Annex VI. It is important to note that the UNICEF country office of a given country has provided the facts and all of the other information in this section. Section 3.3 provides an analysis of the UNICEF country office responses. The last section of Chapter 3 (Section 3.4) discusses salient points observed from the various responses.

UNICEF Country Office HWTS Questionnaire

1. **Country Name:**
2. **Population:**
3. **Population below poverty line (define a level in $ terms):**
4. **Population with access to an improved water supply at the sub-national level:**
5. **Known population with access to HWTS:**
6. **Available treatment technologies (please tick all that are applicable):**
    i. **Boiling**
    ii. **Flocculation/ Disinfection**
    iii. **Addition of bleach or chlorine**
    iv. **Water filter (ceramic, sand, composite, etc.)**
    v. **Solar Disinfection**
    vi. **Let it stand and settle**
    vii. **Any other (please specify)**
7. **In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):**
8. **Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):**
9. **Sales volume amongst low-income groups:**
10. **Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):**
11. **Most popular implementer and the technology promoted by them:**
12. **Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):**
13. **What help do you (country office) seek from the HQs for setting up a successful program for HWTS:**

3.2 Country Profiles

3.2.1 Country Profile: Afghanistan

Population: 24 million

Population below poverty line (define a level in $ terms) 80%

Population with access to an improved water supply at the sub-national level: Access to protected water sources in rural areas 18%. 80% of the population lives in rural areas in Afghanistan

Known population with access to HWTS: 10%

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine[5]

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Addition of chlorine, as it is available in local market

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No Response

Sales volume amongst low-income groups: Not known

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Ministry of Rehabilitation and Rural Development (MRRD), Ministry of Public Health (MOPH)

Most popular implementer and the technology promoted by them: MRRD and MOPH - chlorination

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Heavily depend on UNICEF for supplies, technologies and human resources, as the Government is very weak and does not have the required resources.

b. Access to communities in insecure areas (more than 60% of the area)

c. Concurrent drought and floods in different geographical locations

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

[5] Chlorine in this context means the specially manufactured hypochlorite solution or the chlorine tablets, for drinking water applications, whereas bleach is a commercially available chemical used for household or commercial disinfection/ cleaning.

Household water treatment is one of the priorities in 2009 and beyond. One of the planned interventions is to introduce simple household filters, which are affordable and can be manufactured locally. We are planning to collaborate with Center for Affordable Water and Sanitation Technology (CAWST)[6] to introduce household bio-sand filters. We request HQ to facilitate this process in the beginning of 2009.

[6] http://www.cawst.org/

3.2.2 Country Profile: Angola

Population: 18,685,632

Population below poverty line (define a level in $ terms): 62.2% (Angola MDG Report, 2005) (<1.7 USD/day; rate of 2001)

Population with access to an improved water supply at the sub-national level: No reliable data, though estimated at 53% (national).

Known population with access to HWTS: Not known

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. Water filter (ceramic, sand, composite, etc.): Few urban households use these
iv. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Boiling, bleach and HTH chlorine mother solution (easy to use and relatively low cost).

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Water filters/sand filters need replacement (which is not always available) at least once or twice per year but that depends on the water turbidity level.

Sales volume amongst low-income groups: 1,500 bottles of Certeza per week in Luanda (around USD1000), estimate for year, USD 78,000.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): National Water Directorate, 18 Provincial Water Departments, Population Services International (PSI)[1]/ United States Agency for International Development (USAID)[2], National Boy Scouts, Red Cross Angola

Most popular implementer and the technology promoted by them: Bottle of Certeza (commercial bleach at 1.5% concentration in a nice bottle, sold for USD 0.67) promoted by PSI/USAID

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Size of country (18 Provinces),

[1] http://www.psi.org/

[2] http://www.usaid.gov/

b. Transport routes (still mining problems),

c. Distribution and marketing capacity and related costs,

d. Willingness and capacity to pay (poor people)

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Information on promotional tools/social marketing best practices that can be replicated and on simple/low cost technologies; information/advocacy for potential partnerships with the private sector at the international level

3.2.3 Country Profile: Burkina Faso

Population: 14 millions (2008)

Population below poverty line (define a level in $ terms): 46.5 % in 2003

Population with access to an improved water supply at the sub-national level:

National: 72%; 66% for rural area and 97% in urban area (JMP – 2008).

Known population with access to HWTS: Not available

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Ceramic filters
v. Let it stand and settle
vi. Any other (please specify)

- Use of synthetic cloth (provided by Global 2000 for guinea worm eradication)
- Use of Abate® product to treat surface water (provided by Global 2000 for guinea worm eradication). [Author's Remark: not used in households]

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Depends on many factors (For example: capacity to buy/procure)

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Not available

Sales volume amongst low-income groups: Not available.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Ministry of Health through health centers, mainly in case of cholera outbreak

Most popular implementer and the technology promoted by them:

Health Centers: Addition of bleach or household chlorine products

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Situation analysis to start household water treatment campaign.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:
Guidelines, tools and training for an effective HWTS campaign.

3.2.4 Country Profile: Burundi

Population: 8,038,618

Population below poverty line (define a level in $ terms): 81% (international poverty line of USD1.25 per day in 2005)

Population with access to an improved water supply at the sub-national level: 71% as per the State of the World's Children 2009[1]

Known population with access to HWTS: No response

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Boiling is the most and large widely used technology because it is available at each household even in urban or in rural areas.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): N/A

Sales volume amongst low-income groups: N/A

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): PSI (Population Services Information)

Most popular implementer and the technology promoted by them:

PSI–Water treatment using household chlorine products.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Ensuring water treatment at the household level particularly in endemic cholera outbreak area.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Providing technical support and financial resources

[1] http://www.unicef.org/sowc09/

3.2.5 Country Profile: Cambodia

Population: 13. 4 million

Population below poverty line (define a level in $ terms): 34.7% (a poverty line of USD 0.45 per day)

Population with access to an improved water supply at the sub-national level: 53.7%

Known population with access to HWTS: 80% (Cambodia Demographic and Health Survey, 2005)

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Ceramic pot filer and Bio-sand filter
v. Solar Disinfection
vi. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency)

- Ceramic Filter – Due to both availability and efficiency

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement)

- Monthly maintenance: scrub ceramic element to unclog pores and wash receptacle tank to prevent bacterial growth
- The ceramic element has an average lifespan of two years.
- Receptacle and spigot are expected to last five years.

Sales volume amongst low-income groups

Based on IDE (International Development Enterprise – one of the two major manufacturers of ceramic filters in Cambodia) data – total sales volume in 2006 was 25,000 units– of which roughly 80 percent was amongst low-income groups.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

NGOs :

- RDI[1] (Resource Development International) and IDE[2] (International Development Enterprise), Cambodian Red Cross – Ceramic Filters,
- Samaritan Purse, Church World Service[3] and their local NGO partners – Bio-sand Filters
- ADRA[4] (Adventist Development and Relief Agency): SODIS

Government Agency:

- Department of Rural Water Supply, Ministry of Rural Development

Private implementers:

- Retailers selling commercial water filters mostly manufactured in Vietnam, Korea and China

Most popular implementer and the technology promoted by them

- RDI and IDE – ceramic filter

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Reaching the poorest: The ceramic filters are still unaffordable for the poorest, hence findings ways to support these families without distorting the supply chain being promoted by the manufacturer remains a challenge.

b. The Government has so far been focusing on provision of access to water supply, HWTS is a relatively new area. There is practically nobody with necessary skills or with the experience within the Government to promote HWTS. UNICEF Country Office is making efforts to promote this as a priority area now that access to water (in terms of quantity) has made significant progress. Formulating the most appropriate support to the Government – one that has the right balance between software and hardware – as well as creating an enabling environment is still a challenge.

[1] http://www.rdic.org/home.htm

[2] http://www.ide-cambodia.org/

[3] http://www.cwscambodia.org/

[4] http://www.adracambodia.org/

c. Many HWTS reference documents are about promoting the production and marketing of purifying matters such as chlorine – which is still difficult to apply in Cambodia.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

a. Technical support for setting up a HWTS programme as part of the WASH Project based on the country's specific needs;
b. Tailor-made training modules for promotion of HWTS
c. Generic and adaptable HWTS promotion materials

3.2.6 Country Profile: Central African Republic

Population: 4,302,360

Population below poverty line (define a level in $ terms): 67%

Population with access to an improved water supply at the sub-national level: 30%

Known population with access to HWTS: 3.8% (1.4% rural vs. 7.3% urban)

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Ceramic Water filter: Tried by Action contre la Faim (ACF International)[1] in Ouham Prefecture but not successful. Technical competency not sufficient to make ceramic filters

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Bleach or household liquid chlorination product at 3.3% chlorine concentration or chlorine tablets (Aquatabs)

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Household chlorination depends on available stocks from implementers (NGOs)

Sales volume amongst low-income groups: Not Known

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): UNICEF, Solidarites, ACF, International Rescue Committee (IRC)[2], International Medical Corps (IMC)[3], Triangle GH, Red Cross France, Medecins Sans Frontieres (MSF)[4] Groups, Mercy Corps, General Directorate of Hydraulics, and Centre Régional pour l'Eau Potable et l'Assainissement à faible coût (CREPA)[5]

Most popular implementer and the technology promoted by them:

- Chlorination is done through distributions of Aquatabs by NGOs.

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[1] http://www.actionagainsthunger.org/who-we-are/acf-international-network

[2] http://www.theirc.org/

[3] www.imcworldwide.org/

[4] http://www.msf.org/

[5] http://www.reseaucrepa.org/

- ACF tried the ceramic filters in Internally Displaced Person (IDP) families in Markounda – Ouham Prefecture but there was no good success due to lack of competent technicians in making the ceramics

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

a. Population not well informed (educated, sensibilized) on importance and possible methods of household water treatment and storage.
b. Populations not having enough collecting and storage containers.
c. Not enough stocks of water treatment tablets (Aquatabs) by families.
d. Insecurity in certain geographical areas hinders promotion of HWTS despite implementers having resources.
e. The private sector not well established in locally manufacturing Aquatabs, and/or water treatment chemicals. All is imported, and therefore a barrier to poor population to purchase water treatment chemicals such as bleach.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:
Apart from the obvious financial resource, UNICEF Bangui would like to look again into the possibility of making ceramic filters at local levels as previously tested by ACF in Ouham Prefecture. We would need experienced technical support from any successful regions/countries.

3.2.7 Country Profile: P.R. China

Population: 1.32 billion (Estimated 2007) (Source: National Bureau of Statistics of China, 2008)

Population below poverty line (define a level in $ terms): 135 million (under USD 1 per day) (Estimated 2007) (Source: The State Council Leading Group Office of Poverty Alleviation and Development, 2007)

Population with access to an improved water supply at the sub-national level: 66% of rural population as of 2008 (Source: Ministry of Water Resources, 2008)

Known population with access to HWTS: Main technology used in China is boiling, very small portion of population in remote areas in the northwest of the country are using disinfection, water filter and settlement.

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (ceramic, sand, composite, etc.) [Author's Remark: Water filters to remove Arsenic or Fluoride]
v. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Boiling water in rural area is the traditional practice. Almost all the people use it. Other technologies are only used in special cases, such as in the areas with serious water pollution, with no water supply system, etc. They are not used commonly.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No official data available

Sales volume amongst low-income groups: No official data available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Ministry of Water Resources, Ministry of Health, No NGOs and private sector data

Most popular implementer and the technology promoted by them

Ministry of Water Resources, Ministry of Health, including their subordinate agencies, such as China Centre for Disease Control and Prevention (CDC)[1], Institute of Health Education, private companies are all involved in the works for technology promotion. From the health sector, especially the health promotion units are mainly promoting

[1] http://www.chinacdc.net.cn/n272442/n272530/index.html

boiling water. Many filtration systems, big and small, are also manufactured by companies using sand filters, Reverse Osmosis (RO) and membrane technologies etc.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

Due to the specific situation in China, boiling of water is the dominating practice in rural areas. The challenges are:

- People do not like the smell of chlorine therefore chlorination is not welcomed;
- Household filtration unit is usually expensive and cannot be afforded by the rural farmers, e.g. treatment unit to remove fluoride and arsenic.
- Technologies for further treatment of the sludge from the arsenic removal unit are not available.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Information about approaches and affordable technologies to be introduced. Funding for piloting these technologies for areas having biological contamination problems or chemical contamination problems (such as arsenic and fluoride) is welcomed from the HQs. Technical and financial support from the HQs to conduct a survey on the same.

3.2.8 Country Profile: CONGO / Brazzaville

Population: 3,695,579

Population below poverty line (define a level in $ terms): 50.1%, meaning that half of the Congolese population lives in poverty to below USD 1 per day.

Population with access to an improved water supply at the sub-national level: Service rate in urban areas 45% and 15% in rural areas.

Known population with access to HWTS: 1,600,000

Available treatment technologies

i. Flocculation/ Disinfection
ii. Addition of bleach or chlorine
iii. Water filter: Bio-sand

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): The most successful technology in rural areas remains boiling water. The bio-sand filters with the ferro-cement (concrete) containers are less easy to manufacture, handle and maintain.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Maintenance is required two times per month and after two years the bio-sand filters need replacement. The ferro-cement containers also need to be substituted after ten years.

Sales volume amongst low-income groups: Sales volume is not considered to be very important because of the low-income groups.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Association de l'éducation En Milieu Ouvert (AEMO), CREPA, Comités locaux de Développement (CLD) Madibou

Most popular implementer and the technology promoted by them: The most popular are the ferro-cement bio-sand filters promoted by AEMO

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- The major challenges faced by the UNICEF country office and the government is to give access to clean drinking water to people so they can enjoy basic services in the water sector.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

The Congo is not a UNICEF priority country and has a penalty for funding to compete with some projects because of that. We want funding to develop HWTS strategies with partners.

3.2.9 Country Profile: Côte d'Ivoire

Population: 20.6 million inhabitants

Population below poverty line (define a level in $ terms) 48.9% (<USD 470/yr)

Population with access to an improved water supply at the sub-national level: 65%

Known population with access to HWTS: Not available

Available treatment technologies

i. Flocculation/ Disinfection (PUR)
ii. Water filter: Sand and Ceramic
iii. Let it stand and settle
iv. Any other (please specify): Cloth and pipe filter

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Water filter (ceramic, sand), cloth and pipe filter

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Water filter (ceramic, sand,) needs maintenance and replacement every year; cloth and pipe filter need maintenance and replacement every six (6) months.

Sales volume amongst low-income groups: 1,115,200 sachets PUR were distributed through community networks

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Medical Assistance Programs (MAP)[1] International (bio-sand filter), CARE[2] International Côte d'Ivoire (PUR), NCHRIST (ceramic), PSI (chlorine tablet)

Most popular implementer and the technology promoted by them: MAP International (bio-sand filter), CARE International Côte d'Ivoire (PUR), NCHRIST (ceramic)

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)
Acceptance and availability of the products (PUR) on the local market and the scaling-up

What help do you (country office) seek from the HQs for setting up a successful program for HWTS :

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[1] http://www.map.org/site/PageServer

[2] http://www.care.org/

WASH Côte d'Ivoire seeks technical assistance to design and implement a comprehensive HWTS program for the next five (5) years within the current program cycle 2009-2013, set up fundraising strategies, advocacy for strong ownership of HWTS by the government and the rural population.

3.2.10 Country Profile: DPR Korea

Population: 23,464,000

Population below poverty line (define a level in $ terms): Not defined

Population with access to an improved water supply at the sub-national level:

The National Nutrition Survey 2004 found that the majority of the population (82 %) relies on piped water systems for its water supply. However, a 2004 UNICEF baseline survey undertaken in three focus counties found that 59% of the population had six hours or less of water supply during the day, which is a result of aged and non-functioning water supply systems. However, more accurate and disaggregated data is not available.

Known population with access to HWTS: Not known

Available treatment technologies

i. Boiling
ii. Flocculation/ Disinfection

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Boiling is the most commonly used HWTS method; Due to high education level of communities, people are aware that they need to boil water before drinking.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No data available. In DPR Korea, carrying out KAP (Knowledge Attitude and Practice) surveys are nearly impossible and we do not have details on practice.

Sales volume amongst low-income groups: No data- no market economy for this market segment

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): There are 4 European NGOs (SC-UK, Concern, Triangle, GAA) and IFRC/RC working in WASH field. UNICEF is lead in introducing the concept of point-of-use water treatment through ceramic filters.

Most popular implementer and the technology promoted by them:
Piped water supply through gravity-fed systems is the most widely promoted water supply system in the country. Boiling of water is commonly promoted. All partners have same level of promotion. All partners have very limited access to communities for promoting practice-related issues.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

We have managed to demonstrate ceramic filters to Government partners/NGO partners and they are convinced of the applicability of this technology.

Three Semi-governmental institutions produced filters with similar concept as the Cambodia ones (smaller hole sizes so water passes) which are under testing in Cambodia for quality control. Based on test results, we will try to strengthen local production of filters

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

We are doing fine and regional office support and neighboring country supports in terms of experience exchange is enough.

- Headquarters may guide in providing advocacy to infuse ceramic filters into WASH in schools and heath programs at the global level.
- Headquarters may also position ceramic filters as part of Emergency preparedness and response.

3.2.11 Country Profile: Democratic Republic of Congo (DRC)

Population: 66 million

Population below poverty line (define a level in $ terms):
2.5 million people in Kinshasa live on less than USD 1 per day. In some parts of eastern DRC, people are living on USD 0.18 per day.[1] 41% of total population[2] are below poverty line.

Population with access to an improved water supply at the sub-national level:

Less than 46% of the population has access to safe and clean water, 29% in rural areas (UNDP Report, 2005),

Known population with access to HWTS:

The following information is available as of October 2008:

- 15K households using chlorination to treat water in Goma, North Kivu
- 720 households benefiting from bio-sand filters in Uvira, South Kivu
- 8,000+ households utilizing PUR sachets in the Kinshasa area
- 800K+ population targeted for social marketing of PUR sachets in Kasai Occidental (chlorine also available in stores)

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (bio-sand)
v. Solar Disinfection

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
According to information collected in the fall of 2008, water purification tablets (PUR and Aquatabs) are the most common form of treating water. The cost is acceptable to the population (also distributed heavily to displaced populations during conflicts in this country) and 99.99% efficient.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No data available.

[1] http://www.globalissues.org/article/87/the-democratic-republic-of-congo

[2] http://www.dfid.gov.uk/pubs/files/DRC-countryplan08-10.pdf

Sales volume amongst low-income groups:
Aquatabs® are sold to consumers at roughly the cost recovery price of 250 FC (USD 0.50) for a strip of 8 tabs that can treat 160 liters of water.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): PSI and UNICEF

Most popular implementer and the technology promoted by them:
Aquatabs (as well as PUR sachets) when Aquatabs are not available in country.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- Scaling up on activities.
- Convincing households to purchase the product to improve currently used surface water.
- Ensuring that the poor have sufficient financial means to purchase the product.
- The support of a social marketing and community approach expert would be beneficial.
- High unit cost of the pilot model limited the scaling up of product selling without proper financial support.
- Maintenance of the bio-sand system looks complicated for a typical household
- Specific sand needs to be used in order for the bio-sand filter to work properly. Difficult to locate in this part of country
- Lighter filter could be developed particularly when dealing with transport to very rural communities

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

- Trainings
- Written materials (preferably in French)
- Examples of HWTS available for trainings

3.2.12 Country Profile: Djibouti

Population: 720,000

Population below poverty line (define a level in $ terms) USD 3/day

Population with access to an improved water supply at the sub-national level: 51%

Known population with access to HWTS: No data available. Survey will be conducted

Available treatment technologies

i. Boiling: Used by households during cholera outbreaks
ii. Flocculation/ Disinfection: Yes in urban areas
iii. Use of water filter (ceramic, sand, composite, etc.): Not yet, but planned in early 2009 with support from USAID

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): No data available

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No data available

Sales volume amongst low-income groups: No response

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Office National des Eaux de Djibouti (ONEAD) (National office in charge of water in urban area), CERD (research center) and Direction Epidemoilogie et de l'information Sanitaire (DEIS) (Health Directorate in charge of epidemiological surveillance)

Most popular implementer and the technology promoted by them: chlorine

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Household water treatment is used only during cholera outbreaks jointly by ONEAD and DEIS with financial support of UNICEF through procurement of chlorine

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:
The routine water quality monitoring/surveillance system put in place in the 2008 fourth quarter has shown that:

- In rural areas most of the physico-chemical quality of sources and systems used for drinking water is irrevocably not up to recommended WHO guideline values.

- In semi urban areas, water collected from safe water is likely to become fecally contaminated.

In response to this situation, UNICEF Djibouti has HWTS as one of its priorities. Support is needed from HQ in the following areas:

- **Documentation** (here, we appreciate the continuous support of our colleague Femi)
- **Training course for WASH staff** as well as others opportunities for government partners mainly in French speaking countries. (Here, we appreciate the support from our colleague for the RO office Pierre Fourcassie)
- **Fundraising resources** to promote and disseminate the HWTS mainly in the most populous peri-urban area with about 70% of the population living in Djibouti city[7].

[7] 85% of the population of Djibouti are living in the capital

3.2.13 Country Profile: Eritrea

Population: Government Data= 3.5 Million , UN Data = 4.2 Million

Population below poverty line (define a level in $ terms) = 70%

Population with access to an improved water supply at the sub-national level: Rural 59.7%

Known population with access to HWTS: 500 households from 3 communities of Maekel.

Available treatment technologies:

- Water filter (ceramic, sand, composite, etc.): slow sand filter

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Availability

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Every 6 months

Sales volume amongst low-income groups:
The slow sand filters were not sold to communities and were placed among low-income families

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Private company implementing on behalf of the Water Resources Department

Most popular implementer and the technology promoted by them:
The government through the Water Resources Department implements all water projects

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

Rural communities are very poor, they have the war wounded to look after and many, as a result of the war, are women-headed households. Rural communities can supply labor and locally available materials, but they cannot afford to buy things like cement, ceramic filters etc

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

In Southern Red Sea (SRS) Region, we have a major problem in that all the fresh water wells and boreholes have been dug/drilled, however there is still a need for safe drinking water. UNICEF and the Water Resources Department are interested in getting water from saline wells and through a process of distillation turning it into fresh drinking water. We would like help:

- To understand the extent of the problem in SRS – how many wells are affected by saline intrusion from the Red Sea (no study or survey has been undertaken in the region) and
- Technical assistance to develop low cost distillation plants or other appropriate methods of converting saline water to fresh drinking water at a household level.

3.2.14 Country Profile: Ethiopia

Population: Approx. 77 Million (2008)

Population below poverty line (define a level in $ terms): The latest figures show that this has reduced from 48% in 1990/91 to 34.6% in 2006/07

Population with access to an improved water supply at the sub-national level:
According to the government data, the national average for access to safe rural water supply is over 52% (WASH Joint Technical Review, Ethiopia, October 2008)

Known population with access to HWTS:
No documented data. However, in response to the 2007/2008 emergencies in Ethiopia (mainly Accute Watery Diarrhoea (AWD)), more than 3 million sachets of water purification chemicals (PUR, Watermaker, Chlorfloc, Water Guard – disinfectant solution) have been distributed to affected populations in various regions of the country by UNICEF alone. The use of the combined flocculant/disinfectant by the emergency-affected people lasts mostly for a short period, usually for up to 3-6 months.

Available treatment technologies

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (ceramic, sand, composite, etc.)
v. Solar Disinfection

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Chlorine disinfectant because of social marketing by PSI and lower cost (USD 0.06 per bottle which treats about 1000L of contaminated water) as well as combined flocculants/disinfectant because of free distribution for emergency use + social marketing by PSI.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No documented data

Sales volume amongst low-income groups:
PSI alone through commercial outlets has sold the following quantities (source is PSI Ethiopia)

- Water Guard
  - 422,228 bottles in 2006 (the volume of 1.25% chlorine in a bottle is 150 ml)
  - 539,414 bottles in 2007
  - 1,779,294 bottles in 2008; Total in 3 years = (2,740,936 bottles)
- PUR
  - 480,000 sachets in 2006

- 835,680 sachets in 2007
- 2,959,706 sachets in 2008; Total in 3 years = (4,275,386)

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

- PSI for PUR and Water Guard
- Regional water and health bureaus (PUR, Watermaker, Chlorfloc, Water Guard)
- Ethiopian Kale Heywet Church, Samaritan Purse and Catholic Relief Service (Bio-sand Filters)

Most popular implementer and the technology promoted by them:

- PUR + Water Guard by PSI Ethiopia
- Bio-sand Filters by Kale Heywet church and Catholic Relief Service (CRS)

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

Although combined flocculant/disinfectant chemicals are widely accepted by beneficiary communities, cost of these supplies (USD 0.06/sachet treating 10 or 20 L only) is prohibitively high for continued use by most users. In addition, not adequate emphasis is being given by the implementing partners for the awareness on safe storage and handling practices of water treated by such products.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

- Currently, there is work in progress by a Technical Committee (TC) on Household Water Treatment and Safe Storage established at the end of the October 2007 HWTS International Network to Promote HWTS meeting to expedite the actions proposed under the forum. The Technical Committee has developed a draft Terms Of Reference (TOR) on HWTS, the specific objectives of which are: *(a) to encourage the coordination of HWTS through the appointment of high-level governmental official to coordinate HWTS issues and initiatives horizontally across ministries and vertically through other levels of government, including woredas and kebeles* [Administrative levels] *and (b) to advance a collaborative HWTS strategy within the sub-sector of water, sanitation and hygiene.* The TOR identifies a number of specific activities to be implemented by the TC.
- Secondly, in an effort to support the development of low-cost household water supply (self-supply) options in Ethiopia, promotion of household water treatment and safe storage options is considered as a complementary activity that ensures safety of household water supplies. In this regard, UNICEF has finalized the development of TOR for benchmarking "Standards for Self Supply" (family wells). The purpose of the study is to develop practical guidelines and a means of measurement for Self Supply (family wells); based on sanitary surveillance; facilitating its recognition and support by government in the context of the "Universal Access Plan"; and in this context, establishing the potential of HWTS as a related hygiene intervention.

At this point, no additional support is required from HQ beyond perhaps a collation of country examples of how HWTS was organized and what were the driving forces- i.e, advocacy papers. The start-up of the Technical Committee and commitment has been rather weak in Ethiopia, reflecting the poor coordination between the Ministries of Health, Education and Water. HWTS is still seen as an emergency and temporary intervention and not something which could be used in a complementary fashion to the provision of portable water supply.

3.2.15 Country Profile: The Gambia

Population

The Gambia has a small size population of 1.36 million people with an annual growth rate of 2.8 per cent. Women and children represent 51 per cent and 45 % of the population respectively

Population below poverty line (define a level in $ terms):

The proportion of the population living less than $1 per day is 59 in 2005(State Of World's Children Report, 2008).

Population with access to an improved water supply at the sub-national level:

At national level 82% of the population has access to improved water supply, 91% in urban and 81% in rural

Known population with access to HWTS:

In 2006, 286,000 people, (22% of the population) is practicing some form of household water treatment with 3% using bleach/chlorine and 19% use cloth to strain water (Multiple Indicator Cluster Survey 2005/2006 Report)

Available treatment technologies:

i. Boiling
ii. Addition of bleach or chlorine
iii. Water filter- this mainly cloth
iv. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):

The common methods are bleach/chlorine and use of cloth to strain water. This is because these methods are not costly and are readily available in every village. They are also culturally acceptable

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):

There has not been any assessment of these technologies to measure their efficiency. However, these technologies have been in use for many years.

Sales volume amongst low-income groups:

The country does not yet have any organized group or institution dealing into HWT. Few dealers mainly for swimming pool disinfections mainly import chlorine from Senegal. Bleach is available in local shops in sachets mainly for laundry and cleaning of floor surfaces. UNICEF and water sector is promoting its use for HWT. Within the public private partnership with a local soap industry for hand washing, plans are made to incorporate bleach. This we hope will create market for the bleach.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

We are yet to have any NGO or private sector implementing HWT. We engage government institutions and Red Cross volunteers for community sensitization on HWT

Most popular implementer and the technology promoted by them

They mainly promote use of bleach and chlorine

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Lack of technical know how on some of the effective technologies of HWT
b. No specific organizations implementing HWT at community level
c. No national HWT guidelines, protocols and standards
d. Limited markets for HWTS products like chlorine
e. Poverty of households
f. Lack of private sector participation

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

- Training /capacity development on some of the efficient HWT technologies
- Guidelines and protocols
- Training on promotion of HWTS
- Establish link with institutions in HWT

3.2.16 Country Profile: Guatemala

Population: 13.4 million

Population below poverty line (define a level in $ terms) 15.2%

Population with access to an improved water supply at the sub-national level: 59.5%

Known population with access to HWTS: 74.6% national level.

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. Water filter (ceramic, sand, composite, etc.)
iv. Solar Disinfection

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency) Bleach or chlorine. Cost is low. Availability in all the country. Efficiency is high.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No data available

Sales volume amongst low-income groups: No data

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

- NGOs: 1. International Plan, 2. World Vision, 3. Solar Foundation.
- Government: Instituto de Fomento Municipal (INFOM)[1] and Ministry of Health. Environment Social Cabinet

Most popular implementer and the technology promoted by them:
International Plan, Addition of bleach or chlorine in rural areas.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- Promoting health schools to encourage uptake and behavior change
- Involve communication and social change. Seek integration with governments and civil society to promote and advocate.
- Government assume the sector role in WASH activities.

[1] http://www.infom.org.gt

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

- Technical assistance to improve the activities in the country.
- Increase the visibility to Latin American Countries region. We have great necessities in WASH.

3.2.17 Country Profile: Guinea-Bissau

Population: 1.6 million

Population below poverty line (define a level in $ terms) two thirds of the population lives with less than USD 2 per day

Population with access to an improved water supply at the sub-national level: according to MICS 2006, 59.9% of population has access to improved water supply

Known population with access to HWTS: According to KAP study (2007), 75% apply some HWT

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. Any other (please specify): Cloth filter

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency) Only addition of bleach and boiling promoted by UNICEF

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Daily disinfection of water designated for drinking; without financial support from UNICEF to population (free distribution of bleach only during cholera epidemic)

Sales volume amongst low-income groups: Not Available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): NGO's: Ajuda de Desenvolvimento de Povo para Povo (ADPP)[1], CREPA, NADEL, EAPP; Ministry of Health, WHO

Most popular implementer and the technology promoted by them: Disinfection with bleach by Ministry of Health

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

1. Ministry of Health promoted in previous years the disinfection with lemon; consensus achieved for bleach disinfection

[1] http://www.adpp-gb.org/default.asp

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

- Staff and funds

3.2.18 Country Profile: Haiti

Population: 8.5 million

Population below poverty line: 4.4 million (Less than USD 1 per day)

Population with access to an improved water supply at the sub-national level: 54%

Known population with access to HWTS: Not available.

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Use of water filter (ceramic, sand, composite, etc.)
v. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Chlorination because it was taught after various disasters

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement)

- Chlorination: Efficiently practiced when the need is clearly perceived.
- Filters: Parts not easily available
- Boiling: Practiced in rural settings, only where promotion activities have introduced it.

Sales volume amongst low-income groups: Not Available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): ACF, Oxfam GB, Oxfam Intermon[1], Red Cross, MSF, Agency for Technical Cooperation and Development (ACTED)[2], WHO, CEPA, Service National d'Eau Potable (SNEP), Centrale Autonome Métropolitaine d'Eau Potable (CAMEP)[3]

Most popular implementer and the technology promoted by them: ACF--Chlorination

[1] http://www.intermonoxfam.org/

[2] http://www.acted.org

[3] camephaiti.unblog.fr

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

1. Weak capacity of government agencies, Costs of some technologies, Non-availability of parts (e.g. filter candles)

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

- Technical assistance and funding to scale up program

3.2.19 Country Profile: Honduras

Population: 7,788,296 inhabitants, as estimated by the Instituto Nacional de Estadísticas (INE) on the basis of the population Survey 2001.

Population below poverty line (define a level in $ terms) 59.2% in terms of the income required to buy basic goods for living ("canasta básica": basic goods basket), with an estimated cost of 1,834 Lempiras (USD 97.04) a month for one person.

Population with access to an improved water supply at the sub-national level:

According to the national official figures, the coverage in water supply is 78% at national level, including 92% in the urban areas, and 67% in the rural areas. The JMP (UNICEF – WHO) estimates coverage of 84% at national level, including 95% in the urban areas, and 74% in the rural areas, on the basis of the same national statistics.

Known population with access to HWTS: Not data available

Available treatment technologies

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (sand)
v. Solar Disinfection

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Innovative initiatives like Solar Disinfection (SODIS Project) and bio-sand filters are being promoted. To my point of view, those are the best alternative solutions in terms of cost, availability and efficiency.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement)

Please get in touch with the Engineer Maria Regina Inestroza from the NGO Agua Pura para el Mundo (Pure Water for the World): aguapurahn@gmail.com. They promote bio-sand filters and can provide more detailed information about their experience. Regarding SODIS, please contact Eng. Ángel Alvarado: sodishon@fundacionsodis.org for further information about the experience with SODIS. You can also see: www.fundacionsodis.org

Sales volume amongst low-income groups
No data available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

Agua Pura para el Mundo, Rotary Club, Fundación SODIS, CARE (Project CARE PASOS), Ayuda en Acción, Ministry of Health.

Most popular implementer and the technology promoted by them

Agua Pura para el Mundo, Rotary Club: bio-sand filters
Fundación SODIS, CARE (Project CARE PASOS), Ayuda en Acción, Ministry of Health: Solar Disinfection.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

UNICEF Honduras is beginning with the incorporation of SODIS and the promotion of bio-sand filters at community and household level. Co-operation Agreements are being signed with the above-mentioned NGOs. The first challenge is to ensure the appropriation of the technologies by the supported communities, in the framework of a pilot experience, which will be started in the current year.
On the basis of the results obtained, advocacy and knowledge dissemination among the different actors of the sector should be the aim.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

- Any kind of technical advice will be welcomed. We are also open to any kind of exchange.

3.2.20 Country Profile: India

Population: 1.1 billion

Population below poverty line (define a level in $ terms): No response

Current estimates of population below the poverty line: In India range from 26-44%,

Population with access to an improved water supply at the sub-national level:
Total coverage: 42 %
Urban: 71%
Rural: 27.9%

Known population with access to HWTS: NA

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Use of water filter (ceramic, sand, composite, etc.)
v. Solar Disinfection
vi. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Across India groundwater via handpumps (India Mark Ii and III) is the predominant source of drinking water. However in recent years several factors have resulted in the quality of the water being contaminated. The problem is being addressed by finding alternative sources for chemical contamination and behavioral change for bacteriological contamination.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
Most of the hand pumps are of considerable age, and this is becoming an increasing problem in many states of India.

Sales volume amongst low-income groups:
The cost of HWTS is probably the largest stumbling block for the idea to gain ground in India.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
The known implementers:
Department of Drinking Water Supply, Government of India- www.ddws.gov.in
UNICEF India: www.unicef.org/india

Plan India
WaterAid
UN HABITATI
Ministry of Urban Development

Most popular implementer and the technology promoted by them:

The Department of Drinking Water Supply(www.ddws.gov.in), of the Ministry of Rural Development, Government of India, has a wide reach through its Accelerated Rural Water Supply Programme which primarily promotes groundwater via hand pumps, as well as piped water supply schemes, to ensure water supply in rural areas, which has reached a coverage of around 88%.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

The two biggest challenges are

1. the operation and maintenance of existing schemes, either handpumps or piped schemes, and
2. the feasibility of new large piped schemes and the contamination of groundwater.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

The level of bacteriological contamination at handpumps is an indication of the risk, which also exists for HWTS. With proper hygiene around handpumps the high level of contamination could be reduced considerably. It will be equally difficult to ensure proper handling and use of any HWTS. Households' appreciation of the dangers of contaminated water and the ways to prevent contamination is limited.

3.2.21 Country Profile: Iraq

Population: 29,682,081 (As per 2007 estimate made by COSIT[1])

Population below poverty line (define a level in $ terms): Not available

Population with access to an improved water supply at the sub-national level: 72.5%

Known population with access to HWTS: Less than 20%[2]

Available treatment technologies[2]:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (ceramic, sand, composite, etc.)
v. Let it stand and settle
vi. Any Other (Reverse Osmosis)

In case of multiple technologies, cite the most successful one and also the reason for success (cost / availability / efficiency):

- About 9% of population use "Let it stand and settle" since it is cheap[2];
- About 5% of population use "Boiling" also because it is cheap and affordable[2];
- About 4% of population use "Addition of Bleach/Chlorine" [2];
- Slow and rapid sand filtration (figures are not available);
- Neutralization with lime (figures are not available);

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Not available

Sales volume amongst low-income groups: Not available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

- Maintenance departments of water directorates;
- Private contractors;

Most popular implementer and the technology promoted by them: Not available

[1] Central Organization for Statistics and Information Technology

[2] Obtained from MICS3 (2006)

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. The government is planning for universal water coverage in urban and rural areas, but the main challenge is inadequate annual investment budget (since 2004, ministries often receive less than half of their annual planned budget);
b. A challenge from the government and other agencies is to raise the awareness of people to use simplified household water treatment methods in the absence of sustainable potable water source;
c. Advanced HWTS are not likely to be adopted by the population lacking sustainable water sources due to the low economy level and lack of power required to run some of such systems;
d. Security conditions and unsafe working environment;
e. Lengthy and poorly organized procedures within the Water Directorates and the concerned ministries;

What help do you (country office) seek from the HQs for setting up a successful program for HWTS?

- Available low cost (economic) and easy-to-use water treatment technologies.
- Awareness materials from successful awareness programmes.

3.2.22 Country Profile: Kenya

Population: 34,707,817

Population below poverty line (define a level in $ terms): 44%

Population with access to an improved water supply at the sub-national level: No response

Known population with access to HWTS: 60% of the population reported that they are doing something to improve quality of their drinking water

Available treatment technologies

i. Boiling
ii. Flocculation/Disinfection
iii. Addition of bleach or chlorine
iv. Water Filter: (ceramic, sand, composite, etc.)
v. SODIS
vi. Let it stand and settle
vii. Any other (please specify): Muringa tree/seeds

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Addition of bleach or chlorine because its cost effective and available due to strong social marketing structure in place.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):

The most popular ones are the ones with low maintenance costs/needs.

- Boiling - no maintenance except washing the container used for boiling
- Flocculation/ Disinfection – washing of flocculants after every use
- Addition of Bleach or Chlorine – very minimal maintenance – washing of container
- Use of water filter (ceramic, sand, composite, etc.) – Frequent washing of the filter base required.
- Solar Disinfection – washing of Pet bottles
- Let it stand and settle – washing off settled sediment

Sales volume amongst low-income groups):

- Average monthly sales of PUR by PSI in 2006: 200,000
- Average monthly sales of *WaterGuard* by PSI in 2006: 60,000

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

- Ministry of Public Health & sanitation
- CARE Kenya
- Kenya Water for Health Organization (KWAHO)[1]
- Medipharm
- PSI Kenya
- Eastleigh Community Centre
- Chujio Water filters
- Vestergaard
- Kenya Moringa tree Foundation
- New life International

Most popular implementer and the technology promoted by them: PSI: *WaterGuard*

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- There is no national policy guidelines/ strategy for HWT
- Partners and government have not been adequately sensitized on the importance of HWT
- Some technologies are expensive for the most vulnerable population

What help do you (country office) seek from the HQs for setting up a successful program for HWTS?

- Network WASH professionals at global, regional and country level
- Active in emergencies and development
- 'Communication for behavior change' expertise
- Inter-sectoral expertise (health, education, HIV/AIDS)
- Support at national, sub-national and local levels
- Global monitoring: JMP (with WHO)
- Use in emergencies and in developmental settings: but different approaches
- Promote the practice, products and approaches that work, not specific products or methods
- Work in partnership; learning together

[1] www.kwaho.org/

- Stimulate demand, and market response
- Prioritize capacity building
- Contribute to the International HWTS Network
- With partners, bring HWTS into global fora
- Coordinate efforts with other support agencies
- Recognize HWTS in global sector monitoring
- Advise and encourage Country Offices
- Increase the use of the evidence base
- Promote HWTS in other sectors: education, health
- Bring global expertise to UNICEF's support
- Stimulate private sector participation and promote social marketing approaches
- Stimulate increased donor funding for HWTS
- Documentation and dissemination of best practices
- Build on existing initiatives
- Learn, plan, implement with partners
- Get Government on board
- Basic learning: pilot projects (if needed)
- Support scaling up:
- Stimulate private production and marketing
- Stimulate household demand
- Broaden the range of products
- Raise additional funds for HWTS promotion
- Work with social marketing organizations
- Promote HWTS in other sectors: education, health
- Continued learning, with partners
- Join the International HWTS Network

3.2.23 Country Profile: Madagascar

Population: 19.159 millions (in 2006)

Population below poverty line (define a level in $ terms): 61% less than USD 1/day, 2006

Population with access to an improved water supply at the sub-national level:
JMP reference: Urban access: 76% and rural access: 36%

Known population with access to HWTS: not estimated,

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter: Ceramic candle filter
v. Solar Disinfection
vi. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency)

Boiling is the well-known in the country as water is boiled in the pot where rice has been cooked. It gives taste when drinking it. Cost is difficult to estimate and boiled water available 2 to 3 hours after rice is cooked. It is important to know that rice is the main food in Madagascar. Bacterial analysis shows that the boiled water is free from bacteria. Culturally 90% of the total populations drink 'Ranon AMPANGO' (Water boiled in the cooked rice pot or rice juice)

On the other hand, Population Services International PSI/Madagascar, introduced in 2000, a purification solution in Madagascar, marketed under the brand name *Sûr'Eau*. A smaller bottle of 150ml was developed in 2004 with higher concentration of sodium hypochlorite (1.64%) that reduced production costs, by more than 50%, to USD 0.185 per bottle.

The study using methodologies of the "Tracking Results Continuously (TRaC)", implemented by PSI Madagascar in 2006, shows the health impact of interventions: 29.9% of target group cited *Sûr'Eau* as an effective way to prevent diarrhoea and 9.7% use *Sûr'Eau* regularly, which means 425,000 families using safe water through *Sur'eau* in 2007. This situation increased in 2008 to 40% of the population. *Sur'eau* is also used for washing vegetables. The use of *Sur'eau* is mainly due to the promotion, the notice of the product developed in the local language and its quality to be friendly to use.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):

Among the technologies that are used, ceramic filters are the ones that need maintenance. Ceramic filter have been introduced in most of the Health Centers, and in some households due to poor water quality noted everywhere. In general, households clean the candles of the filters every 2 to 3 months depending on the turbidity of the water households are filtering. They do the replacement every 2 years as recommended by the manufacturer guides. The ceramic filters have been proven to remove 99.9% of bacteria in the water and are cost effective. It costs USD 34 (2 candles filter), filtering 20 liters per days and this at least for 2 years.

For the SODIS systems, as the technology is called, the1.5 liter bottle regularly used needs to be repainted or totally renewed after 2 to 3 weeks of use as the bottle started getting dirty.

Sales volume amongst low-income groups

Till now there is no study addressing the total volume of sales in the low-income groups. For *Sur'eau,* the study conducted in 2007 by PSI estimated the volume of sales at 150,000 boxes of 40 units of 150ml but this is not only for low-income groups as *Sur'eau* is also used for vegetables washing and other domestic purposes. The number of sales increases mostly at the times in emergency period where large distribution of the product occurs.

Local manufacturers and sellers of the ceramic filters are in a limited number in the country. Since 2008, UNICEF has started its promotion countrywide and local manufacturers have started production. In addition there are a number of filters that are imported in the country.

For the Flocculation/ Disinfection, there are two well-known products: Watermarker and Aquasure. They are usually made available during emergency and now-a-days, there is a promotion of the Aquasure tablet in the country. UNICEF imported in 2008, 500 boxes of 10,000 units, which have been used for emergency purposes. The evaluation of 2008 emergency intervention mentioned Watermaker as the most useful product during the emergency period. Discussion is ongoing for its promotion in the country.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

Implementers	Products	Status of the Implementers
Population Service International (PSI)	*Sur'eau* (Addition of chlorine)	NGO
Health improvement Project (USAID)	SODIS	USAID
BUSH Proof	Ceramic Filter (2 candles)	Private sector/

		NGO
NGO Saint Gabriel	Manufacturer ceramic filter and candles	NGO
UNICEF Madagascar	Promotion of the Products, ceramic filter, Sur'eau, Watermakers (refer Chapter 2), SODIS	INTERNATIONAL
Community Development Association (CDA)	Aquasure Tablet	NGO

Table 3.1: Table listing the names of known implementers in Madagascar

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. The challenges remain the cost of the products to be promoted and their availability. Most of the low-income and poor groups are hard to reach with the cost effective technology of SODIS. SODIS has been seen as the most cost effective well-known treatment. There is a need for a lot of promotion for the product.
b. There is also no policy of water treatment that includes HWTS technologies, neither are they taken into account in the MGDs, there is a lot of resistance at the Ministry level to promote this technology national wide.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

There is a need to assign more technical resources for the promotion of HWTS technologies. These include the development of promotional materials, evidence based documents to be translate in local languages and advocacy to include result of the HWTS in-country JMP reports.

3.2.24 Country Profile: Malawi

Population: 13,066,320 [Source: 2008 population census]

Population below poverty line (define a level in $ terms): 52% [2005 Integrated Household Survey]

Population with access to an improved water supply at the sub-national level: 74.2%; 2006 MICS, UNICEF

Known population with access to HWTS:
Not yet known, varies with season; more population accessing during the rainy season owing to threat of cholera.

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection - Water Guard Wa Ufa (in powdered form) developed by Procter and Gamble and promoted by PSI/Malawi. A 4 gm sachet costs K10 (USD 0.07) and treats 10 liters of water which covers drinking water requirements for a household per day. It is relatively expensive for poor families
iii. Addition of bleach or chlorine – Use of liquid Water Guard
iv. Use of water filter (ceramic, sand, composite, etc.) – Not wide-spread nor is it programmed
v. Let it stand and settle – especially in the rural communities in Malawi.

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency) –
Addition of chlorine branded as Water Guard, product is accessible in groceries and shops, it is easy to use, just 1 bottle cap treats 20 liters of water.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): "Disposable" system. For bottle contents sold in local retail outlets.

Sales volume amongst low-income groups
- Water Guard sold by PSI/Malawi for 2008, over 700,000 bottles was sold. One bottle treats 1000 liters
- Chlorine (HTH) solution (1% Stock Solution) given free to communities during emergencies, especially during the rainy season.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers) –
- Ministry of Health (Government)
- PSI/Malawi - Use of water guard
- Medicines san Frontiers (NGO)

Most popular implementer and the technology promoted by them –

The most popular implementer(s) are Ministry of Health and PSI/Malawi. The most popular technology is the use of chlorine-based products such as HTH (70%), and Water Guard. PSI/Malawi is most popular in the promotion of Water Guard (chlorine-based products) developed by CDC, Atlanta, Georgia.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

- High cost of product.
- Emergency programs, which are annual events during the rainy season owing to cholera outbreaks, distribute free water treatment products, thus negatively affecting commercialization of products.
- Sustaining water treatment at household level throughout the year
- Social marketing/promotion
- Monitoring product use and coverage
- Non compliance by the beneficiary communities
- Beneficiaries complaining of the odor in chlorine.
- People use the Water guard/ chlorine as detergents.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Funding and technical assistance to develop strategies and go to scale with programming HWTS in Malawi.

3.2.25 Country Profile: Republic of Maldives

Population: 298, 968 (census 2006)

Population below poverty line (define a level in $ terms)
1% of population is below poverty line USD 1 per person per day (MPND - 2005)
10% of population is below poverty line USD 2.3 per person per day (MPND -2004)

Population with access to an improved water supply at the sub-national level:

- Safe water (Rain Water) access in Atolls (admin unit) – 76%
- Safe water (Desalinated, pipe borne) access in Male' (capital) – 100%
- (MDG Report – 2007)

Known population with access to HWTS: 26% (Census 2006)
(It's not clear if this figure includes Male where 100% pipe borne supply is available)

Available treatment technologies:

i. Boiling (3%)
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine (17%)
iv. Use of water filter (ceramic, sand, composite, etc.) (6%)

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency)
Valid information is not available.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement)
Valid information is not available.

Sales volume amongst low-income groups
Valid information is not available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

- Maldives Water & Sanitation Authority -(MWSA)
- Male' Water & Sewerage Company (Pvt.) Ltd. - (MWSC)

Most popular implementer and the technology promoted by them

- Maldives Water & Sanitation Authority -(MWSA) – Desalination + Disinfection
- Households with Rain Water Harvesting Tanks

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

a. Unavailability of verifiable data on HWTS
b. Lack of capacity of government agencies

c. Difficulty in making regular travels to island communities (by sea & air)

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:
Under the present context of Annual Works Plan (AWP), such need may be identified depending on the progress in other new initiations (developing policy support etc.)

3.2.26 Country Profile: Mali

Population: 12,324,009 (2008)

Population below poverty line (define a level in $ terms) 63.8% (2007)

Population with access to an improved water supply at the sub-national level: 58% (2007)

Known population with access to HWTS: Not Known

Available treatment technologies

i. Boiling
ii. Flocculation/ Disinfection: Use of PUR
iii. Addition of Bleach and Chlorine: In the districts where risks of cholera/diarrheas have been identified and where health authorities have implemented specific hygiene awareness campaigns
iv. Any other (please specify): Cloth Filters or synthetic screens are used in guinea worm endemic areas

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Addition of bleach

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
Very few assessments implemented so far. The most generalized HWT technique is bleach addition, and the quality of the bleach produced locally is hardly controlled.

Sales volume amongst low-income groups: Not Known

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
The most involved implementers are:
Government Agencies: The National Directorate of Health (From the Ministry of Health)
International Agencies: USAID, WHO, UNICEF
NGOs: PSI and Antenna Technologies[1]

Most popular implementer and the technology promoted by them:

Health authorities (national/local levels) promoting water treatment with bleach through the mobilization of Health Volunteers (HVs) in cholera/diarrheas endemic areas. Most of these HVs are equipped with pool testers to follow-up the chlorine concentration in treated water sources/storages.

[1] http://www.antenna.ch/

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- Supply of appropriate products to local level for HWT (transportation costs for bleach as well as more storage, follow-up of expiry date and refilling of the stocks) versus producing the products locally
- Monitoring of the quality/the efficiency of the treatments implemented
- Building evidence and going to scale
- Advocacy to improve the implication of more Government Agencies. In current situation, HWTS is only supported by health authorities. The institutions in charge of water supply (Ministry of Energy), sanitation (Ministry of Environment and Sanitation) and Education (to promote HWT and safe storage through schools) should get involved.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

- Provide guidelines / experience sharing for HWT and safe storage strategies/programs
- Provide guidelines for the monitoring of HWTS focused on creating evidence of the impact of such strategy.
- To be discussed: send a resource person to launch and follow-up a pilot phase for HWTS here in Mali (this pilot phase is planed for 2009)
- To be discussed: If it appears to be efficient, strengthen the partnership with Antena-Technologies to promote their approach for HWT. Notably, work with WHO to gain recognition of the process proposed by Antena-Tech.

3.2.27 Country Profile: Mauritania

Population: 3,032,178

Population below poverty line (define a level in $ terms): 46.7% under USD 1/day

Population with access to an improved water supply at the sub-national level: 52% improved source, 42% open wells, 6% surface water or other non-potable sources

Known population with access to HWTS: Not known

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection: Those using the only surface water source: Senegal River
iii. Addition of bleach or chlorine: Especially in peri-urban areas around the capital, Nouakchott, because water arrives to household indirectly via water vendors
iv. Use of water filter (ceramic, sand, composite, etc.): Those using the only surface water source: Senegal River
v. Let it stand and settle: Those using the only surface water source: Senegal River
vi. Any other (please specify)- Most people keep their underground unpolluted water contamination free by carrying it home in closed jerry cans and then emptying it in a ceramic, small necked vessel, kept covered with a cloth or plate. This also keeps the water cool.

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):

Most communities use groundwater sources, hence very few treat their water at the household level. Hardly any wood is available due to the dry climate of the country, hence disinfection via UV is most cost effective, but its not well established. Normally, it is only necessary to promote proper handling and storage of groundwater.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): N/A

Sales volume amongst low-income groups: Not known.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Groupe de Recherche et d'Echanges Technologiques (GRET)[1], Tenmiya (ONG)

Most popular implementer and the technology promoted by them: No Information

[1] http://www.gret.org/

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government) challenges:

Just to maintain the water clean, to make sure all household handle and store their water adequately.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

- A study to see what is necessary in villages near the Senegal River (only source of surface water) and to see if the technology can be built in situ. Examples of such technologies could be ceramic filters or cement bio-sand filters (with sand or gravel inside).
- Help in finding out if SODIS would kill all river pathogens, including parasite ova and eggs, or if filtration plus SODIS would be necessary.
- Technical support in communication and funds to implement a HWT program, especially for riverine populations.

3.2.28 Country Profile: Mongolia

Population: 2,687,000

Population below poverty line (define a level in $ terms): 31.6%

Population with access to an improved water supply at the sub-national level:

Access to improved water sources remains a key challenge in the country. Only 17% of rural households have access to improved water sources compared to 62% of urban area. However, even in urban areas, particularly peri-urban, most of people buy portable water from non-centralized water points. Children usually fetch water through *containers (*70% use the same container for collecting water and household domestic water, and only 36% store the drinking and household water separately) or handcarts transport it over distance from 200 to 500 meters, on mostly hilly paths and roads. Water consumption per capita per day is as low as 4-8 liters, which is much lower than minimum daily consumption recommended by WHO.

Type of water sources used by Mongolian people is described as follow:

- 30.8% of population use the water from central water piped supply;
- 24.8% of population from potable water distribution service;
- 35.7% of population from water distribution kiosk;
- 9.1% of population from surface water, snow and ice.

Known population with access to HWTS:

There is no nation-wide data on access to HWTS, however the data collected by UNICEF, ACF, Japan International Cooperation Agency (JICA)[1] and World Bank are available. This represents the 2008 surveys conducted in 597 households, in 14 districts of Ulaanbaatar and other two rural provinces by UNICEF and also 780 households in the peri-urban areas by ACF respectively. Only 46–61% of households boiled their water for drinking purposes and most of the other respondents were not aware of, nor do they practice, other purifying methods such as UV radiation, filtration and chemical treatments. 83% of water storage containers that were used were unsafe. Other studies conducted by World Bank and JICA in 2006 also points to poor practice and unsafe water treatment and storage.

Available treatment technologies and in case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):

i. Boiling,
ii. Flocculation/Disinfections,
iii. Addition of bleach or chlorine
iv. Water Filters

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): N/A

Sales volume amongst low-income groups: N/A

[1] http://www.jica.go.jp/mongolia/english/

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
ACF is promoting an appropriate model of water storage containers (non-chemical, with lid and outlet taps) in selected peri-urban areas of Ulaanbaatar on pilot basis. However, ACF does not promote chlorine tablets, filters and the other HWTS products.

Most popular implementer and the technology promoted by them: N/A

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

a. Poor personnel hygiene practice and behaviour among the population mainly in peri-urban and rural areas due to lack of understanding and knowledge on the importance and impact of household water quality;
b. There is no accessibility to improved water supplies in most of rural and peri-urban areas;
c. Heavily relying on imported HWTS products (water storage containers, chlorine, filters, etc. are all imported, mainly from China). Therefore, the low-income community cannot purchase the product at these higher prices. To ensure sustainability, local manufacture should be encouraged to produce a variety of HWTS products.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

It would be helpful if HQ or Regional Office could provide resource person to conduct training of counterparts on social marketing to promote HWTS products through Public Private Partnerships. Also, it is noted that a good combination of hardware and software are essential for better results in this area. UNICEF develops Behavior Change Communication (BCC) materials to conduct public awareness campaigns and provides a variety of trainings on safe treatment and storage of drinking water at the household, community and school levels, but water supplies are very limited in peri-urban and rural areas. We need sufficient funds to ensure improved drinking water quality and increased amounts of water.

3.2.29 Country Profile: Mozambique

Population: 20.5 million (2007 Population Census)

Population below poverty line: 54% (INE, DHS 2003)

Population with access to an improved water supply at the sub-national level: 71% of urban population, 26% of rural population, 42% of total population (JMP 2008)

Known population with access to HWTS: No data available

Available treatment technologies

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (ceramic, sand, composite, etc.)
v. Solar Disinfection
vi. Let it stand and settle
vii. Any other: strain through cloth. In addition to microbiological water treatment technologies, chemical treatment technologies are also being applied in Mozambique to deal with arsenic and fluoride found to be present.

In case of multiple technologies, cite the most successful one and also the reason for success (cost/availability/efficiency):
Household water treatment with CERTEZA has proven to be very successful in Mozambique. This is due to (i) heavy promotion and social marketing; and (ii) local acceptance of the product (as opposed to bleach, for instance, which is not that widely accepted among the local population due to its association with cholera)

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
The Ministry of Health (MISAU) has carried out a study on the efficiency and sustainability of Solar Disinfection. However, results of this study have not yet been shared with UNICEF to date.

Sales volume amongst low-income groups: No information available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

- International Relief and Development (IRD)[1]: SODIS
- Helvetas: bio-sand filters

[1] http://www.ird-dc.org/

- National (Associação Desafio Jovem de Moçambique, etc.) and international (Oxfam, Samaritan's Purse International Relief, World Vision, etc.) and other NGO partners: CERTEZA and chlorine –particularly during emergencies)

Most popular implementer and the technology promoted by them:
National and international NGOs respond to emergencies by using the household water treatment product CERTEZA, which is highly popular and widely used in Mozambique (a highly emergency prone country). However, the Government does not recognize CERTEZA as an improved water treatment technology, nor is it reflected in the JMP indicators as an improved water sources.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):
Any water treatment technology, prior to its application, needs to be approved by the Ministry of Health. Apart from the above-mentioned study on Solar Disinfection, no other such studies (e.g. on filters) have been carried out so far, thus limiting the technologies that can be used. This poses a major challenge to UNICEF, which would need to design and fund a study before advancing with the use of new water treatment technologies.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Help from HQ could come in the form of

- Scientific evidence (compendium of literature) on the successful use of technologies preferably in Sub-Saharan Africa;
- Advocacy package for household water treatment;
- Financial support to carry out baseline studies;
- Guidelines on how to engage the private sector, including information on legal aspects of agreements with companies such as Unilever or on approved products from HQ; and
- Inclusion of indicators on household water treatment within the JMP (which, at the moment, does not recognize household water treatment as an improved technology).

3.2.30 Country Profile: Myanmar

Population: 51.1 million (Ref: Economic Intelligence Unit estimate 2006)

Population below poverty line (define a level in $ terms): No official data available

Population with access to an improved water supply at the sub-national level: 74%

Known population with access to HWTS:

- Most of the Myanmar people are using simple improvements technique such as boiling, coagulation with alum or filtration through cloths,
- Filter Water with Cloths: 76% of the rural population
- Boiling water: 20% of the rural population
- Keep water over night for settlement: 10% of population
- Use of Chlorine products: 2% of population
- Use of ceramic water filters: < 1% of population

(ref: KAP survey 2006)

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filters: Ceramic
v. Cloth Filters
vi. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Most people are using single filtration techniques using cloth filters or boiling the water. The application is mainly related to tradition and cost. Boiling of water before drinking is decreasing over the past years due to the increase in fuel/ firewood price. However, the use of WaterGuard (hypochlorite solution) is increasing, especially in the Aueyawaddy Delta region. Ceramic water filters are also locally produced in Myanmar and the demand for these filters is far above the local production capacity of about 10,000 to 12,000 filters per month.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): No official or government endorsed data available.

Sales volume amongst low-income groups:
WaterGuard (250 ml of 5% chlorine solution): 30,200 bottles within 6 months
(Totaling app. USD 2,000 per months)

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

PSI, CDA, Thirst Aid[1], UNICEF

Most popular implementer and the technology promoted by them

- PSI/UNICEF - Chlorination using locally produced chlorine solution (WaterGuard)
- Thirst Aid/UNICEF – Ceramic Water Filters
- CHEB (Central Health Education Bureau under the MOH- Boiling of water
- ACF and ADRA – Slow Sand filtration

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

There is a positive attitude of the people towards HWTS and people are willing to contribute resources for these simple technologies and services. However, the available options are still beyond the affordability of most rural people. Chlorination is often rejected due to the smell and the successful pilot projects with ceramic water filters (CWF) or WaterGuard are difficult to bring to scale. While the demand for CWF as well as WaterGuard is increasing the lack of resources, to increase the local production capacity impedes the scaling up of these initiatives in a sustainable manner.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Principles, approaches and technologies for HWTS are pretty clear and any successful introduction and scaling up of successful initiates should come from within the country. HQ support should focus on the setting up a network for HWTS and sharing of experiences, successes and lessons learned.

[1] http://www.thirst-aid.org/

3.2.31 Country Profile: Nepal

Population: 27 million

Population below poverty line (define a level in $ terms): Not Available

Population with access to an improved water supply at the sub-national level: 78%

Known population with access to HWTS: With access may be around 10% but less than 1% practicing.

Available treatment technologies:

i. Boiling
ii. Addition of bleach or chlorine
iii. Water filter: Bio-sand and ceramic filters with colloidal silver
iv. Solar Disinfection
v. Let it stand and settle
vi. Any other (please specify): Kanchan Arsenic filter, SONO filter

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
We did product trials to identify the most accepted method but all were equally accepted and therefore we are promoting four methods – boiling, chlorination, filters (ceramic filters with colloidal silver & bio-sand) and SODIS.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
Chlorination products are sold in various quantities with the smallest lasting a family about 4 weeks and the large size lasting a family about 8 weeks for a household of 5-6. We are currently evaluating the Kanchan Arsenic Filter (Arsenic removal filter using the principle of bio-sand filter and iron nails) and have only started installing the Sono filter and therefore not sure on their period of service. The ceramic filters with colloidal silver filters need regular cleaning, more often if the water is a bit turbid, and are expected to provide service for two years before the colloidal silver needs to be re-impregnated or the filter element replaced.

Sales volume amongst low-income groups Information: Not available.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

UNICEF works with the government district water supply offices and in some districts with the government women's development offices. Those offices for the local training and promotion work recruit NGOs. Filters for Families and the Nepal Red Cross Society distribute arsenic filters provided by UNICEF and provide training to families on their use and maintenance. Madhyapur Clay Crafts (ceramic filter producer), Environment and Public Health Organization (ENPHO)[1] (chlorination- Piyush, bio-sand filter and SODIS), PSI (chlorination).

Most popular implementer and the technology promoted by them

All implementers are promoting all four methods. Where local ceramic filters are produced, these are quite popular and in other places the small bottle of sodium hypochlorite solution (Piyush- produced by ENPHO) is proving more popular than the larger bottle produced by PSI (WaterGuard). The product produced by ENPHO has lower concentration and is dispensed by small hole and counting number of drops, whereas the PSI product has to be measured in a cap which is not as accurate and sometimes ends up with more solution than required giving the water a bad taste and smell.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

For UNICEF we lack the staff to move the HTWS forward at a reasonable pace and to provide support to the districts and monitor the activities at the grassroots. Our BCC expert was taken away from us two years ago and we have not had the support we need from the country office's programme communications section. The other challenge is lack of resources to scale-up the initiative that has been started in Nepal. Schools have actively taken up HWTS and children have the potential to introduce this in their own homes. On the private sector front, it has been difficult to mobilize the private companies to actively market their products in the areas where UNICEF has supported the promotion and awareness campaigns. This is due to the fact that the majority of the private sector who produce the proven technologies are primitive and have limited resource to promote at mass scale. Thus they also need support to do marketing of their own product. However, a small start has been made in one district where the producers train and provide their products to sell through community organizations, particularly women's groups. This experiment is proving quite successful and will be replicated in other districts.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

We are already well into developing HWTS programs and would need additional funding and a fulltime staff (preferable with a business & behavioral change communications background) to support, monitor and build on lessons being learned. Exchange program/regional-working group to share the lessons learnt and best approaches so that countries learn from each other and replicate.

[1] http://www.enpho.org/

3.2.32 Country Profile: Nicaragua

Population: 5,483,000

Population below poverty line (define a level in $ terms): No Response

Population with access to an improved water supply at the sub-national level: 48.5% of the population in rural areas (2004)

Known population with access to HWTS: NA

Available treatment technologies

i. Boiling
ii. Flocculation/ Disinfection - PUR
iii. Addition of bleach or chlorine
iv. Water filter (ceramic & sand)
v. Solar Disinfection
vi. Let it stand and settle
vii. Any other (please specify) Rain water harvesting plus disinfection

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Filtration, (ceramic and sand) is low-cost and is available throughout the country. Bleach or chlorine is also available due commercial distribution and easy access.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): NA

Sales volume amongst low-income groups: NA

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers) Most of local and international NGO's and aid agencies. Some Government agencies like Health Ministry.

Most popular implementer and the technology promoted by them: NA

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. Health and hygiene education.
b. Operation and maintenance of water supply systems due to the cost to the user.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS: NA

3.2.33 Country Profile: Niger

Population: 13,500,000 inhabitants (2008 extrapolation from census 2001)

Population below poverty line (define a level in $ terms): 62.1% with less than $1 per day

Population with access to an improved water supply at the sub-national level:

The national coverage rate for drinking water was 39% in 1990 and it was only up to 42% in 2006, with a disparity between urban and rural areas of 83% and 30% respectively. A Nutrition Health Survey shows 48.6% have an improved water supply (June 2008). In the regions of Maradi and Zinder, the water access is under the national average: 27% and 38% respectively.

Known population with access to HWTS:

Only 36% oh fouseholds utilize household water treatment methods: (Rapport d'enquête nationale Nutrition et Survie de l'Enfant Niger, Juin/Juillet 2008). The most common method is to utilize only a clean cloth (88%)

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. Water filter (ceramic)
iv. Any other (please specify): Utilization of a clean cloth

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):

The ''Rapport d'enquête Nationale Nutrition et Survie de l'Enfant Niger, Juin/Juillet 2008'' shows :

- 1.5% boil water;
- 2.7% adds bleach or chlorine;
- 6.9 utilize ceramic filters;

It seems that there is no reason to treat water at household level. The utilization of cloth is probably due to the guinea worm eradication to filter the water from surface water sources.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): There is no study about these issues

Sales volume amongst low-income groups: N/A

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

- Canadian NGO (Samaritan's Purse)
- Plan International
- Helen Keller International

Most popular implementer and the technology promoted by them

- The Heath Centers are the main providers on material of water treatment during cholera outbreaks.
- UNICEF and WHO provide chlorine tablets
- Samaritan's Purse working on nutrition utilize this household treatment techniques in some villages

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

UNICEF Niger is well aware about the HWTS strategy, which is a main component of the WASH Strategy. However, the lack of an institution able to make a proper social marketing in Niger is a main constraint to implement such an initiative.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

- Supporting Niger to fund a social marketing implementer such PSI
- Advocacy for the utilization of such strategy after a study of the options

3.2.34 Country Profile: Sudan

Population: (Total population: 40.17 million as per 2006 Sudan Household Health Survey (SHHS) report) Population of North Sudan: 30.07 million (The report covers North Sudan)

Population below poverty line (define a level in $ terms): Not available

Population with access to an improved water supply at the sub-national level:
Total: 58.7%
Urban: 69.4%
Rural: 51.6%

Known population with access to HWTS: No data available

Available treatment technologies

i. Boiling: Present but not too common
ii. Flocculation/ Disinfection: Mostly for urban large water supply systems. Not practiced at household level
iii. Addition of bleach or chlorine: Common in high risk areas affected by cholera or Acute Watery Diarrhea (AWD)
iv. Use of water filter (ceramic, sand, composite, etc.) Limited (used by Urban communities especially in Khartoum)
v. Let it stand and settle: Limited to open ponds (Hafirs)

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): In Gedarif state in 2008, use of chlorine tablets for household treatment was emphasized. Besides, chlorination at source, both for private and public wells was carried out. Chlorine is most successful and promoted as part of emergency response and depends on the external support, mainly from UNICEF.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Not known

Sales volume amongst low-income groups: Not known

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): 15 State level Water Environment and Sanitation (WES) offices in coordination with NGOs, Ministry of Health with UNICEF support.

Most popular implementer and the technology promoted by them: WES project in each state and chlorination is commonly promoted.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

a. A government fund for chlorinators was not made available in time by some State Governments, which had implications for implementation.
b. Many power pump schemes do not have chlorination system due to lack of funding.
c. Chlorine powder/tablets are provided by donors free of cost and are not available in the local market.
d. There are cases where private well owners are reluctant to chlorinate their wells as it would increase operational cost and local communities do not prefer water with chlorine smell.
e. Expiry dates of the supplies for water treatment prevent to stockpile in large quantities. However “first-in-first-out” approach is followed to prevent waste.
f. It is unlikely that without private sector involvement, use of bio-sand filtration or chlorination could be scaled up. Finding interested private sector partners under the current security situation in Darfur areas is a big challenge.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

- Request for senior advisor involved in HWT to organize advocacy workshops at Federal and selected state levels with high prevalence AWD areas.
- Sharing of standards and designs of filters and technical support to train local potters for making filters.
- Identify successful private sector to locally produce and promote chlorine solution.

3.2.35 Country Profile: Pakistan

Population: Approximately 162 million

Population below poverty line (define a level in $ terms): 32%, National Poverty Line in Pakistan is at Rs.748 (USD 115/year; 1 USD = Rs. 78 at Jan 2009 rates) per adult per month in 2001 prices

Population with access to an improved water supply at the sub-national level: According to JMP UNICEF/WHO, 90% of Pakistan's population has access to improved water supply with 29% having water piped into dwellings and 61% accessing 'other' improved sources. The coverage of improved water supply at the sub-national (provincial level) ranges from 33 % (rural areas of Balochistan Province) to 97% (urban areas of Punjab).

Known population with access to HWTS: This has not been quantified, and while several technologies (see question 6 below) are available, sustained access and knowledge on HWTS are critical issues that need to be addressed in Pakistan.

Available treatment technologies:

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (ceramic, sand, composite, etc.)
v. Solar Disinfection
vi. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency)
Although no data is available, boiling of water is the most commonly used technology. This is primarily due to awareness (that there is benefit in boiling water) and availability (no special technology required).

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement)

- Efficiency of above cited technologies varies, but is most critical in regard to filters, as failure to replace / clean filters as required renders them useless.
- Boiling requires sustained access to energy supply (in the current context of the economy and political situation in Pakistan this becomes even more critical)
- Commercial treatment options for disinfection/flocculation (including PUR sachets, Aquatabs, etc.) while not requiring maintenance, again require sustainable and cheap access at local levels.

Sales volume amongst low-income groups:

Data not available. Thus far within Pakistan, high cost of household water treatment options and lack of awareness regarding the benefits of HWTS means that people are reluctant to 'purchase' these options.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers)

UN Agencies: UNICEF and WHO
Pakistan Council for Research in Water Resources (PCRWR)[1], Ministry of Science and Technology
Government: Local Government and Rural Development Departments, Public Health Engineering Departments and Health Departments
USAID's Pakistan Safe Drinking Water and Hygiene Promotion Project
NGOs: National Rural Support Program (NRSP)[2] and other national and international NGOs
Universities: such as National University of Sciences and Technology

Most popular implementer and the technology promoted by them:

No comparative study has been undertaken to this effect. Due to the considerable variance in geography, needs, populations, etc., it would be difficult to define and if defined would be very subjective.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government)

In 2009, UNICEF plans to support the Government of Pakistan in development, and subsequent implementation, of a National Plan for the Promotion of HWTS. The development of this plan would improve significantly the amount of information/details regarding HWTS in Pakistan and help to address some of the challenges currently faced. Some of the current challenges in promotion of HWTS include:

a. Lack of relevant technical expertise in country,
b. Availability of options at local/locally manufactured levels,
c. No in-country quality assurance mechanism and/or certification process for locally produced options,
d. Lack of awareness of the general population regarding the benefits, misperceptions in communities regarding certain HWT options,

[1] http://www.pcrwr.gov.pk/

[2] http://nrsp.org.pk/

e. Affordability/sustainability: high costs transferred to already economically marginalized populations, transfer of knowledge regarding operation and maintenance
f. Economic/political instability in-country

What help do you (country office) seek from the HQs for setting up a successful program for HWTS.

UNICEF Pakistan would benefit from the following support from HQ:

- Sharing of documentation: including guidelines for Program development, successful National Plans for Promotion of HWTS in countries similar to Pakistan, lessons learned (including failures) from similar programs, classification and availability of treatment options internationally (in particular those that UNICEF in-countries has supported development of that may be replicated) and their efficiency/affordability including options for local production, developed Information Education and Communication (IEC) material for various options that may be refined as per local need,
- Technical support for review of plans, in particular where limited expertise in country exists,
- Support/guidance in design of certification/quality assurance mechanism that may be replicated in country for locally produced goods.

3.2.36 Country Profile: Philippines

Population: 80 million (2003 estimate)

Population below poverty line (define a level in $ terms): 30% (2003 estimate)

Population with access to an improved water supply at the sub-national level: 87% but with wide disparities across regions and within provinces, especially in rural areas and urban slums.

Known population with access to HWTS: No data

Available treatment technologies

i. Boiling
ii. Flocculation/ Disinfection
iii. Addition of bleach or chlorine
iv. Water filter (ceramic, sand, composite, etc.)
v. Solar Disinfection

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Boiling and Chlorine Solution (Chlorine use mainly promoted by Department of Health)

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
At least once a week for the cleaning of the water container

Sales volume amongst low-income groups:
2007 – 97,546 bottles, 2008 – 172,604 bottles of 1.25% of Sodium Hypochlorite-Hyposol)

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
Department of Health, Selected Local Government Units, Phil Center for Water and Sanitation, Plan International, HELVETAS, WHO, UNICEF

***Most popular technology promoted in the country* -** Chlorine Solution

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government) :

For UNICEF Philippines Country Office, WASH has been embedded in Project 2: Child Health and Sanitation of Health and Nutrition Programme in the Country programme. Hence, there is no funding base for WASH interventions as WASH has been revived just couple of years ago. Sustainability of the practice at the household level due to unavailability of the chlorine solution, changing behavior – back to old practice once there is no incidence of illness among family members.

What help/support do you (UNICEF) seek from the HQ for setting up a successful program for HWTS: Support to advocacy activities, Funding support

3.2.37 Country Profile: Rwanda

Population: 8,800,000

Population below poverty line (define a level in $ terms): 56.9% (USD 1/person/day)

Population with access to an improved water supply at the sub-national level: 64%

Known population with access to HWTS: No data available

Available treatment technologies:

i. Boiling: Majority of the population, which lives in rural settings, uses this technology at household level; wood is the mostly used fuel with its impact on deforestation.
ii. Addition of bleach or chlorine: No data available for household level. A chlorine derivate product called "*SurEau*" is currently in use in health institutions to ensure safe drinking water for patients.
iii. Water Filter (ceramic, sand, composite, etc.): No data available. Filters are commercialized in urban settings and major centres.
iv. Let it stand and settle: No data available but commonly used practice.

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Boiling is the most successful; this has to do with affordability and the knowledge by many households of their lack of access to safe water. It is difficult to price this, for some families it takes an entire day for women or children to collect branches in the forest.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Need further research to get the information

Sales volume amongst low-income groups): Need further research to get the information

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

There is no exhaustive assessment conducted yet but I can name some PSI (promoting *SurEau*) and Compagnons Fontaniers du Rwanda (COFORWA), Ministry of Infrastructure (MININFRA)[1], HUYE, ROTO and SULFO

[1] www.mininfra.gov.rw/

Most popular implementer and the technology promoted by them:

PSI with their chlorine derivate product to add to water and ROTO with their safe storage plastic tanks manufactured locally.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

Household water treatment and safe storage has not been so far systematically promoted in Rwanda. Populations have had to find their way out by themselves, as they have been facing for years a chronic shortage of access to safe water in towns, which is much more acute, in rural areas. The Government has put much more emphasis on attempting to create more drinking water supplies schemes. In the meantime, there were efforts made to develop HWTS to provide safe drinking water in primary schools and health institutions using appropriate technology with local materials at an affordable cost and integrating water quality control activities and better hygiene practices at community level. For years, funding remained the main obstacle beside the inadequate human resources & capacity. Furthermore, MININFRA is being advised to take into account HWTS when reviewing the sector strategy.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS :

Support country program for HWTS scaling up with successful technologies (after studies and field piloting projects eventually). The fact that neighboring countries such as Kenya, Uganda and Tanzania were successful developing some HWTS programmes can be a good contribution.

3.2.38 Country Profile: Senegal

Population: 11,600,000 (estimated in 2008)

Population below poverty line (define a level in $ terms): 42.6% of households in 2006 lived below the poverty line

Population with access to an improved water supply at the sub-national level: In late 2007, the overall rate of access to drinking water was estimated at 98% in urban areas and 72% in rural areas

Known population with access to HWTS: Approximately 60% of households have access to tap water or a public standpipe.

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. Water filter: Candle
iv. SODIS

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Treatment with bleach is the most used because bleach is available even in the remotest villages. Its price is very affordable and effectiveness is certain.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): NA

Sales volume amongst low-income groups): NA

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

National Department of Health (MOH), manufacturers of household bleach (Javel Cross, Max Javel), Service National de l'Hygiène (Ministère de la santé), Fabricants d'eau de javel (Javel Croix, maxi Javel)

Most popular implementer and the technology promoted by them:

Bleach (Eau de javel)

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- Adaptation of the quantity of bleach in its chlorine content to the amount of water to be treated
- Encouraging people to treat drinking water in all seasons and not only during outbreaks of cholera or large religious gatherings.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Mobilization of financial resources and support for exchanges of experience among countries)

3.2.39 Somalia

3.2.39.1 Country Profile: Central & Southern Zone (CSZ)- Somalia

Population: 6,186,510 (Figures used for planning purposes in CSZ)

Population below poverty line (define a level in $ terms): No information

Population with access to an improved water supply at the sub-national level:
Approximately 60% of households have access to tap water or a public standpipe.

Known population with access to HWTS: No information

Available treatment technologies

i. Flocculation/ Disinfection
ii. Addition of bleach or chlorine
iii. Water Filter (ceramic, sand, composite, etc.)
iv. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Chlorination is most effective because UNICEF provides it for free and it is cheaper to distribute. Due to high contamination of water from open sources, it proves to be most effective

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Chlorination on daily basis for open wells

Sales volume amongst low-income groups): NA

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): > 40 NGOs and Community Based Organizations (CBOs)

Most popular implementer and the technology promoted by them:

Mumin Global carrying out regular chlorination in Baidoa town.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- Accessibility to project sites and monitoring of activities: due to insecurity, staff and partners are not able to implement and monitor chlorination activities in some locations.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

Expertise and staff who can spend more time devising and promoting technologies in order to scale-up HWTS

3.2.39.2 Country Profile: Somalia / North West Zone (Puntland)

Population: 662,000

Population below poverty line (define a level in $ terms): 40% people in Puntland State of Somalia live below poverty line

Population with access to an improved water supply at the sub-national level: 29% of people have access-improved water supply in Puntland State of Somalia

Known population with access to HWTS: 20% in Puntland has access to household water treatment.

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. SODIS
v. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Majority of households in Puntland State of Somalia practice water boiling, it is a common traditional practice to kill harmful pathogens. Putting water to settle as means of treatment is also widely practice, especially when the water is turbid. The practice of boiling and/ or letting it to settle are common practice because they are cheaper as compare to other methods. However, use of chlorine becomes common among people affected by crisis in Somalia, although the sustainability of this practice depends of external support through humanitarian agencies.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
The two methods of water treatment (boiling and letting water to settle) at household level do not require any major maintenance except for washing of boiling/ storage containers or replacement of worn-out containers. The only major challenge with boiling has to do with acquiring expensive firewood which scarce in Puntland (arid region).

Sales volume amongst low-income groups): Little percentage of low-income groups is able to replace their water containers and the rest depend on humanitarian agencies' support. Firewood for boiling water is expensive too, thus this makes many households that cannot afford to buy firewood drink untreated raw water.

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

The following agencies are actively involved in promotion of household water treatment: Somali Relief Society (SORSO), Shilaale Ecological and Rehabilitation Concern (SHILCON), Puntland State Agency for Water and Natural Resources (PSAWEN), Golden Utility Management Company (GUMCO), Galkayo water company, Garowe water company and Hodman water company

Most popular implementer and the technology promoted by them:

Most of the above-mentioned agencies promote water boiling and water chlorination.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

Major challenges UNICEF faces in promoting water treatment at household level includes:

- Difficulties faced in accessing remote areas as result of insecurity as well as poor road network,
- Limited resources versus huge continued demand and expensive chlorine and firewood cost which make efforts being exerted less sustainable.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

- Most important request that UNICEF Somalia may need from HQs is to share knowledge on other cheap and appropriate HWT technologies that are being practiced in other parts of the world and that can be adopted for Somalia.
- Mobilization of resources (funds and qualified people), which could help in promoting household HWT.

3.2.39.3 Country Profile: Somalia (North West Zone - Somaliland)

Population: 1,920,450

Population below poverty line (define a level in $ terms): NA

Population with access to an improved water supply at the sub-national level: 40%

Known population with access to HWTS: 16%

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. Water Filter (ceramic, sand, composite, etc.)
iv. Let it stand and settle
v. Any other (please specify): use of ASAL

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Aquatabs only distributed by organizations like UNICEF, WHO and PSI. It was found to be very effective at household level. ASAL -Acacia tree trunk fibers are traditionally seen as the most appropriate and effective water purification approach.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
In major towns and water systems drip chlorinators need regular maintenance and replacement every other year. Whereas, household filters need maintenance every six months.

Sales volume amongst low-income groups): NA

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
Ministry of Water and Mineral Resources, Ministry of Health and PSI

Most popular implementer and the technology promoted by them:
Ministry of Water and Mineral Resources that promotes chlorination

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):
Major challenges faced:

- No regular chlorination in place.
- Availability of chlorine
- Accessibility
- HWTS for rural community households

- Security situation in some parts of the country.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:

- Literature for reference.
- Expertise for situational analysis and study local methodologies.
- Funding for implementation.

3.2.40 Country Profile: Sierra Leone

Population: 4.8 million

Population below poverty line (define a level in $ terms): 57% of population living below USD 1/Day

Population with access to an improved water supply at the sub-national level: 47%

Known population with access to HWTS: 10,695 (75 Communities)

Available treatment technologies

i. Water Filter: Bio-sand
ii. SODIS

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
Solar Disinfection has been implemented in the field. Only training of stakeholders has taken place for Bio-sand Filtration system (Supported by GOAL[1] and CAWST), no implementation can taken place of Bio-sand Filtration system.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): NA

Sales volume amongst low-income groups): NA

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers): Safer Future and GOAL

Most popular implementer and the technology promoted by them: SODIS

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):
Currently designing a programme to promote HWTS options, however UNICEF has commenced supporting SODIS in 100 Communities through Safer Future.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:
HWTS is at its infancy stage; hence UNICEF Sierra Leone requires technical back stopping in designing the programme and later evaluation (end of year – 2009)

[1] http://www.goal.ie/

3.2.41 Country Profile: Sri Lanka

Population: 19.4 million

Population below poverty line (define a level in $ terms): 20% of population living below USD 25/Month.

Population with access to an improved water supply at the sub-national level: 8 million

Known population with access to HWTS: 1.5 million

Available treatment technologies

i. Boiling
ii. Flocculation/Disinfection
iii. Addition of bleach or chlorine
iv. Water Filter: (sand)
v. SODIS
vi. Let it stand and settle
vii. Any other (please specify): Fluoride filter

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): The Ministry of Health recommends boiling as the safest option, while others are popularized through support agencies.

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): HWTS are required in rural areas where there are no formal water supplies and the people go for the least cost option. A survey needs to be conducted to evaluate the efficiency of these as no record available at present.

Sales volume amongst low-income groups): Not available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
Helvitas introduced SODIS, CAWST introduced bio-sand filters and Tropical and Environmental Diseases and Health Associates (TEDHA)[1] introduced “chlo water” (chlorine disinfectant for house hold water treatment)

Most popular implementer and the technology promoted by them:
The above systems are popularized by the implementers and are equally accepted by people in rural areas.

[1] http://www.tedha.org/

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

UNICEF initiated, through the government, an institutional framework for water quality surveillance and mobilized support agencies to build capacity to implement Water Safety Plans at household as well as community level.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:
Share information on successful implementation in other countries and provide more resources to implement the ongoing activities and expansion of these.

3.2.42 Country Profile: Tanzania

Population: 34 million according to the Population and Housing Census, 2002

Population below poverty line (define a level in $ terms):
According to the National Strategy for Growth and Poverty Reduction, the MKUKUTA Annual Implementation Report 2007/08 (October 2008), in rural areas where the majority of the poor live, around 37.4% live below the basic needs poverty line, and 18.4% live below the food poverty line.

Population with access to an improved water supply at the sub-national level:
According to the MKUKUTA (National Strategy for Growth and Poverty Reduction) Annual Implementation Report 2007/08 (October 2008), the proportion of the population with access to clean and safe water in rural areas increased marginally from 55.7 percent in 2006/07 to 57.1% in 2007/08. The increase is equal to an increase of service coverage to average additional 1.1 million people, from 17.7 million beneficiaries in 2006/2007 to 18.8 million beneficiaries in 2007/2008.

Known population with access to HWTS:
About 28% of child caregivers report ever having treated their drinking water with *WaterGuard*, with 15% having treated it the last week. Awareness of household water treatment is relatively low, with only 49% having heard of *WaterGuard*. A higher proportion – 43%, reported ever having boiled their water to make it safe to drink. (PSI, 2008)

Available treatment technologies

i. Boiling
ii. Flocculation/Disinfection
iii. Addition of bleach or chlorine
iv. Water Filter: (ceramic, sand, composite, etc.)
v. SODIS
vi. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
- Boiling (traditionally done by most households albeit intermittently due to availability of fuel, women's workload etc)
- Addition of Beach or Chlorine (PSI have been promoting this for more than 5 years all over the counry, products availability is also a motivating factor in the districts where it is used most)

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):

Has not been determined, but a study is planned which aims to provide information on this.
Sales volume amongst low-income groups): Not available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

- PSI
- Connect international/ Southern Highlands Participatory Organisation (SHIPO)[1]
- Anglican Church Tanzania Diocese of Ruaha
- SON International
- Africtank

Most popular implementer and the technology promoted by them:

- PSI, mainly chlorination by WaterGuard/Aquatabs, to some extent, other locally known methods (boiling) also promoted
- Currently also promoting an integrated Young Child Survival and Development (YCSD) (Health, Nutrition and WASH) behavior change communication package under a 2-year Project Cooperation Association (PCA) with UNICEF targeting about 500,000 households in 7 UNICEF learning districts. The package includes Hygiene, Sanitation & HWTS; Malaria Prevention; Exclusive breastfeeding; Diarrhea Management (incl. use of ORS); New Born Care at home; Delivery at Health Facility; Routine Child Health Services, and Management of a Sick Child.

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

- Low capacities of stakeholders at all levels
- Unreliable/no motivation system for volunteer actors at the community level (Village Health Workers, CORPs).

What help do you (country office) seek from the HQs for setting up a successful program for HWTS:
Good quality documentation of lessons of the integrated approach being adopted in Tanzania

[1] http://www.shipo-tz.org/

3.2.43 Country Profile: Thailand

Population: 65,064,070 (for 2006 in MICS report)

Population below poverty line (define a level in $ terms):
5,420,000 in 2007 (USD 42.45/person/month or 1,443 Baht/person/month or USD 509/year) – data from National Statistical Office

Population with access to an improved water supply at the sub-national level:
44,974,622 (see details in MICS report Table 24)

Known population with access to HWTS: 65,064,070 (see details in MICS report)

Available treatment technologies

i. Boiling
ii. Addition of bleach or chlorine
iii. Water Filter: (ceramic, sand, composite, etc.)
iv. SODIS
v. Let it stand and settle

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency): Not available

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Not available
Sales volume amongst low-income groups): Not available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
NGOs such as Adra, World Vision, Rotary, International Federation of Red Cross and Red Crescent Socities(IFRC)[1], etc.
Government – Municipality, Sub-district Administration Office, Metropolitan Waterworks Authority, Provincial Waterworks Authority/Private – East Water, Veolia Water, Thames Water, etc)

Most popular implementer and the technology promoted by them: Not Available

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government): Not Available

What help do you (country office) seek from the HQs for setting up a successful program for HWTS? No Response

[1] www.ifrc.org/

3.2.44 Country Profile: Uganda

Population: Approximately 2.8 million

Population below poverty line (define a level in $ terms):
Although there has been a decline in the percentage of people living below the poverty line, because of the high population growth rate of 3.4%, the absolute number of people living below the poverty line (seven million – 60% children) has scarcely decreased. Uganda is ranked 154 out of the 177 least developed countries (UNDP 2007). In 2008, the Ugandan economy faced strong inflationary pressure from exogenous shocks, primarily related to high global commodity prices that led to an annual inflation rate of 7.3%[1]. Over 60% of the population is food insecure and targeted humanitarian programmes remain necessary every year

Population with access to an improved water supply at the sub-national level: 63% in the rural areas and about 90% in the urban areas.

Known population with access to HWTS: Not available

Available treatment technologies

i. Boiling
ii. Flocculation/Disinfection
iii. Addition of bleach or chlorine

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):

i) Boiling (for reasons that firewood is widely available as a cheaper fuel option; and knowledge about boiling is wide spread across the country; no known side effect associated with boiling)
ii) Chlorination using tablets because of cost and ease –to-use

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement): Not available

Sales volume amongst low-income groups): Not available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):

[1] Bank of Uganda (2008). Annual Report for year ended 30 June 2008

WASH Cluster members- mainly engaged in emergency responses, such as Oxfam, PSI, Cooperazione e Sviluppo (CESVI)[2] and district local governments, specifically the Departments of Health, and Water, National Water and Sewerage Corporation**.**

Most popular implementer and the technology promoted by them: PSI Uganda, point of use treatment with PUR (flocculation) and Water Guard tabs (disinfection with chlorine)

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):

At Government/ UNICEF level

- Inadequate/ unclear strategy for promoting household water treatment
- Inadequate monitoring at house hold level
- Inadequate resources for investments for promoting the practice. Often, efforts and resources are limited to addressing emergencies (like floods in eastern Uganda, refugee influx and internal displacement in western and northern Uganda respectively) and disease outbreaks (like cholera in Kasese, western Uganda)
- Inadequate staffing in some districts, coupled with poor motivation has undermined efforts to keep the momentum of HWT practices created during emergency responses in the affected areas.

At household level

Low household incomes and less affordability for water treatment (firewood/ fuel for boiling; few storage facilities; and little space in houses)

What help do you (country office) seek from the HQs for setting up a successful program for HWTS?

Share lessons- where success is being recorded, what seems to work and why, as well as what can't work and the reasons for that too.

[2] http://www.cesvi.org/

3.2.45 Country Profile: Vietnam

Population: 86 million

Population below poverty line (define a level in $ terms):
15.5% of households (definition: rural areas: USD 12.1/capita/month; urban: USD15.8/capita/month)

Population with access to an improved water supply at the sub-national level: 78% by 2008

Known population with access to HWTS: Not available

Available treatment technologies

i. Boiling
ii. Flocculation/Disinfection
iii. Addition of bleach or chlorine
iv. SODIS
v. Let it stand and settle
vi. Any other (please specify): Traditional methods (using special leaves)

In case of multiple technologies, cite the most successful one and also the reason for success (cost/ availability / efficiency):
No comparative study has been done on different technologies in use and their cost and efficiency. However, boiling is most commonly practiced (74% rural population boils water before drinking).

Measurable efficiency of the technology/technologies (how often do they need maintenance and replacement):
This practice is very weak in Rural Vietnam and no data is available on this. However, available information on household arsenic filters in project areas indicate that sand filter media is replaced once in every 2 to 3 months.

Sales volume amongst low-income groups): Not available

Number and names of known implementers (NGOs/ Government Agencies/ Private Implementers):
UNICEF, HELVETAS[1], Ministry of Health (MOH), Ministry of Agriculture and Rural Development (MARD) and all other partners working on water supply

[1] http://www.helvetas.ch/

Most popular implementer and the technology promoted by them: MOH has been promoting water boiling, flocculation/disinfection and addition of bleach or chlorine; and HELVELTAS (Swiss NGO) with solar disinfection

Challenges faced by UNICEF country office, the country's government and the implementing organization (if different from the government):
Lack of relevant data/information on HWTS policy, strategy, guidelines, comprehensive national and sub-national action plans and programmes. However, WHO, UNICEF, MARD and MOH are currently working on the situation analysis and development of a National Plan of Action on HWTS.

What help do you (country office) seek from the HQs for setting up a successful program for HWTS?

Technical assistance in developing water quality monitoring and management mechanism/framework including HWTS.

3.3 Analysis of the results:

Section 3.2 has given a detailed account of the responses obtained from 45 UNICEF country offices. This section presents graphs and analysis of these results.

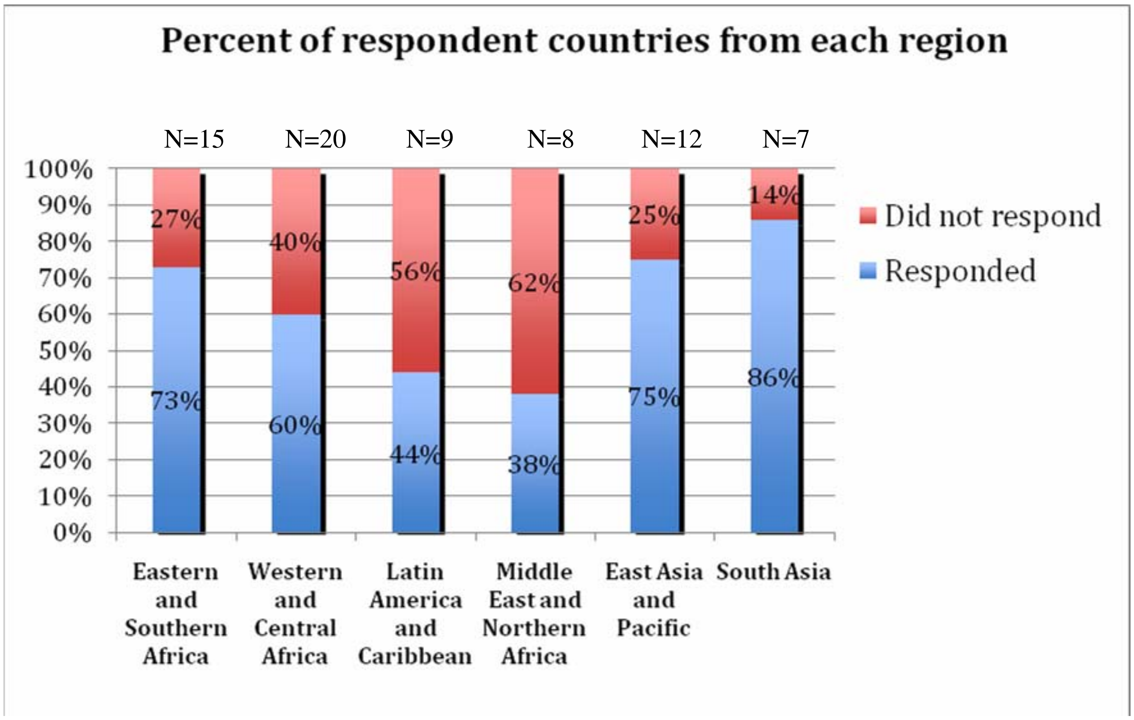

Figure 3.2 Percent of respondent countries from each region

Figure 3.2 shows that about 3/4th or more of the countries from the Asia and the Pacific regions have responded. Only 44% of Latin America and Caribbean countries responded. The responses from Africa is split, with a high percentage of countries from Eastern, Southern, Western and Central Africa responding while the ones in Middle Eastern and Northern Africa are not as responsive.

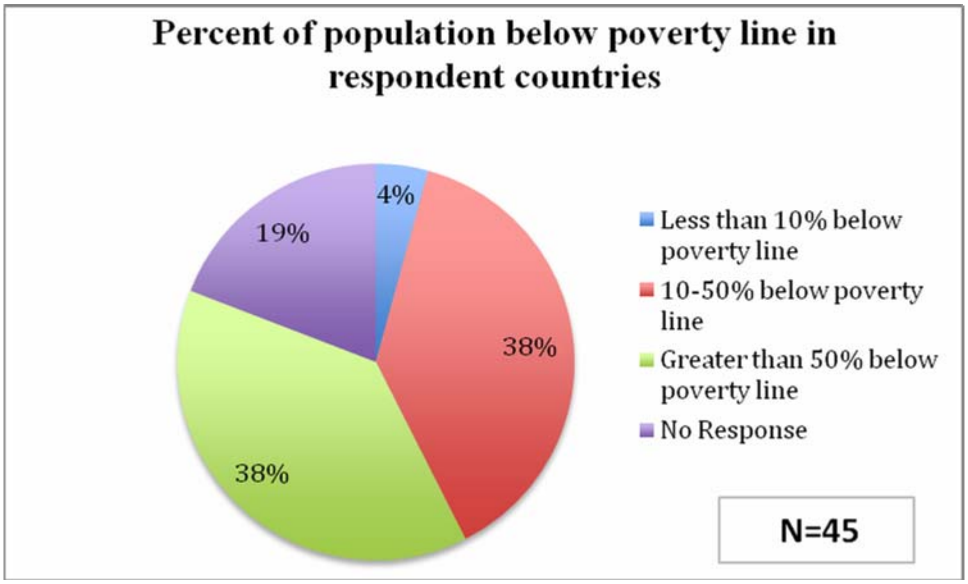

Figure 3.3: Percent of population below poverty line in respondent countries

Figure 3.3 shows the percentage of population below the poverty line in each of the respondent countries. More than 50% of the populations are below the poverty line in 38% of the respondent countries, while another 38% of the countries have a population of 10-50% that falls below the poverty line. Finally, 4% of the respondent countries have less than 10% of population below the poverty line.

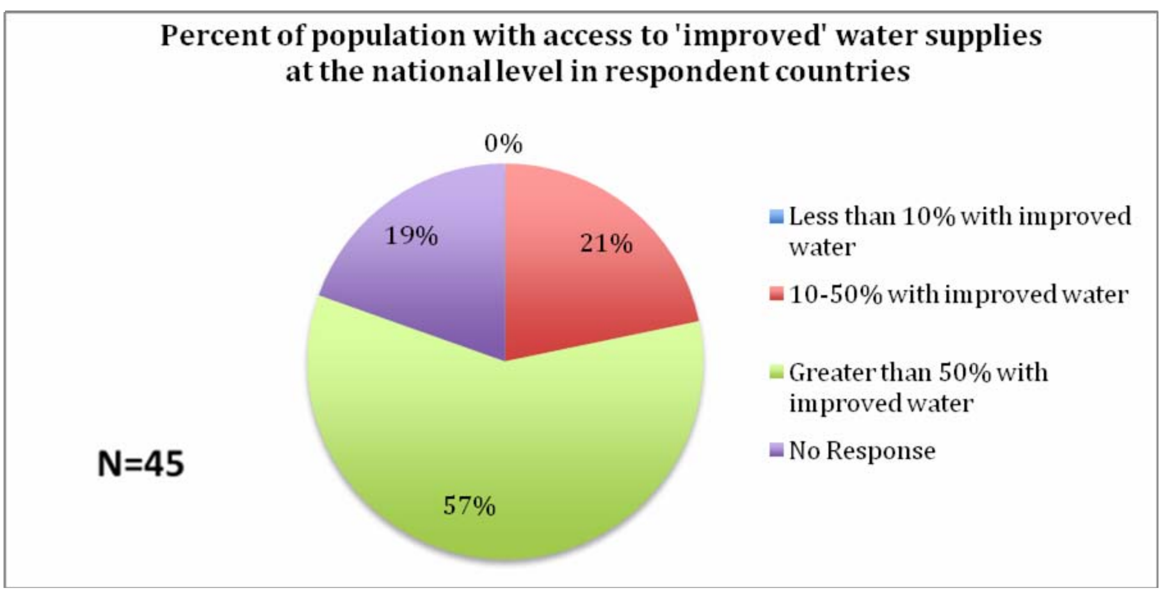

Figure 3.4: Percent of population with access to 'improved' water supplies at the national level in respondent countries

An ‘improved’ water source as defined by the Joint Monitoring Program is any one of the following:

- Piped connection
- Public standpipe
- Borehole
- Protected dug well
- Protected spring
- Rainwater

From Figure 3.4 we see that 57% of the respondent countries have made available improved water sources for more than half of their populations, whereas 21% of countries are able to provide only 10-50% of their populations with these improved water sources.

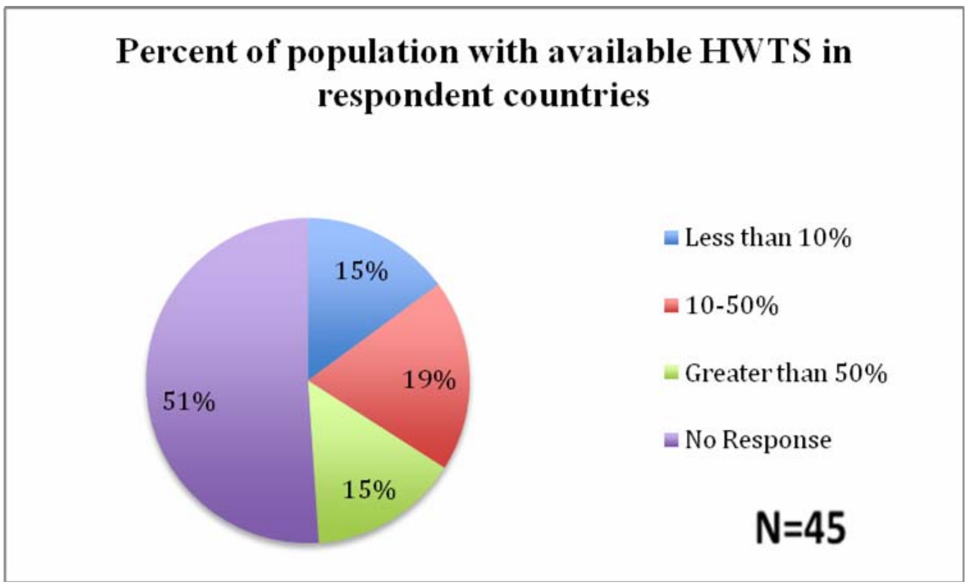

Figure 3.5: Percent of population with available HWTS in respondent countries

Figure 3.5 indicates that 51% of the country offices did not have any data on the availability of HWTS technologies within their countries. On the other hand, of the 49% of the country offices that do have data, 15% reported an availability of greater than 50% of HWTS technologies amongst their populations.

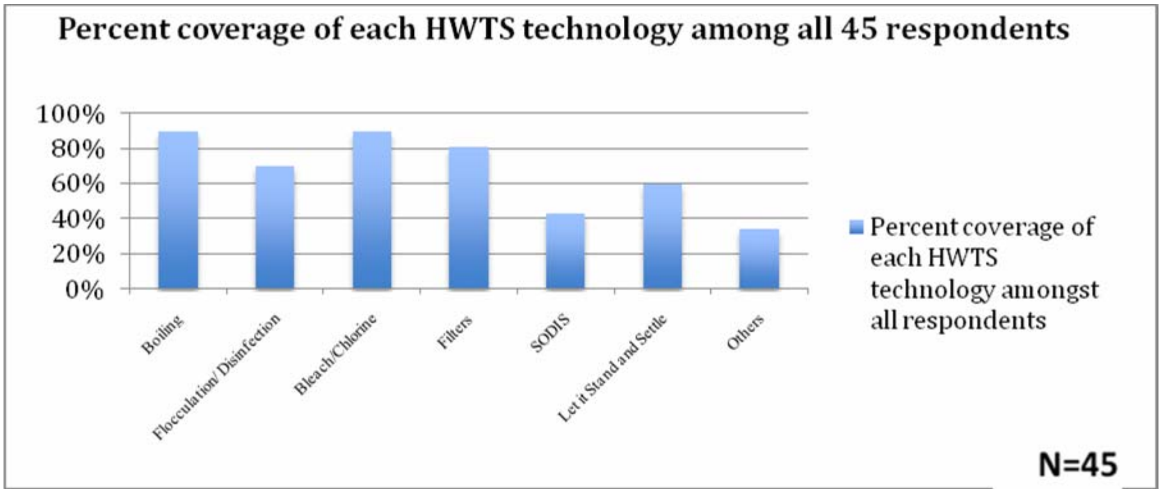

Figure 3.6: Percent coverage of each HWTS technology among all 45 respondents

Figure 3.6 shows that boiling and chlorination are the most widely used HWTS amongst the 45 countries. Note that these percentages just signify the presence of a particular technology in a country. They do not indicate percent coverage.

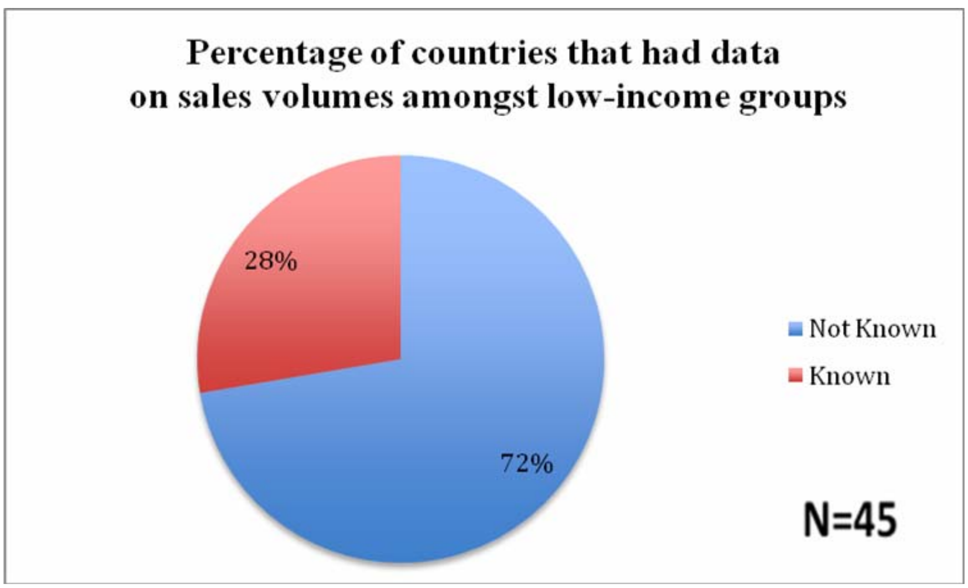

Figure 3.7: Percentage of countries that had data on the sales volumes amongst low-income groups

Figure 3.7 shows us that 72% of the countries do not know data on sales volumes.

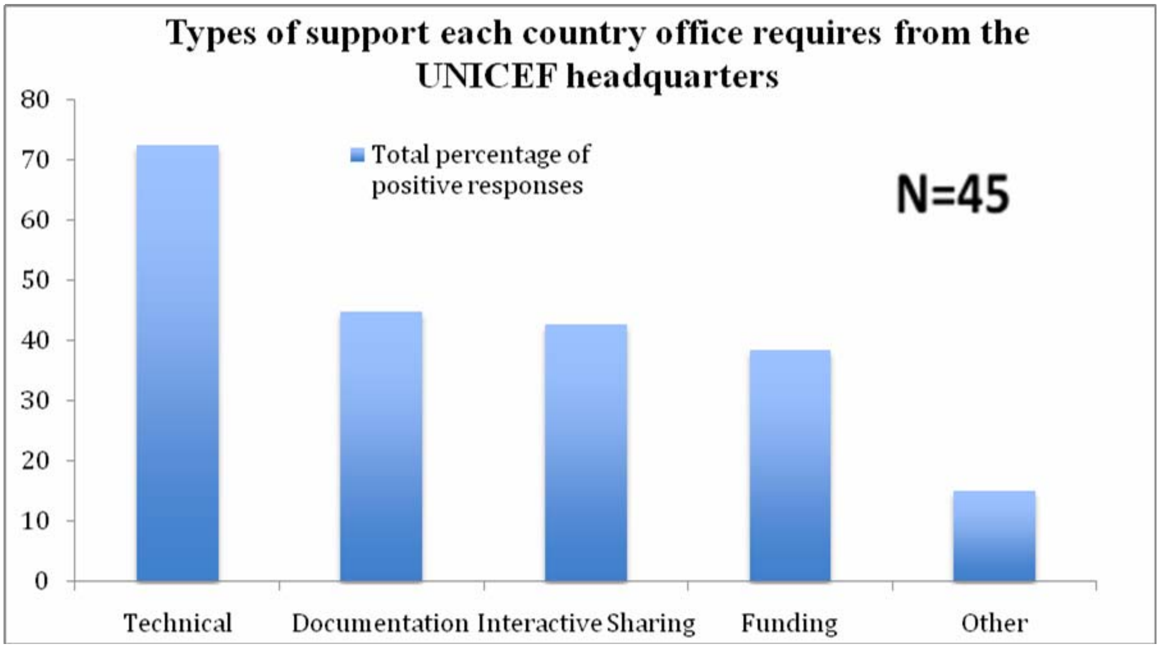

Figure 3.8: Figure representing the type of support the country offices require from the UNICEF headquarters

The country offices asked for various types of support from the headquarters, the author sub-divided these into five categories, namely

1. ***Technical:***
   Technical support encompasses the need for technical training or workshops. The need for a technically trained person was also put forth as a need by some country offices.
2. ***Documentation:***
   Documentation means providing case-studies, policy options, implementations and information on various HWTS tchnologies.
3. ***Interactive Sharing:***
   Some countries expressed interest in interacting with other country offices or getting in touch with successful implementers. Some offices also requested setting up regional forums to increase interaction among neighboring countries.
4. ***Funding:***
   Requests for funding, to take the program ahead or to conduct more research were included in this category.
5. ***Others***
   Support demands that didn't meet any of the above criteria were classified in this category.

Figure 3.8 indicates that most country offices lack proper technical expertise and that most of them are keen to interact with one another and share information. It is interesting to note that requests for technical support, documentation and interactive sharing ranked higher among the types of support requested over funding.

3.4 Discussion

Based on the results of UNICEF country offices survey, it is clear that each country office grapples with different problems in scaling up HWTS technologies. The nature of problems might be similar in some cases, but the degree to which they affect a particular country might be very different. Different cultural, economic and social preferences of people across the world makes it hard to implement HWTS technologies. Political instability coupled with social unrest (like in case of countries such as Somalia, Afghanistan, Iraq or Sudan) also makes implementation and scale up a hard task. While the ideal situation might be to develop just one HWTS technology and scale it up across the world, this is not feasible. Acknowledging this fact one must develop robust technologies that can be adapted to a particular set of preferences, cultural and environmental circumstances.

Few country offices insist on getting more resources, both human and monetary from the headquarters, although 72% of the respondent countries are keen on getting some technical support from the headquarters. The HWTS programs at the country offices sought help in deploying or testing out new technologies, or in adapting to and adopting a technology that has proven to be successful elsewhere in the world. For instance, UNICEF Bangui (Central African Republic) seeks support from other countries and from the headquarters to check the feasibility of manufacturing ceramic filters locally. Moreover, nearly 43% of the countries that responded are interested in creating a common forum/knowledge pool where WASH officers from different offices may interact, share information and hopefully share experiences of what works and what doesn’t work on the ground in a particular set of conditions. Another suggestion made by some countries, such as Democratic Republic of Congo, was that there should be more documentation made available to the country offices. These documents could either offer technical support by educating the WASH staff about the various HWTS technologies that are available or provide successful case studies or advocacy papers from across the world.

HWTS as a temporary solution

Another problem that has been cited by a few countries, like Ethiopia and Mauritiana, is that the HWTS program is still looked on as an emergency or temporary intervention, or as a need only for those using unimproved sources. This often leads to reluctance on the part of policy makers who tend to strive for excellence by investing in a piped water network. In such cases, the author believes, it is important for the UNICEF Headquarters to support the UNICEF country staff by providing them with updated statistics and information about other successful HWTS implementation programs and their derived health benefits, which the country office could use as a means to advocate for HWTS implementation in their country. In this case it must be noted that once scale-up becomes successful in a few countries, it would only be a matter of time before all countries get interested in HWTS.

Limited information from UNICEF country offices on HWTS

Another important finding of this survey has been that the amount of information available with the UNICEF country offices is very limited. In most cases the country offices did not have much of the information that was asked for from them. As a starting step, it would be a good idea for the UNICEF Headquarters to help the country offices develop this databank, so that it can be utilized for this project now, and for other projects in the future.

Reaching the poorest

HWTS technologies are still relatively expensive for the poorest of the poor. For instance in Cambodia, the country office is faced with a challenge of providing ceramic filters, which are still unaffordable for the poorest. Hence, research must go into finding ways to support these families without distorting the supply chain that is promoted by the manufacturer.

Emergency HWTS distribution's impact on sales

The country office from Malawi pointed out a special challenge towards scaling-up HWTS technologies. Malawi faces annual emergency events during the rainy season owing to cholera outbreaks. Water treatment products are distributed for free during these events. This makes commercialization of these products harder through the other parts of the year.

Stumbling blocks of policy in HWTS promotion

In Mozambique, national and international NGOs respond to emergencies by using the HWTS product CERTEZA, which is highly popular and widely used. However, the Government does not recognize CERTEZA as an improved water treatment technology, neither is it reflected in the JMP indicators as an improved water source. Any water treatment technology, prior to its application, needs to be approved by the Ministry of Health. This lack of recognition of the value of HWTS in providing safe water makes scale-up harder. In such cases, the country office first has to design, fund and conduct a study before advancing with the use of any HWTS technology.

Lack of education

Educating the user about the right practices for both treatment and storage is probably the hardest challenge scale-up faces. This is because behavioral change takes some time to get ingrained in a community. For instance in India, bacteriological contamination at handpumps contaminates the water. The same can happen with HWTS systems. With proper hygiene around handpumps the high level of contamination could be reduced considerably, however it has not been achieved. It will be equally difficult to ensure proper handling and use of any HWTS. The root cause of these problems is the lack of appreciation on the part of households towards the dangers of contaminated water and ways to prevent contamination.

Growing Interest in HWTS across the world

After having interacted with 45 UNICEF country it was clear that there is definitely a growing interest around the world in understanding, developing and scaling up HWTS technologies, although the extent of involvement may vary from country to country. The author recommends setting up a common forum where WASH officers could meet and discuss their country's WASH program. Such forums could potentially meet annually or bi-annually and share information on their HWTS programs. However, in doing so one must acknowledge the fact that all countries may not have similar resources to spend on the 'HWTS-development and scale-up' program, thus there would be a need to setup multiple regional forums. Another way to execute this more effectively could be by initiating industry- academia partnerships within the countries. The involved academic institutions and industries would work as knowledge houses, research and development centers and also information-diffusers to the community.

CHAPTER 4: HWTS IN THE INDIAN CONTEXT

4.1 Background

India shares many characteristics with other developing countries. Because rainwater harvesting is limited and because desalination is not practical in India, the two main sources of water are groundwater and surface water. However, increasing demands coupled with the over-drawn water tables has reduced the availability of water from 5000 cubic meters per capita in 1950 to 2000 cubic meters in 2007, which is further expected to reduce to 1500 cubic meters by 2025. The over-utilization of the groundwater resources over the past six decades has led to a situation where the country has great amounts of untreated sewage to be dealt with, for which the country does not have adequate infrastructure, with the result that nearly 90% of India's wastewater is discharged into the surface water without treatment (Baytel Associates, 2007). India faces groundwater contamination issues such as saltwater intrusion, fluoride, heavy metals, nitrates, chlorides, pesticides and microbiological contaminants (Baytel Associates, 2007). The result is that even populations with access to water do not have access to safe water. In urban areas, 85% of the population has access to improved drinking water, but only 20% of the available supplies meets the current health and safety standards (Jha, 2001).

As the educated middle-class population in the country is steadily growing, the purchasing power is also increasing. Companies such as Eureka Forbes Ltd., Hindustan Unilever Ltd., Usha Shriram Brita Pvt. Ltd., Bajaj Electricals Ltd. And recently also TATA[1], have used this as an opportunity to sell HWTS systems across the country. In fact from 1995 to 2005, the annual unit sales of HWTS products grew threefold, to almost 3 million units (Baytel Associates, 2007). The systems developed for this class of the population includes high-end combined filtration and ultraviolet (UV) disinfection systems that cost about $150 (Baytel Associates, 2007). In the recent past one has also seen these companies introduce Reverse Osmosis (RO) systems in the Indian market. Initially priced at about $300, these state-of-the-art treatment units have been a great success too, and with cheaper Chinese versions of these systems becoming increasingly available, the price to the consumers is also coming down at a fast rate.

Additional salient facts regarding the point of use treatment system market in India are presented below,

- Nearly one-fifth of India's population uses folded cloth filters to remove sediments and larger contaminants (Baytel Associates, 2007).
- In 1999, more than 8% of India's households purified water through boiling, and almost 6% were using candle filter drip pots (Baytel Associates, 2007).
- Recent studies suggest that 20% of urban and peri-urban residents boil their water, 34%

[1]http://epaper.timesofindia.com/Repository/ml.asp?Ref=Q0FQLzIwMDkvMTIvMDcjQXIwMTgwMg==&Mode=HTML&Locale=english-skin-custom (Accessed on December 7, 2009)

filter through cloth or net, 21% use a candle filter, 13% have a high-tech filter, and 9% have a tap filter (Sharma 2007)

In light of these facts it has become evident that the Indian HWTS market needs to make a shift to accommodate not only the relatively high-end treatment market demand, but to step up the production of affordable, efficient and basic systems that could cater to the needs of the greater portion of the population. Hence, over the past two to three years a paradigm shift in the Indian HWTS markets has been observed, where the same manufacturers have come up with a portfolio of low-cost treatment systems such as the Pureit and the Usha Brita filter. The target population for these products are the poor and lower middle classes hence these systems are priced anywhere between US $ 20-40.

The following section presents factsheets on some of these major India technologies, based largely on information provided by the manufacturers.

4.2.1 Aqua Guard Water Purification System

Household Water Treatment and Safe Storage (HWTS)

Product and Implementation Fact Sheet

Figure 4.1: Aqua Guard Water Purification System (Source: eurekaforbes.com)

Technology Description

- Aqua Guard Water Purification (AGWP) system is a unit that utilizes a 3-stage purification process consisting of sediment filtration, treatment with activated carbon, followed by ultraviolet treatment.
- AGWP system has been tried and tested by over 100 laboratories in India, USA, UK and South Africa.
- Eliminates disease-causing viruses and bacteria from the water.
- It does not involve the addition of any harmful chemicals or resin.
- It has an additional feature, which involves boiling the water for 20 minutes to ensure that the water is safe and pure. This feature is called “e-boiling +”.
- The essential minerals and salts in the water, which are good for the human body, are retained after the water passes through the system.
- It has an Electronic Monitoring System that monitors the purification process and stops the flow of water immediately, if the level of purification is inadequate.

What contaminants does it remove (based on manufacturer’s claims)?

It removes all known disease-causing bacteria and viruses (http://www.eurekaforbes.com/).

How does it remove contaminants?

AGWP system utilizes a three-stage purification process. It device consists of a 2-in-1 compact cartridge, which combines the sediment filter with the activated carbon. Water first passes through the sediment filter which strains out the suspended impurities for enhanced filtration, as shown in the Figure 4.2 below. Water then passes through specially treated silver impregnated activated carbon, which reduces color, odor, organic impurities, chemical impurities and free gases like chlorine. Silver impregnation works as a bacteriostatic. In the next stage, water is subjected to ultraviolet treatment where ultraviolet rays e-boil the water. This kills the water-borne disease-causing bacteria, virus and protozoans. Electronic impulses are produced to prevent scaling of the quartz tube thereby ensuring that precious minerals and nutrients are retained in the water. Moreover, the ultra-violet (UV) lamp is switched off if water is not drawn for 10 minutes, thus enhancing the life of the UV lamp.

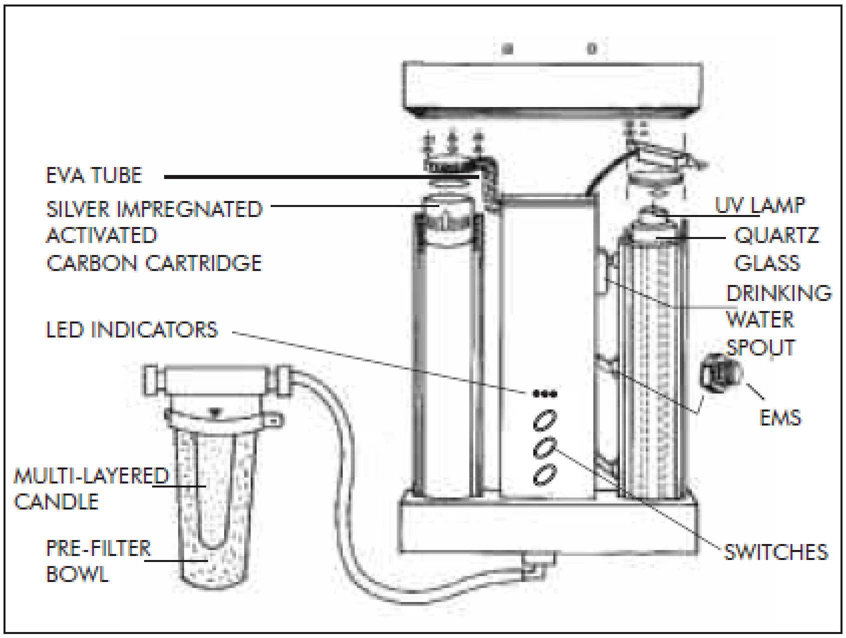

Figure 4.2: Schematic describing the various parts of the Aqua Guard Purification System

Capacity (flow rate and/or batch volume)

Depending on the input water pressure, the flow rate of water is about 1 liter/ minute.

Cost of Technology (per single unit)

Capital: USD 160 per unit

O&M Cost: USD 20 per year

Effective Household Water Management with this Product

Operation

1. The unit turned on by pressing the ‘power’ switch. The red light-emitting diode (LED) glows for 5 seconds indicating that the power is on.
2. After 5 seconds, the yellow LED glows for around 30 seconds indicating that the unit is processing water.
3. When the green LED glows, one can hear three beeps indicating that the unit is ready to deliver clear, safe drinking water.
4. When drinking water is required, one needs to press the ‘flow’ switch and water starts flowing through the unit. While filling water, a pleasant musical tone can be heard by pressing the ‘music’ switch on the console.
5. If the unit is not used for a day or two, prior to filling water from it, one should allow 2-3 glasses of water to flow out before using the water for drinking.
6. Also, the main switch and water supply to the unit should be shut off in case the unit is not going to be used for more than 3-4 hours.

Maintenance/Cleaning

It is recommended that the area around the AGWP system be kept clean and dry. It is advised to wipe the system with a soft cloth once in a while, and keep the spout clean and closed with the cap provided. The sediment filter and activated carbon cartridge needs to be cleaned by an authorized service technician during the bi-annual routine service to make sure that it works well.

Replacement period

As per the manufacturer’s instructions, authorized technicians should conduct routine check-ups of the AGWP system at least once in 6 months. (http://www.eurekaforbes.com/).

Water Quality Results – Independent Tests

AGWP systems have been tried for the last 20 years, and tested by over 100 laboratories in India, USA, UK and South Africa (http://www.eurekaforbes.com/)[1].

Health Impact Studies

Proven reduction of viruses, bacteria and protozoa (http://www.eurekaforbes.com/).

Patents and Certifications

- Certified by the Indian Medical Association (IMA)

[1] The manufacturer had been contacted for these studies, however they haven’t been able to provide the same

Advantages

As per manufacturer's claims:

- Uses proven technology and effective in destroying all disease-causing bacteria and viruses.
- Simplicity of use
- It has a built-in voltage stabilizer which ensures normal functioning even at fluctuating/low voltage
- Minerals and nutrients known to be good for human body are retained in the water.
- AGWP system is voted as the only Superbrand in India in its category. The Superbrand Council is an independent body comprising of leading professionals from different fields, which pays tribute to exceptional brands worldwide.

Observed in the field:

- The system is available in almost all big towns and cities.
- The in-built voltage stabilizer is very helpful in the Indian context, where voltage fluctuation is very frequent

Disadvantages

Observed by the author and feedback given by respondents in Lucknow:

- Comparatively expensive
- Sediment filter and activated carbon cartridge needs to be cleaned regularly for it to function properly.
- After sales service is not efficient

Name of Implementing Organization

Manufacturer: Eureka Forbes

Type of Implementing Organization

Private Commercial

Location and Extent of Implementation / Sales

Aquaguard is India's largest selling water purifier.

References

Aquaguard Classic – User Manual, downloaded from http://corporate.eurekaforbes.com (accessed on November 24, 2009)

Aquaguard Classic – Brochure, downloaded from http://corporate.eurekaforbes.com (accessed on November 22, 2009)

Contact

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4.2.2 Kent Mineral RO Water Purifiers

Household Water Treatment and Safe Storage (HWTS)

Product and Implementation Fact Sheet

Figure 4.3: Kent Reverse Osmosis System (Source: www.kent.co.in/)

Technology Description

- KENT Reverse Osmosis (RO) is a computer controlled water purifier based on its patented Mineral RO^{TM} technology.
- Using a four-step process, it removes dissolved impurities offers double purification through a RO process followed by UV sterilization.
- The Total Dissolved Solids (TDS) controller helps to retain essential natural minerals in the purified water.
- Secondary purification by ultra filtration (UF) after RO ensures enhanced water quality throughout service cycles.
- This purifier is suitable for all types of raw water sources, from bore-wells, overhead storage tanks, water tankers, or municipal supply lines.
- It has 8 liters of purified water storage capacity, which makes purified water available on demand even in the absence of electricity / water supply.

- Awarded as the best domestic water purifier 2006-2007 by *The Water Digest*[8] in association with United Nations Educational, Scientific and Cultural Organization (UNESCO).

What contaminants does it remove (based on manufacturer's claims)?

Bacteria, viruses, and dissolved impurities like heavy metals, rust, salts, chemicals, and pesticides.

How does it remove contaminants?

This is a 4-step process where raw water is first purified process a sediment filter, followed by an activated carbon then followed by a RO membrane. Essential natural minerals are then released into the RO purified water by the patented Mineral RO process. A control valve is also provided to adjust the TDS level of purified water on site (TDS controller). The purified water is then sterilized by UV process to give double protection from bacteria and viruses.

Capacity (flow rate and/or batch volume)

Kent RO system has a purifying capacity of 15 liters / hour.

Cost of Technology (per single unit)

Capital: Rs. 14,000 – 15,000 / unit (USD 300)

O&M: Rs. 1000/ year (USD 20)

Operation

Kent Mineral RO water purifier has a fully automatic operation with auto-start and auto-off.

Maintenance/Cleaning

The equipment needs cleaning once every six months, when the filters need to be back-washed. The membrane needs to replaced once every two years.

Replacement period

Monitoring filter needs to be replaced regularly in order to maintain the optimum filter & water quality. For instance, based on the turbidity of the influent water the sediment filter needs to be changed. The filter costs about USD 20. The membrane, which needs to be replaced once every two years costs about USD 50.

[8] http://www.waterdigest.in/index.php?top=index

Advantages

As per manufacturer's claims:

- RO separation process removes dissolved impurities like heavy metals, rust, salts & chemicals
- The TDS controller & the patented Mineral RO technology retains essential natural minerals in the purified water
- Secondary purification by UV or UF after RO ensures enhanced water quality throughout service cycles
- After a pre-set time, a filter change alarm is audible that indicates time to replace the filters. If the filters are not changed within next 60 hours of use, the purifier stops functioning.

Observed in the field:

- Easy to use
- Water quality is very good, removes all physical, chemical and microbiological impurities.

Disadvantages

Observed by the author and feedback given by respondents in Lucknow:

- Comparatively expensive
- Monitoring filter needs to be replaced timely to helps maintain the optimum filter & water quality.
- Large quantity of water is wasted compared to the amount of water filtered, therefore this system is inappropriate where drinking water is scarce or expensive.
- Requires special installation
- Bulky and consumes electricity

Name of Implementing Organization

Manufacturer: Kent

Type of Implementing Organization

Private Commercial

References

http://www.kent.co.in (accessed on November 24, 2009)

Manufacturer's brochure downloaded from http://www.kent.co.in/kent_pride.html (accessed on November 24, 2009)

Contact

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4.2.3 Aquatabs

Household Water Treatment and Safe Storage (HWTS)

Product and Implementation Fact Sheet

Figure 4.4: Aquatabs (Source: http://www.aquatabs.com/)

Technology Description

- Aquatabs are effervescent (self-dissolving) tablets which, when added to unsafe drinking water, make the water safe to drink.
- They are used to self-disinfect water at the point-of-use at the household level
- These tablets dissolve clear within minutes and disinfect the water within 30 minutes.
- Aquatabs are available in 6 tablet strengths: 3.5mg; 8.5mg; 17mg; 33mg; 67mg; 167mg, depending on the volume and nature of water to be treated.
- Aquatabs utilise materials specifically approved to International standards for use in drinking water with NSF ANSI Standard 60 Certification.
- The active ingredient in Aquatabs is Sodium Dicholorisocyanurate (NaDCC). NaDCC is approved by the US Environmental Protection Agency (EPA) for routine treatment of drinking water, meets European Standards for drinking water (EN12931: 2000) and World Health Organization (WHO)/ The Food and Agricultural Organization (FAO) specifications for drinking water.
- Aquatabs enable areas without access to water disinfection systems to benefit from the advantages of chlorination without any infrastructure requirements in a speedy and cost effective manner.

What contaminants does it remove (based on manufacturer's claims)?

Aquatabs are used to kill microorganisms in water, to avoid diseases such as cholera, typhoid, dysentery and other water-borne diseases.

How does it remove contaminants?

Chlorine disinfection

Capacity (flow rate and/or batch volume)

- Aquatabs tablets are available in 6 tablet strengths: 3.5mg; 8.5mg; 17mg; 33mg; 67mg; 167mg, depending on the volume and nature of water to be treated.
- Each tablet is dissolved in a specified volume of water, according to the following dosage chart:

Litres	High Risk	Low risk
1 Litre	8.5mg	3.5mg
4-5 Litres	33mg	17mg
10 Litres	67mg	33mg
20-25 Litres	167mg	67mg

Table 4.1: Dosage chart for Aquatabs

- If the water to be treated is being consumed from a known source (such as with a household water supply), then the low risk dosing, as shown above, can be used. In all other situations, then the high risk dosing should be used.

Cost of Technology (per single unit)

Capital: Rs. 15 per 30 tablets (USD 0.45/ 30 tablets, 33mg)

Operation

1. Select the tablet size depending on the volume of water to be treated.
2. Add the tablet to the water and ensure thorough mixing.
3. Wait at least 30 minutes and the water becomes safe for drinking.
4. If, at the outset, the water is turbid, first filter through a cloth and then add Aquatabs using a double dose.

Maintenance/Cleaning

It is recommended that Aquatabs are stored in cool, dry conditions, away from direct heat and sunlight.

Replacement period

Aquatabs are a recurrent use product. To ensure that water is disinfected and safe to drink, Aquatabs must be added to all drinking water on a regular (daily or every time supply runs out) basis.

Water Quality Results – Independent Tests

Aquatabs have been independently tested in field trials worldwide on a very wide range of water types (e.g. varied pH, turbidity, hardness, pathogenic challenge) and have been consistently proven to reduce total and fecal coliform levels and other micro-organisms to zero or low risk. Moreover, these tables have undergone successful comparative taste trials internationally and have proven acceptability to all cultures

Health Impact Studies

A randomized controlled health impact trial in Northern Region Ghana by Centers of Disease Control will be published in near future. Aquatabs have been in use for over 20 years and no side effects have been reported to date.

Advantages

As per manufacturer's claims:

- Easy to use
- Safe to store and handle
- Cost effective and affordable to low-income groups
- Lightweight and transportable
- Provides a chlorine residual that is easily monitored to indicate successful use
- Makes disinfection possible without infrastructure requirements and in a speedy manner
- Simple to apply with no operation and maintenance requirements, and requiring little skill to provide a controlled means of chlorination in remote situations.
- Provided in a range of sizes to suit various dosage-volume requirements

Disadvantages

Observed by the author and feedback given by respondents in Lucknow:

- May not be acceptable to users due to the taste or odor of chlorine
- Low efficacy in waters with high turbidity or high organic content

Name of Implementing Organization

Manufacturer: Medentech

Type of Implementing Organization

Private Commercial

Location and Extent of Implementation / Sales

Aquatabs are used for household water treatment with over 13 million daily users globally. Over 1 billion tablets were distributed in 2008 alone, for emergencies worldwide where over 790 million liters of water were purified and made safe for drinking. In the same year (2008), Medentech supplied Aquatabs through Social Marketing programs, where over 470 million tablets were used to purify 1.4 billion liters of water.

References

Blandon, Elizabeth. "The Health Impact Study of Aquatabs in Tamale: a Work in Progress" Powerpoint Presentation. Centers for Disease Control, Atlanta, Georgia, November 17, 2006.

Manufacturer's brochure downloaded from http://www.medentech.in/water-contamination-disinfection-products/aquatabs-water-purification-tablets.html

www.aquatabs.com

Contact

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4.2.4 Bajaj Water Filters

Household Water Treatment and Safe Storage (HWTS)

Product and Implementation Fact Sheet

Figure 4.5: Bajaj Water Filter (Source: http://www.bajajelectricals.com/c-203-water-filters.aspx)

Technology Description

- Bajaj Candle Water Filters are made of Salem Stainless Steel[9].
- These filters have two containers – the top container with a lid for candle, and a bottom container with nickel-plated brass tap for the outlet of drinking water.
- The candle used for filtration is made of specially formulated ceramic.
- Filters are available in different capacities, with one or more candles depending on the capacity of the filter.
- These filters do not require the addition of any resins and does not require electricity to operate.
- These filters do not require a continuous supply of water.

What contaminants does it remove (based on manufacturer's claims)?

The micro porous candle filter removes all suspended impurities from water.

How does it remove contaminants?

These filters use specially formulated ceramic filter to filter water for drinking.

Capacity (flow rate and/or batch volume)

The filtration capacity of these filters is 0.75 liters/hour.

[9] http://www.salemsteels.com/

Cost of Technology (per single unit)

Capital: Rs. 1,200 / filter (USD 20-30)

O&M: Replacement filter candles cost about Rs. 600 (USD 12-16)

Operation

The filters have simple operations and are easy to use. Water needs to be poured into the top compartment. It flows through the candle containing the ceramic filter into the lower compartment, which is then ready for drinking and can be poured out from the tap in the lower compartment.

Maintenance/Cleaning:

The filters get clogged frequently, hence they need to be backwashed and cleaned frequently (once a week or more, depending on the turbidity of the source water).

Replacement period

The filter candle needs to be changed at regular intervals in order for it to function properly.

Advantages

As per manufacturer's claims:

- Simplicity of use
- These filters use a completely natural process to filter water and do not require electricity.
- They do not require the addition of resins and do not require a continuous supply of water.

Disadvantages

Observed by the author and feedback given by respondents in Lucknow:

- Filter candle elements requires regular cleaning when they becomes clogged with particles
- Flow rate can be slow and may not provide sufficient water quantity
- Ceramics may break if handled improperly. Hairline cracks may develop and not be detectable to the user.

Name of Implementing Organization

Manufacturer: Bajaj

Type of Implementing Organization

Private Commercial

References

http://www.bajajelectricals.com/pc-647-203-aqualife-water-filter.aspx (accessed on November 24, 2009)

Contact

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4.2.5 PUREIT (Hindustan Unilever) Water Treatment Systems

Household Water Treatment and Safe Storage (HWTS)

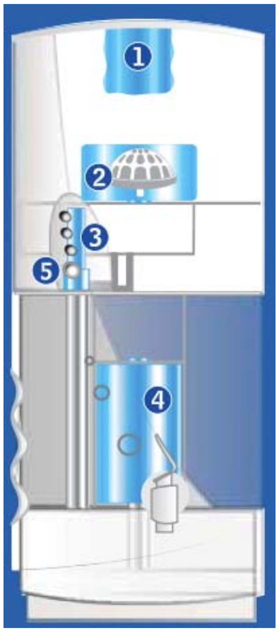
Product and Implementation Fact Sheet

Figure 4.6: A fully operational Pureit System in the one of the surveyed households in Lucknow.

Technology Description:

Pureit purifies the drinking water in four stages, beginning with the removal of visible dirt, followed by the removal of harmful parasites and pesticide impurities. Then, the harmful viruses and bacteria are killed and finally the water is rendered clear and odorless by removing remaining impurities.

Each of the four treatment stages is executed by a different component of this system. The names and the functions of each of these components are explained in the figure and text below:



1. MICROFIBRE MESH™: Removes visible dirt
2. COMPACT CARBON TRAP™: Removes remaining dirt, harmful parasites and pesticide impurities.
3. GERMKILL PROCESSOR™: Uses 'programmed chlorine release technology' and its stored Germkill power (residual chlorine) targets and kills harmful bacteria
4. POLISHER™: Removes residual chlorine, giving clear, odorless and great tasting water.
5. BATTERY LIFE INDICATOR™: Ensures total safety because the germkill power indicator turns red, when exhausted, warning the user to replace the battery.

Figure 4.7: Setup of a Pureit filter (Source: Pureit Brochure, 2008)

What contaminants does it remove (based on manufacturer's claims)?

Removes dirt, harmful parasites, pesticide impurities and kills viruses and bacteria

How does it remove contaminants?

The mesh filter removes the suspended particles while the carbon trap removes other impurities. The germkill processor kills viruses and bacteria

Capacity (flow rate and/or batch volume)

The filtration capacity of these filters is 18 liters/day.

Cost of Technology (per single unit)

Capital: Rs. 2,000 / filter (USD 40)

O&M: Germkill processor battery costs about Rs. 365 (USD 8)

Operation

These filters have simple operations and are easy to use. Water needs to be poured into the top compartment. It flows through the filter, which is then ready for drinking and can be poured out from the tap in the lower compartment.

Maintenance/Cleaning

The filter mesh needs to be backwashed frequently (once every 2-3 weeks). The Germkill processor battery need replacement once every 1500 liters (around 3 months for an average Indian family size of 5 assuming consumption of 3.2litres/capita/day).

Replacement period

The Germkill processor battery needs replacement once every 3 months or 1500 liters.

Advantages

As per manufacturer's claims:

- Simplicity of use
- These filters use a three-step filtration and disinfection process and do not require electricity.
- It does not require the addition of resins and does not require a continuous supply of water.
- System shuts off on its own, once the battery expires, thus protecting the user

Disadvantages

Observed by the author and feedback given by respondents in Lucknow:

- Expensive
- Made of plastic, hence vulnerable to breaking
- After sales service is a problem

Patents:

EP2104647[10]: 'Gravity-fed water purification apparatus with venturi dosing device'

Name of Implementing Organization

Manufacturer: Hindustan Unilever (HUL)

Type of Implementing Organization

Private Commercial

References

http://www.pureitwater.com/index1.htm

Contact

Pureit.hul@unilever.com

---

[10] Agarwal, Swati (Hindustan Lever Ltd Research Centre64, Main Road, Bangalore, Whitefield 560 066, IN), Chatterjee, Jaideep (Hindustan Lever Ltd Research Centre 64, Main Road, Bangalore, Whitefield 560 066, IN), Dagaonkar, Manoj Vilas (Hindustan Lever Ltd Research Centre 64, Main Road, Bangalore, Whitefield 560 066, IN), Majumdar, Udayan (Hindustan Lever Ltd Research Centre 64, Main Road, Bangalore, Whitefield 560 066, IN) 2009, Unilever N.V. (Weena 455, 3013 AL Rotterdam), Unilever PLC (Unilever House 100 Victoria Embankment, London

CHAPTER 5: WATER SAMPLING AND TESTING METHODOLOGY

5.1: Overview of the Water Sampling and Testing Methodology

The main objectives of conducting water quality testing in Lucknow were to:

1. Determine the water quality of the treated water of all households and, in some cases, the actual sources in Lucknow where sanitary surveys were conducted. Water quality tests were performed using the EC-Kit.

2. Compare the EC-Kit to the standard laboratory testing method of Multiple Tube Fermentation (MTF). This comparison was conducted for 42 split samples that were collected in the field and analyzed at the Indian Institute of Technology (IIT), Delhi.

The following section describes the water sampling and testing methodology used by the author in the field research at Lucknow, Uttar Pradesh, India. It is summarized in figure 5.1 below.

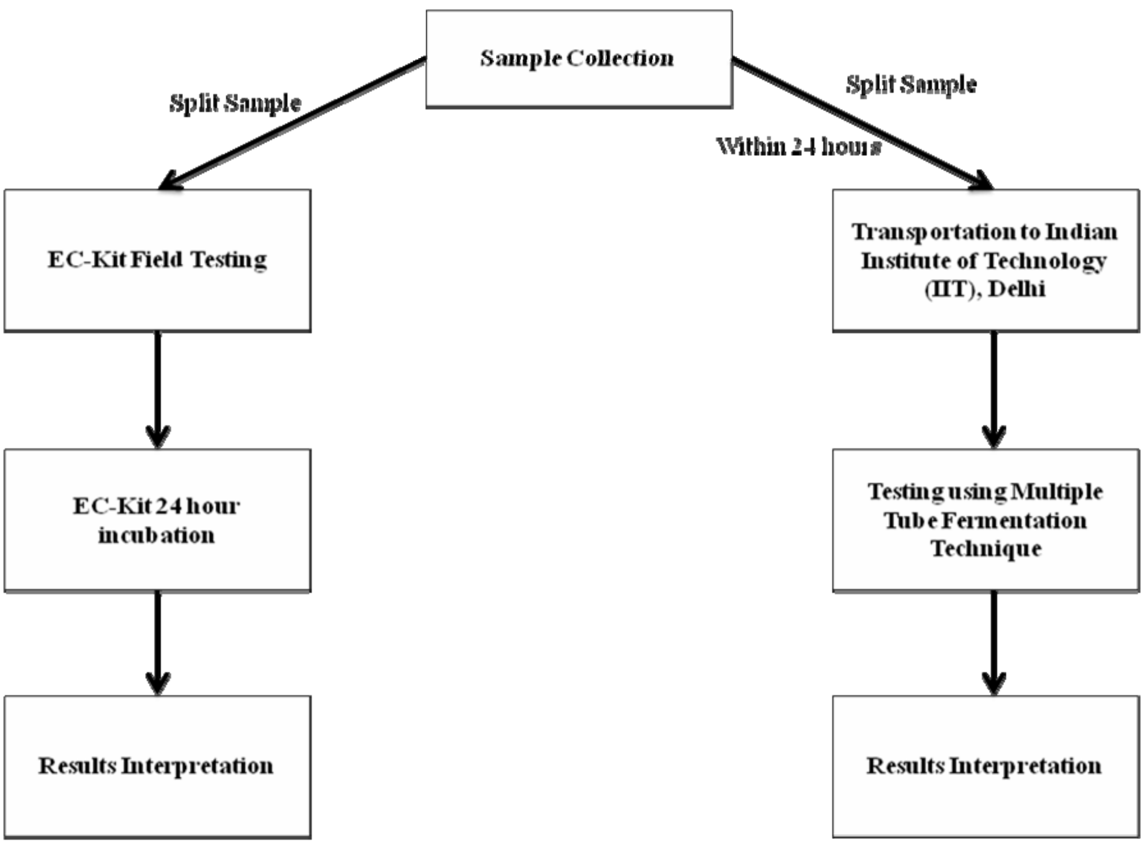


Figure 5.1: Flow diagram representing general sampling and testing methodology

Sterile conditions were ensured at all stages of sampling, transportation and testing. In Lucknow, 10 mL of water was collected into the Colilert glass tubes and, to maintain sterile conditions, the ceramic tile base for the Petrifilm test was first wiped with alcohol. One mL water samples were dispersed on the Pertifilm, using a 1 mL graduated sterile plastic pipette. The collected samples were stored and incubated in the waist belt incubator provided in the EC-Kit. The samples to be tested in laboratory using the MTF technique were collected and taken to the Indo-French Waste Water (IFWW) laboratory located at the Indian Institute of Technology (IIT), Delhi in sterile 100 mL transparent plastic Whirl-Pak® bags[1]. The bags were kept on ice in a cooler bag and transported to Delhi, where the lab technicians tested the samples within 24 hours of collection.

During the sampling process, samples were collected from either the source directly or from the point of use. When samples were collected from the source, the author either put the Colilert tube directly under the water flowing out from the source filling the Colilert tube to the pre-marked 10 mL line, or for the Petrifilm test the source samples were first collected in the Whirl-Pak® bags. When samples were collected after an HWTS system, the sample was taken from a cup or container that was first rinsed five to six times with water from the system. In the case of point-of-use samples from a cup or container, the samples were taken either directly from storage containers (like bottles, jerry cans, plastic and steel buckets, drums) by pouring or from drinking water glasses (stainless steel or glass) that were commonly used by the householder. In the case of the samples that were transported to the IIT Delhi, the author used the same distinction between the source and the point-of-use samples (in certain cases from the outlet tap/opening in the safe storage container or from a drinking water glass at the user's house) and filled the sample into Whirl-Pak® bags[2]. At the time of sampling, special attention was paid to the numbering of samples, each sample was given a unique three-digit code that corresponded with the survey number.

5.2 Sampling Procedure for the EC-Kit- Total Coliform and *E.coli*

Even though great advances have been made in the field of water and wastewater engineering, microbial water quality testing has historically been accessible only where there are laboratory facilities and technically qualified staff. The EC-Kit[3] is a simple, inexpensive, easy-to-learn and easy-to-interpret water quality testing kit that allows the user to analyze the microbial quality of water by the simultaneous detection of *E.coli* and total coliforms. The EC-Kit combines two tests together, namely

- Colilert- 10 mL pre-dispensed test (a presence-absence test *E.coli*/total coliform test)
- Petrifilm- (quantifies *E.coli* and the total coliform contamination of the sample)

[1] Whirl Pak bags were of the type without sodium thiosulfate because the sodium thiosulphate interferes with the Pertifilm Test

[2] At the time, the author felt that obtaining point-of-use samples from the actual containers and vessels used by the households would be an appropriate methodology but in hindsight he realizes that this sampling method would not adequately distinguish between treated water from a HWTS system versus water contaminated (or not) from a container or glass.

[3] The EC-Kit is the product name given to the Portable Microbiology Laboratory (PML). The PML was the innovation of Prof. Robert Metcalf of the University of California at Sacramento State. Susan Murcott, in collaboration with Robert Metcalf, contributed to this idea by the invention of the waist-belt incubator and by packaging the PML into portable cooler bags with different models (10, 25, 50, 100 tests) and by giving the product the simpler brand name (EC-Kit).

The kit is much cheaper ($3.00/both tests) method as compared to other conventional microbiological standard methods, such as Membrane Filtration and the Multiple Tube Fermentation Technique. The other advantages that make it a robust product are:

- Easy to use (no media preparation is needed)
- Light weight, portable and can be stored for 12 months under proper conditions.
- Does not require an electric incubator unit (both the Petrifilms and the Colilert tubes can be safely incubated in the waist-belt incubator that is provided using body heat)
- Covers a range of risk categories: Each of the two methods in the kit allows detection in a different range and hence different levels of risk.

Given these benefits, the kit can be a useful product in field locations across the world that may lack access to a continuous source of electricity or clean water, as is needed in regular microbiology laboratories worldwide.

Components of the EC-Kit and their purpose:

Item	Purpose
10 mL pre-dispensed Colilert glass tubes with powdered media[4]	Presence/Absence test that determines whether or not *E.coli* and total coliform bacteria are present
Petrifilm[5]	Determines quantitatively how many *E.coli* and total coliform bacteria are present
Sterile Whirl-Pak® Sampling Bags	Used for sterile water sample collection
Sterile Plastic Pipettes	Used to transfer 1 milliliter test sample water onto Petrifilm
Waist belt incubator	Enables user to incubate test samples using body heat, thereby eliminating the need for costly lab incubators and electricity.
Cardboard Squares	Keep Petrifilms protected and flat during incubation
Rubber Bands	Used to hold cardboard squares together
Black light (UVA) + 4 AA Batteries	Tells if the sample fluoresces blue when this light is shone on the Colilert tube, meaning it is positive for *E.coli* .
Cooler bag	For transport and containment of all EC-Kit supplies
Ice pack	For sample preservation at a cool temperature if sample is being carried back from the field before running tests.
Laminated Instructions	Gives step-by-step procedure training to both technical or non-technical users

Table 5.1: Components of the EC-Kit

[4] http://www.idexx.com/view/xhtmL/en_us/home.jsf

[5] http://www.idexx.com/view/xhtmL/en_us/home.jsf

5.2.1 The Colilert® Test

This IDEXX test uses the Defined Substrate Technology (DST®), a substrate medium that does not contain any organic sources of nitrogen and contains only two carbon sources: ONPG (ortho-nitro-phenol-beta D-Galactopyranoside) and MUG (4-methyl-umbelliferone-beta-glucuronidase). The test uses a 10 milliliter pre-dispensed tube that detects the presence/absence of *E.coli* down to the equivalent of 10 Coliform Forming Units (CFU) below which their presence is considered low risk.

In case of the negative result, the sample in the tube looks the same visually, after 24-hours of incubation with body heat, as when it was collected. However a positive sample turns yellow after incubation (Murcott, 2009).

Testing Procedure:

1. For the first test, a one-milliliter sterile pipette was used to fill up one reference Colilert tube with 10 mL of sample. After which a line was drawn at the 10 mL water level using a fine-tipped permanent marker pen. All other Colilert tubes were marked at the same 10 mL mark using the first tube as a reference.
2. The tubes were labeled with the unique three-digit sample number that corresponded to the survey number for each household. In households where the source water was also tested, while labeling the three-digit unique number was followed by the term 'Source' to identify between samples.
3. For all the subsequent tests, the cap was removed, and then the Colilert tube was filled with a 10 mL sample in one of two ways
   - The Colilert tube was filled to the 10 mL mark by adding water directly from the source, which in the present study was either a public supply tap or a hand pump.
   - A sterile pipette was used to transfer the sample from the household containers such as bottles, earthen pots, stainless steel buckets or the HWTS system or a drinking water glass, based on what the user put forth.

   In either of the two cases it was made sure that the sample did not exceed 10 mL.
4. The cap was then replaced and the tube was shaken a couple of times to ensure that all the media present in the tube dissolved into the water sample.
5. The sample was then incubated for 24 hours at body temperature using the waist belt incubator.
6. After 24 hours incubation, the samples were examined for a color change from clear to yellow. The tubes were also examined in the dark by shining a UV/black light on the samples that tested positive to check for blue florescence.

Interpreting Results

After 24 hours:

- If the samples were clear, it was concluded that no coliforms were present in the sample and that the water was safe to drink.
- If samples were yellow and did not fluoresce under the UV/black lamp it meant that total coliform bacteria were present in the sample, although they did not have

a significant public health impact because these coliforms are environmentally derived.

- If yellow sample fluoresces blue under UV/black, at least 1-10 *E.coli* are present in the water sample, and the water poses some health risk.

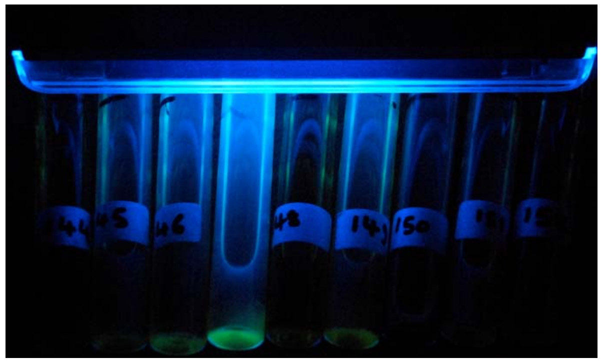


Figure 5.2: Author's samples under the UV lamp. Samples 145, 146, 147 and 149 fluoresce while the others don't, confirming the presence of *E.coli* in those samples

5.2.2 The Petrifilm™ Test

The Petrifilm test uses sample-ready plates to quantify *E.coli* and total coliforms with a minimum detection limit of 1 *E.coli* per 1 mL (high risk) to quantify the level of *E. coli* and total coliform contamination in a water sample. The Petrifilm pre-coated contains:

- Violet Red Bile (VRB) nutrients (a gelling agent),
- BCIG (5-bromo-4-chloro-3 indolyl-beta D Glucuronide), an indicator of glucuronidase activity (this is the same enzyme that hydrolyzes MUG in the Colilert test and which is produced by *E. coli*, but not by other coliform bacteria)
- Tetrazolium, which is an indicator that enables the developed colonies to be counted (which gram negative bacteria reduce to a red color to enhance colony visualization),
- A top film on the plate that traps gas produced by lactose fermenting *E. coli* and coliforms
- The 3M Company produces it.

As prescribed by the manufacturer, the Petrifilms were stored at a refrigeration temperature of about 8-10 ˚C and were consumed within a month of opening the packet (Murcott, 2009).

Sampling Procedure

The sample collection procedure involves putting the Petrifilm on a flat, sterile surface (ceramic tile), which had been wiped down with isopropyl alcohol and then adding the 1mL sample that has been collected using a sterile pipette. Once the sample disperses over the entire media plate, Petrifilm is allowed to sit for about one minute or more and then the Petrifilm is carefully secured between two cardboard pieces using a rubber band.

These samples are then stored and incubated using the waist belt incubator provided in the EC-Kit.

Interpreting Results

After 24 hours:

- The number of red and blue colonies with gas bubbles formed on the Petrifilm after the incubation are counted.
- For high counts (>30 colonies total), the number of colonies developing on one of the twenty pre-formed grids of the Petrifilm is counted and then multiplied by 20, to give an approximate CFU count.

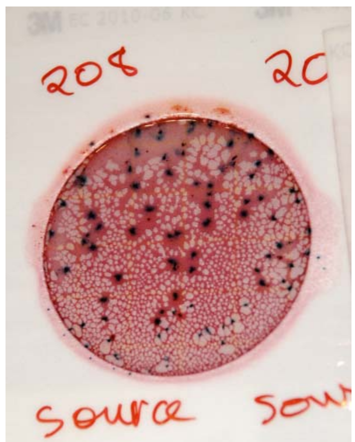


Figure 5.3: Lucknow source sample picture depicting the formation of red and blue colonies with gas bubbles on the Petrifilm.

The *E.coli* counts from the EC-Kit tests enable the determination of different levels of risk. Table 5.2 shows the World Health Organization's risk rankings for thermotolerant coliform in the two left columns (WHO, 1997). As can be observed from the table, when there are less than 10 thermotolerant coliform CFU per 100mL sample, the WHO quantifies the risk of waterborne disease as low. While using the Colilert and the Pertifilm tests this low risk range gives a negative result for both tests. However, a water sample with at least one *E.coli* per 10 mL Colilert (i.e. MUG+ that comes out positive) and no presence of *E.coli* on the Petrifilm shows an intermediate risk (corresponding to between 10 – 100 CFU/100 mL on the left two columns side of Table 5.2). High and very high-risk waters are identified by ranges of 1-10 (high) or > 10 (very high) *E.coli.*

Risk Level (WHO, 1997)	***Thermotolerant* in sample (coliform forming unit per 100 mL) (WHO, 1997)**		**Colilert *E. coli* Result (Metcalf, 2006)**	**Petrifilm *E. coli* (Metcalf, 2006)**
Conformity	<1		- (clear = below detection)	0
Low	1-10		- (clear = below detection)	0
Intermediate	10-100		+ (blue florescence)	0
High	100-1000		+ (blue florescence)	1-10 (blue with gas bubbles count)
Very High	>1000		+ (blue florescence	10 (blue with gas bubbles count)

Table 5.2: Risk levels for different levels of contamination (Source: WHO, 1997, Metcalf, 2006)

5.3 Laboratory Test: Multiple-Tube Fermentation Technique

The coliform group consists of several genera of bacteria belonging to the family Enterobacteriaceae. This group is defined as all aerobic and facultative anaerobic, Gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 hours at 35 ˚C.

The standard test for the coliform group can be carried out by the Multiple Tube Fermentation (MTF) technique among others (example, membrane filtration, enzyme substrate, etc.). In the MTF, multiple tubes are used in the fermentation, and the Most Probable Number (MPN) of organisms present are reported. MPN is based on certain probability formulae and is calculated using the assumption of a Poisson distribution (random dispersion). It is an estimate of the mean density of coliforms in the sample and provides the best assessment of water treatment effectiveness and the sanitary quality of untreated water. However, if the sample is not adequately shaken before the portions are removed or if clumping of bacterial cells occurs, the MPN value will be an underestimate of the actual bacterial density (Standard Methods 2005).

Standard Total Coliform Fermentation Technique

1. Presumptive Phase:

The lauryl tryptose broth is used in the presumptive portion of the multiple-tube test.

a. Reagents and culture medium:

Dehydrated products were mixed thoroughly and heated to dissolve in the Water. The medium was dispensed into the fermentation tubes with an inverted vial, covering at least one-half to two-thirds of the vial. This was followed by sterilization, and the pH was kept at 6.8+/-0.2. The tubes were then closed with metal or heat-resistant plastic caps.

b. Procedure:

1. 20 mL portions of water was added to five fermentation tubes containing sample
2. Sample-water mixture was shaken vigorously (approximately 25 times)
3. Tubes are inoculated in set of five with equal sample volumes in increasing decimal dilutions
4. Test portions were mixed into medium by gentle agitation
5. Inoculated tubes were then incubated at 35 +/- 0.5˚C.
6. After 24 +/- 2 hours each tube was swirled and examined for heavy growth, gas, and acidic reaction (shades of yellow color).
7. If no gas or acidic growth had formed, it was re-incubated and re-examined at the end of 48 +/- 3h.
8. The presence or absence of heavy growth, gas, and acid production was recorded. If the inner vial was omitted, growth with acidity signifies a positive presumptive reaction.

c. Interpretation:

The presence of acidic growth or production of gas in the tubes or bottles in a period of 48 hours (+/- 3 hours) constitutes a positive presumptive reaction. These tubes confirming a positive test were submitted to the confirmed phase. An arbitrary 48 hour limit for observation did not include occasional slow growing members of the coliform group.

2. Confirmed Phase

a. Culture Medium:

The tube fermentation for the confirmed phase is done using the green lactose bile broth. Dehydrated ingredients are heated to dissolve in water after mixing thoroughly. Before sterilization, sufficient medium is dispensed into the fermentation tubes with an inverted vial, to cover the inverted vial at least one-half to two-thirds after sterilization. After sterilization the pH should be 7.2 +/- 0.2. Metal or heat-resistant plastic caps were used to close the tube.

b. Procedure:

Within 24 hours of incubation all the primary tubes showing heavy or acidic were submitted to the confirmed phase. If active fermentation or acidic growth appeared in the primary tube earlier than 24 h, it was transferred to the confirmatory medium, preferably without waiting for the full 24h period to elapse. Primary tubes or bottles were submitted to the confirmed phase, if they showed active fermentation or acidic growth at the end of a 48 hour incubation period.

The primary tubes showing gas or acidic growth were shaken in order to re-suspend the organisms. One loopful of culture was transferred, using a sterile metal loop 3 mm in diameter, to the fermentation tube containing brilliant green lactose bile broth. The applicator was removed and discarded. The tube containing the inoculated brilliant green lactose bile broth tube was incubated for 48 +/- 3 hours at 35 +/- 0.5 ˚C.

Formation of gas in any amount in the inverted vial of the brilliant green lactose bile broth fermentation tube at any time within 48 +/- 3 h constituted a positive confirmed phase. The MPN value was calculated from the number of positive brilliant green lactose bile tubes.

MPN Calculation:

The table shown below was used to calculate the MPN values for each of the tests. For combination of tubes or dilutions that did not appear in the table, the estimation was done using Thomas' formula:

$$MPN/100mL = \frac{No. of\ positive\ tubes\ X\ 100}{\sqrt{(mL\ sample\ in\ negative\ tubes\ X\ mL\ sample\ in\ all\ tubes}}$$

		95 % Confidence Limits				**95 % Confidence Limits**	
Combination of Positives	**MPN Index/ 100mL**	**Lower**	**Upper**	**Combination of Positives**	**MPN Index/ 100mL**	**Lower**	**Upper**
0-0-0	< 2	-	-	5-0-0	23	9.0	86
0-0-1	2	1.0	10	5-0-1	30	10	110
0-1-0	2	1.0	10	5-0-2	40	20	140
0-2-0	4	1.0	13	5-1-0	30	10	120
				5-1-1	50	20	150
1-0-0	2	1.0	11	5-1-2	60	30	180

1-0-1	4	1.0	15				
1-1-0	4	1.0	15	5-2-0	50	20	170
1-1-1	6	2.0	18	5-2-1	70	30	210
1-2-0	6	2.0	18	5-2-2	90	40	250
				5-3-0	80	30	250
2-0-0	4	1.0	17	5-3-1	110	40	300
2-0-1	7	2.0	20	5-3-2	140	60	360
2-1-0	7	2.0	21				
2-1-1	9	3.0	24	5-3-3	130	80	410
2-2-0	9	3.0	25	5-4-0	170	50	390
2-3-0	12	3.0	29	5-4-1	130	70	480
				5-4-2	220	100	580
3-0-0	8	3.0	24	5-4-3	280	120	690
3-0-1	11	4.0	29	5-4-4	350	160	820
3-1-0	11	4.0	29				
3-1-1	14	6.0	35	5-5-0	240	100	940
3-2-0	14	6.0	35	5-5-1	300	100	1300
3-2-1	17	7.0	40	5-5-2	500	200	2000
				5-5-3	900	300	2900
4-0-0	13	5.0	38	5-5-4	1600	600	5300
4-0-1	17	7.0	45	5-5-5	>=1600	-	-
4-1-0	17	7.0	46				
4-1-1	21	9.0	55				
4-1-2	26	12	63				
4-2-0	22	9.0	56				
4-2-1	26	12	65				
4-3-0	27	12	67				
4-3-1	33	15	77				

4-4-0	34	16	80				

Table 5.3: MPN Indexes and 95% Confidence limits for various combinations of positive results when five tubes are used per dilution (10 mL, 1.0 mL and 0.1 mL) (Source: Standard Methods 20th Edition)

3. Completed Phase:

The completed test is only used to establish the presence of coliform bacteria and to provide quality control over the data. Hence it was used for about 10 % of the positive confirmed tubes. Double confirmation into brilliant green lactose bile broth for total coliforms and *E.coli* broth for fecal coliforms was used. Parallel positive brilliant green lactose bile broth culture with negative *E.coli* broth cultures indicate the presence of non-fecal coliforms and must be submitted to the completed test procedures to validate the presence of coliforms.

CHAPTER 6: SANITARY SURVEYS IN LUCKNOW: METHODOLOGY AND RESULTS

6.1 Method

To better understand the challenges associated with scale up of HWTS technologies, the author felt that it was essential to get a first hand experience of the field conditions that probably contribute to enhancing or deterring the success of these systems. However to understand a complex problem, such as this, one needs to look at the problem through different lenses. For instance, in this case, it became important to understand the difference in performance of the HWTS technology in the field and the laboratory. Moreover, it was essential to get a clearer understanding on how the users perceive and use HWTS systems. To facilitate this goal, the PATH India managers in New Delhi connected the author with AED Lucknow to carry out the field studies. While in Lucknow, the author worked in tandem with Pratinidhi, AED Lucknow's partner on projects related to HWTS. Pratinidhi had sub-divided the city of Lucknow into five zones, namely North, South, East, West and Central. The organization had HWTS scale-up projects running in each of these zones.

How Pratinidhi as an organization functioned was that they had a three-step market strategy in every locality by which they tried to educate and influence the people about the importance of HWTS. The first step was called "the testing", here the workers from Pratinidhi went to every tenth house in a particular locality and tested the drinking water sample using the hydrogen sulfide bacteria presence/absence test. The second step involved going back to the locality and educating the entire community, by showing them the contaminated samples from their locality. The second step also involved marketing and selling three specific products: Aquatabs, SafeWat and Pureit filters.[1] The third step in this process involved follow-ups and was usually conducted a week after the second step. This process required the NGO workers to visit the households where they had provided some treatment system/technology and make sure that it was being used in the correct manner. This process continues in cycles and the NGO workers in a particular locality re-visit each household every 3-4 weeks.

The author usually accompanied the NGO workers to areas where they were going to conduct the third step i.e. the follow-up. This was done so that the author could get to conduct surveys amongst a subset of population that had already been exposed to HWTS and had adopted one of the three specific products or another. The process of interviews was simple and straightforward; the houses were selected arbitrarily and involved making cold calls to different households in a locality. The objective of this study design was to concurrently conduct water quality analysis and a sanitary survey.

With this study design, the author could better understand the risk levels associated with the drinking water at the point of consumption i.e. after HWTS treatment.

[1] Factsheets on these products are in Chapter 4

6.2 Survey Design

Key questions in the sanitary survey conducted in Lucknow were based on indicators set forth by the Indicators Task Force requested by UNICEF in 2008, co-chaired by Megan Wilson of PSI and Susan Murcott of MIT. With critical feedback from Mr. Oluwafemi Odediran at the UNICEF, headquarters in New York, Mr. Orlando Hernandez at USAID and my MIT thesis supervisor, Susan Murcott, the author came up with a survey design that would obtain information on:

- Type of water supply (source, availability and type of connection)
- Water collection (time spent, type of vessel used, typical house member/members involved in collecting water)
- Cost of water
- Water Treatment (user's and more broadly the community's understanding of the importance of treating water)
- Type of treatment technology (availability, validity and performance[2])
- Safe Storage (based on observation, the type of container used and the user's behavior in handling treated/untreated drinking water)
- Demographics (location and age of the respondent; family demographics, level of education and monthly income)

This survey instrument had 55 questions, each of which was based on one of the seven variables mentioned above. This survey was reviewed and was exempted by the Committee On the Use of Humans as Experimental Subjects (COUHES) at MIT. The survey is provided in Annex III.

[2] Validity in this case refers to whether the HWTS system in use is being used beyond its service life or beyond the expiration date put forth by the manufacturer. On the other hand performance refers to the effectiveness of the HWTS treatment system in removing microbiological contamination.

6.3 Survey Results

The author conducted 240 sanitary surveys over a period of three months in the city of Lucknow. The raw data set of the results can be found in Annex IV. The following section presents the results of these surveys:

6.3.1 Water Supply

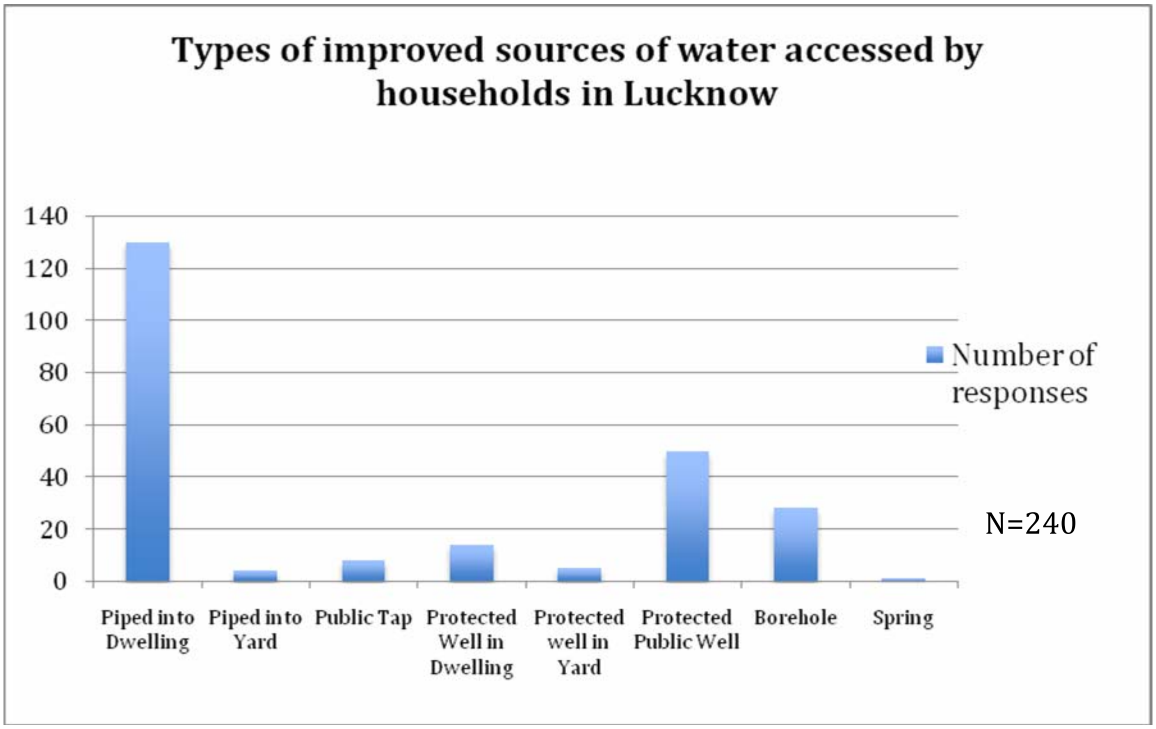


Figure 6.1: Types of improved sources of water accessed by households in Lucknow

Figure 6.1 indicates that all the 240 respondents have access to ‘improved’ water supplies of which more than half are piped connections. The piped connections in the city are provided only by the public utilities run by the Government of Uttar Pradesh. Based on Table 1.1, it can be inferred that the water source for the piped connections is either groundwater (250 MLD) or water from the Gomti River (200 MLD).

The other sources of water supply that are used by people in Lucknow, include protected public wells (referred to as hand pumps in India) or boreholes.

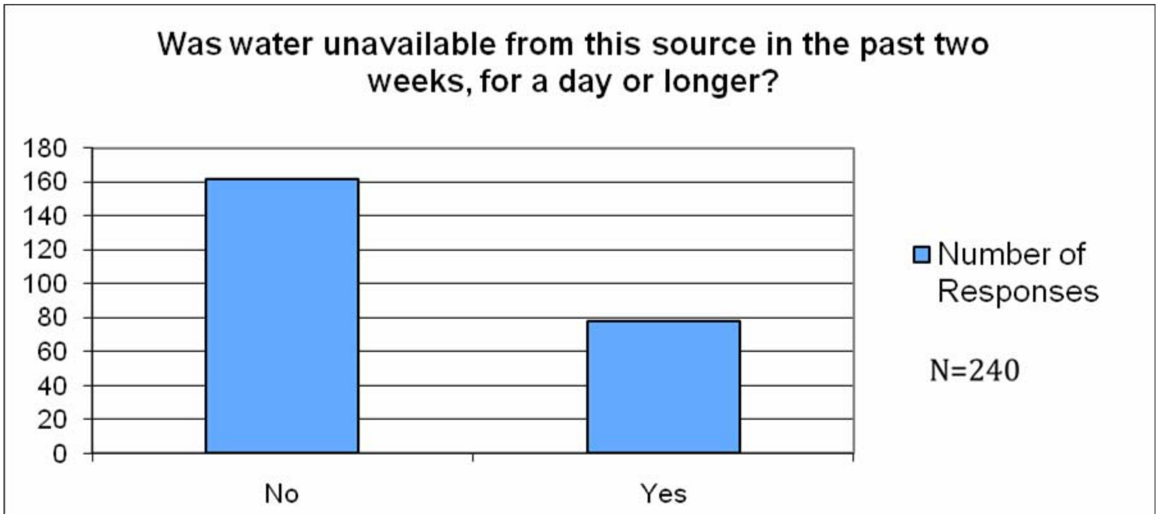


Figure 6.2: Availability of Supply

Responses from 67% of the users (Figure 6.2) suggest that water supply from water sources was fairly dependable (i.e. was not unavailable for a day or longer in the past two weeks). However, about 33% of the supplies amongst the survey population were unavailable for a day or longer in the past two weeks.

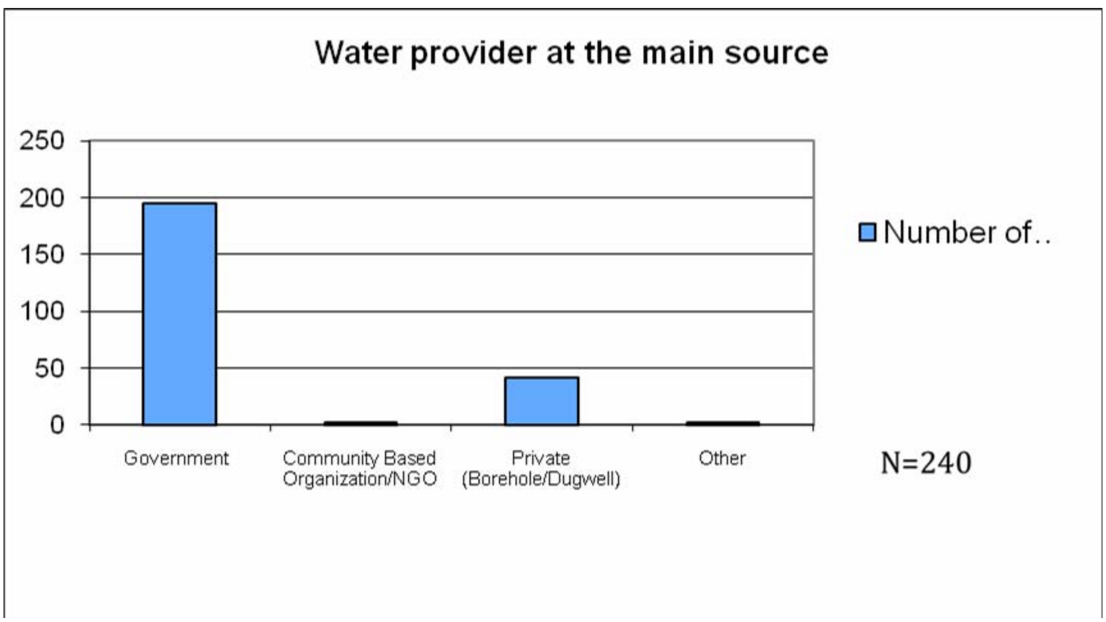


Figure 6.3: Water provider at main source

Figure 6.3 highlights the fact that most of the water is supplied by government-operated water utilities. It must also be noted that there is no private water supplier in the city, the users who chose the option of private water supplies had their private borehole or well dug.

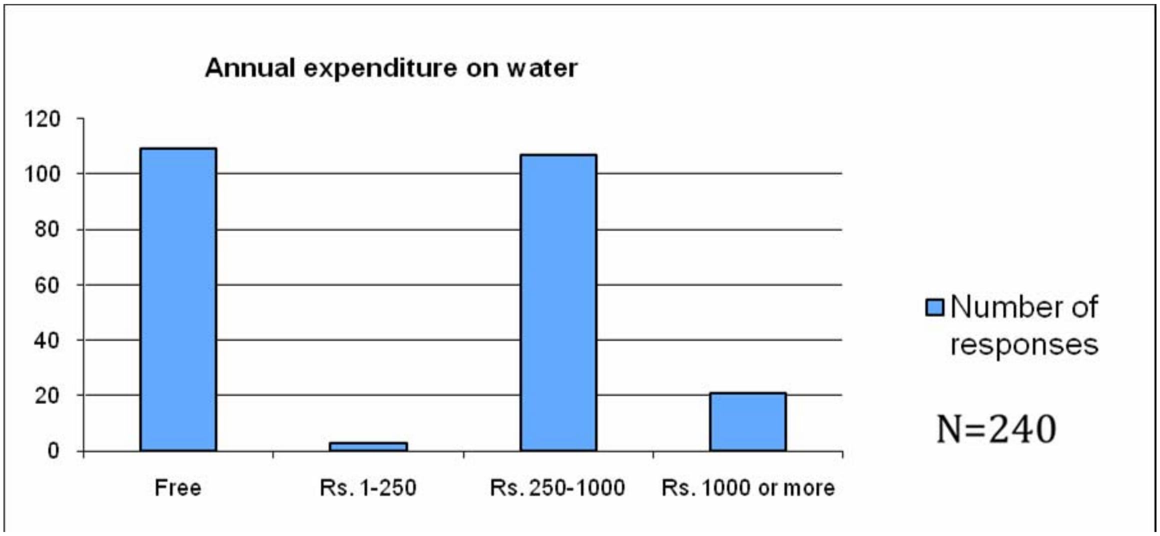


Figure 6.4: Annual expenditure on water

Figure 6.4 shows the annual expenditure on water by the sample population. While nearly half of the respondents don't pay anything for their water, either because they use the hand pumps installed by the government or because they had installed their own private boreholes, the other half pays an annual water tax to the government, which varies, based on the size of the plot one lives on. The average water tax paid by the respondents was Rs. 650 (USD13.00) per year. Water meters haven’t been introduced in the city.

Figure 6.5: Time taken to collect drinking water

Since most households that participated in the study had access to a piped water supply, the time taken to collect drinking water is usually reported to be less than 30 minutes.

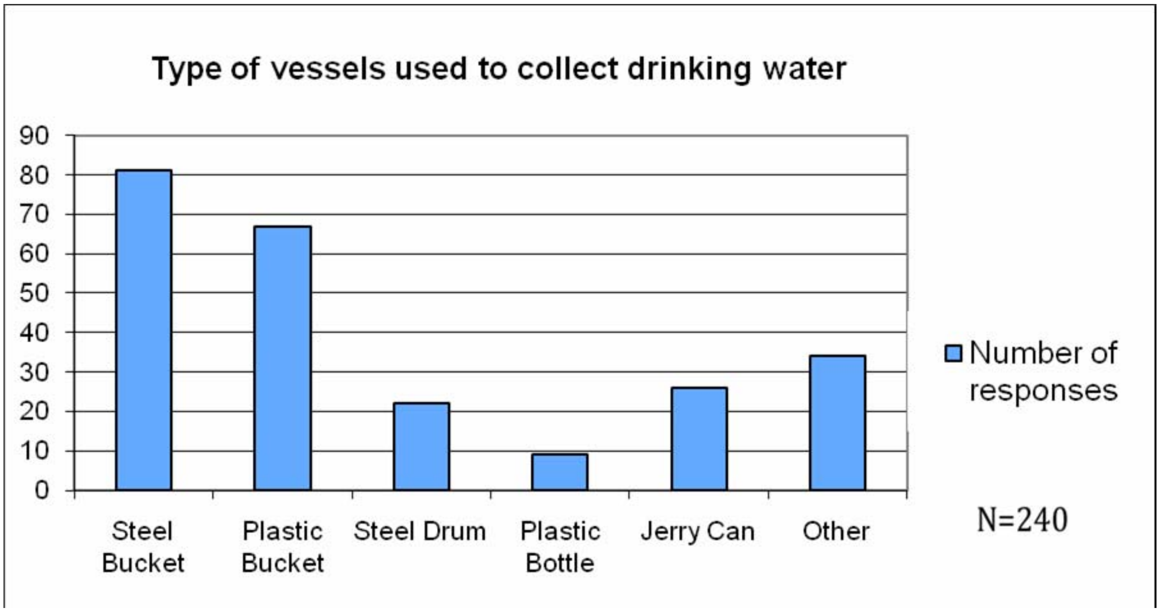


Figure 6.6: Type of vessels used to collect water

The typical vessel used by households to collect their water was a bucket that was either made of stainless steel or plastic (Figure 6.6). The average capacity of these buckets ranged between 10-15 liters.

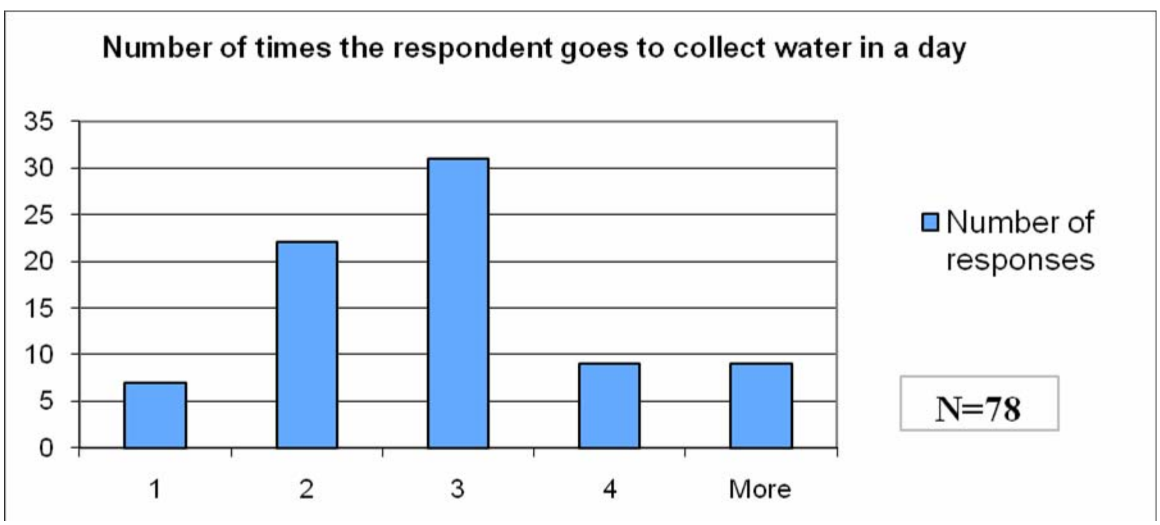


Figure 6.7: Number of times the respondent goes to collect water in a day

Only 78 of the 240 respondents had to go outside the premises of their household to collect water. Of those 78, respondents had to go 1, 2, 3, 4 or more times to collect water per day (Figure 6.7). The water sources, which were usually hand pumps or public taps, were not more than150-200 meters away from the house.

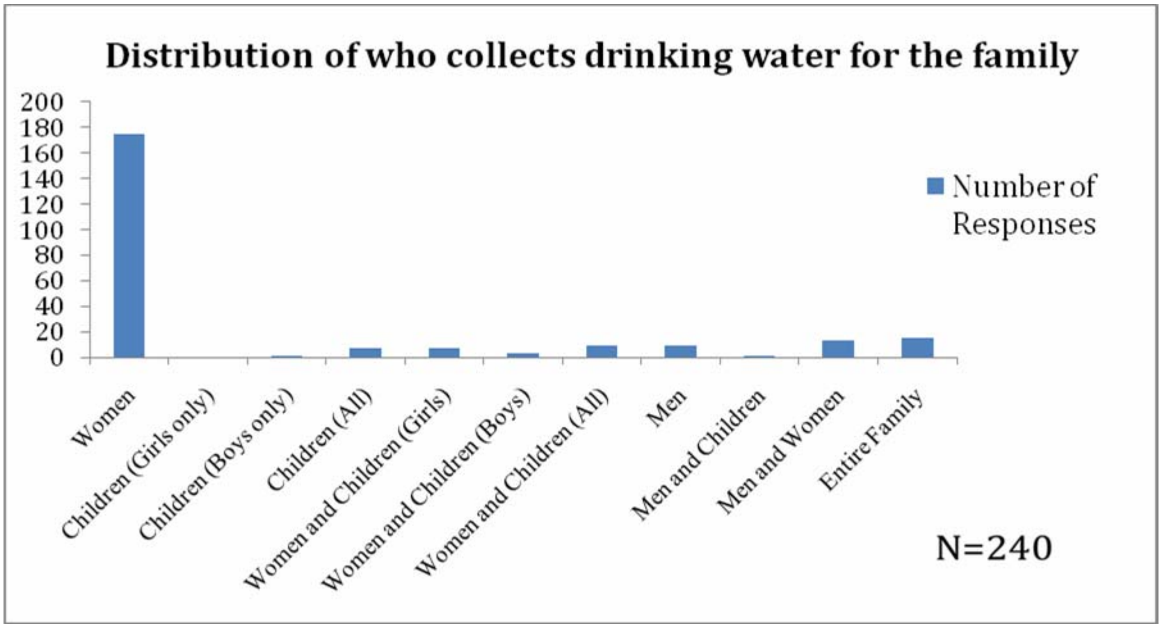


Figure 6.8: Distribution of who collects drinking water for the family

The JMP (2008) reported that in 64% of the cases world over the water is collected by women. The situation in Lucknow was no better where in 73% of the 240 households, it was the women who collected water (Figure 6.8).

6.3.2 Behavioral Questions

The following results highlight the perception of the sample population towards HWTS.

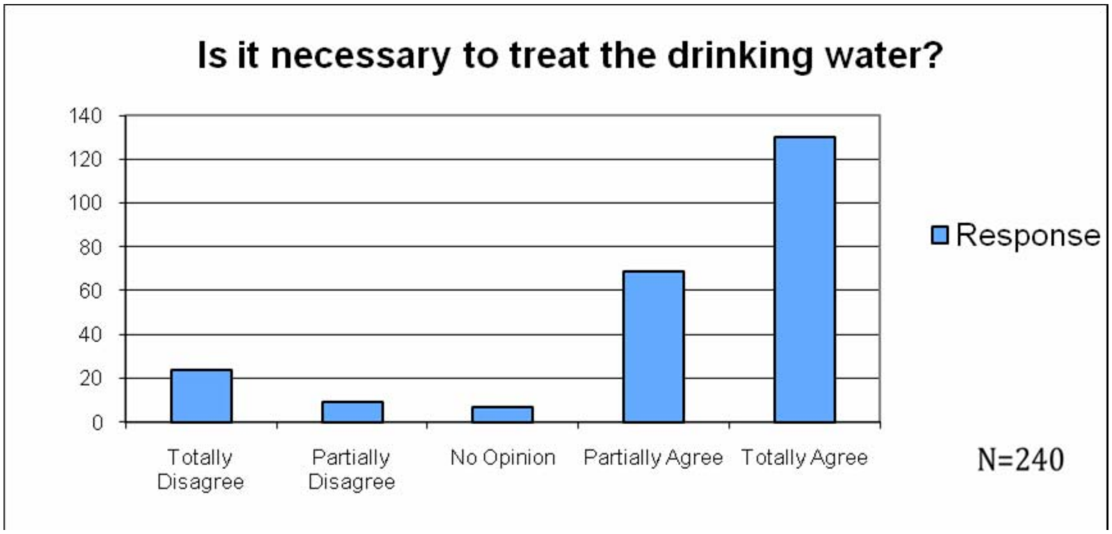


Figure 6.9: Respondents preferences on necessity of treating their drinking water

The results of Figure 6.9 are encouraging, since nearly 55% of the sample population recognized the importance of treating water.

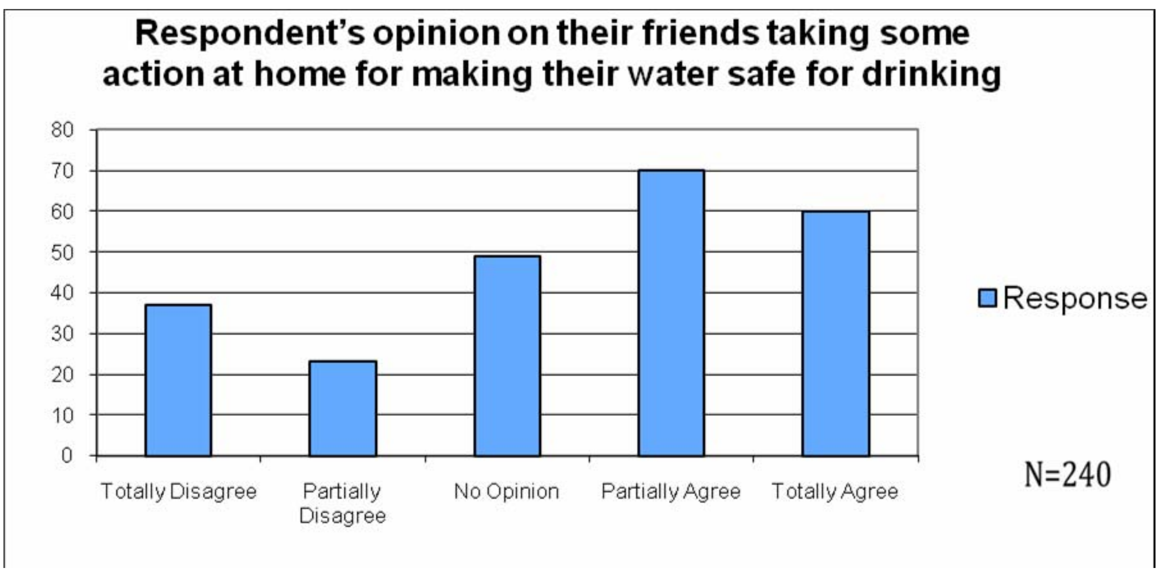


Figure 6.10: Respondent's opinion on their friends taking some action at home for making their water safe for drinking

The results from Figure 6.10 were fairly well distributed amongst all response options. From Figure 6.10 it can be inferred that nearly 130 of the 240 households reported that their friends treat their drinking water.

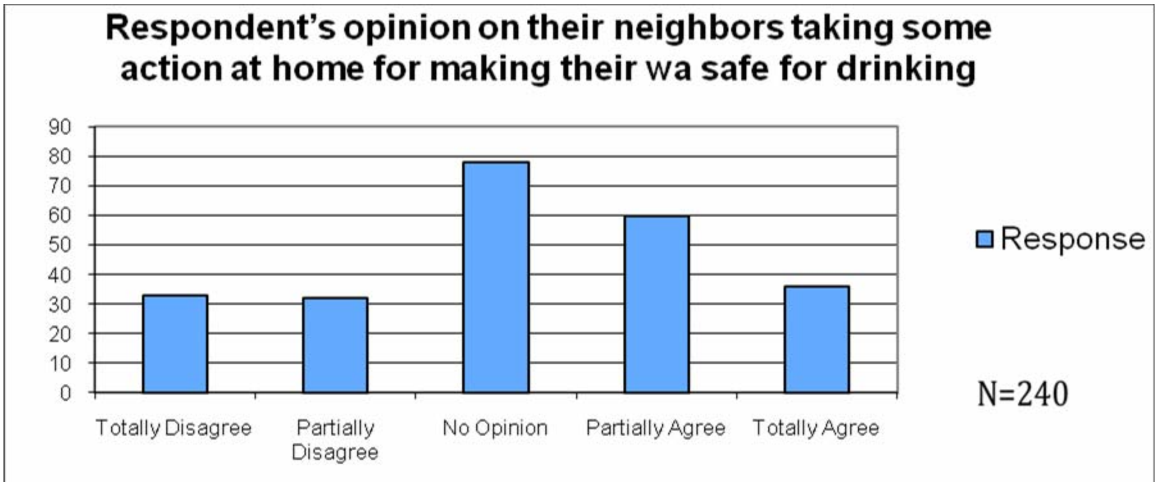


Figure 6.11: Respondent's opinion on their neighbors taking some action at home for making their water safe for drinking

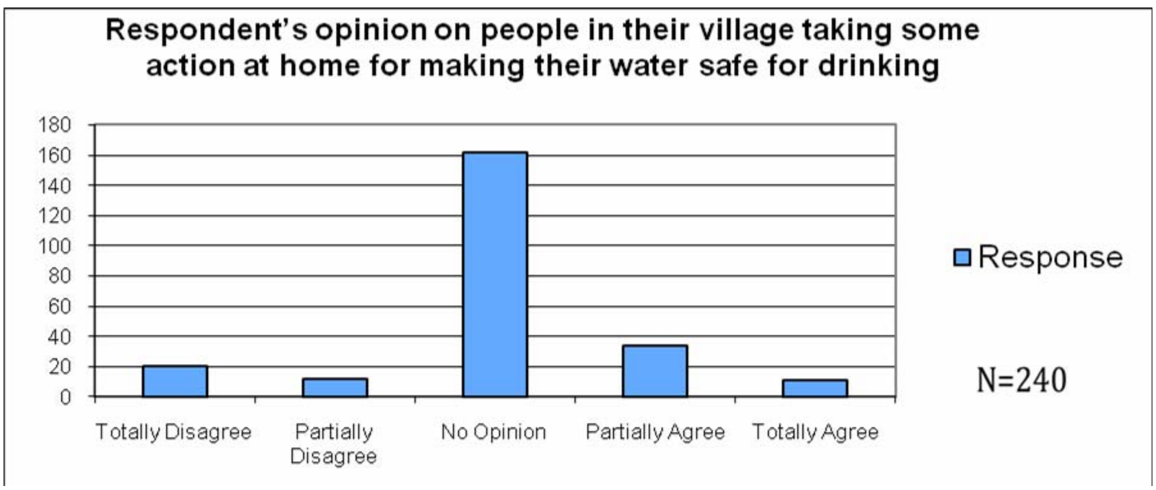


Figure 6.12: Respondent's opinion on people in their village taking some action at home for making their water safe for drinking

From Figure 6.11 and 6.12 and using the observations the author made in the field, it was apparent that there was little or no communication amongst neighbors over issues pertaining to HWTS since most of the respondents had no opinion to these questions.

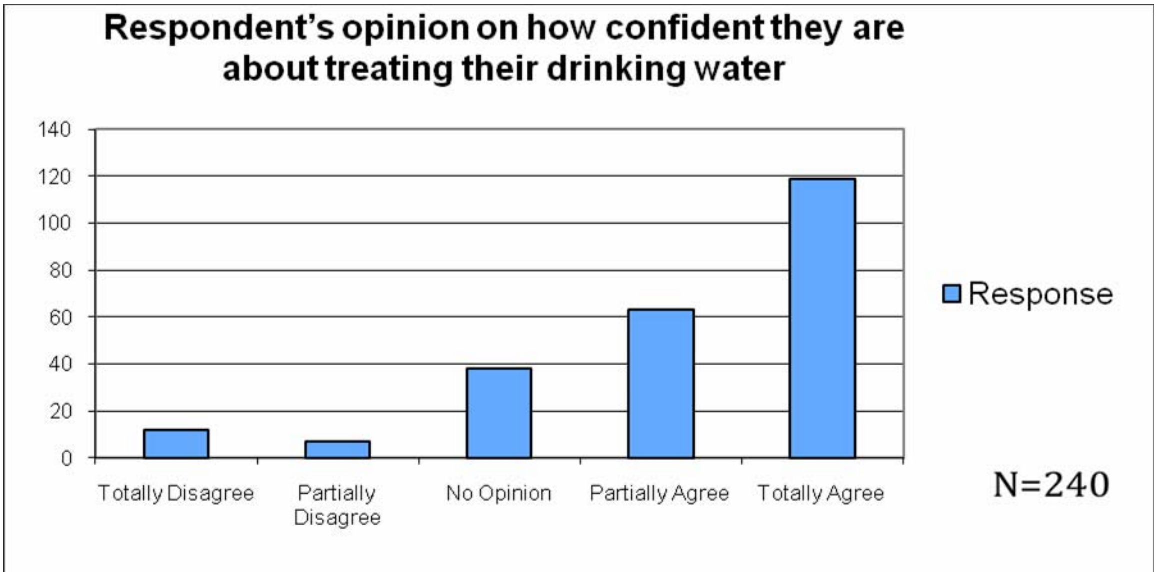


Figure 6.13: Respondent's opinion on how confident they are about treating their drinking water

Figure 6.13 indicates that 50% of the respondents felt that they could make their water safe for drinking. There was only a small fraction of the sample population (about 6%) which felt that they were unable to treat their drinking water.

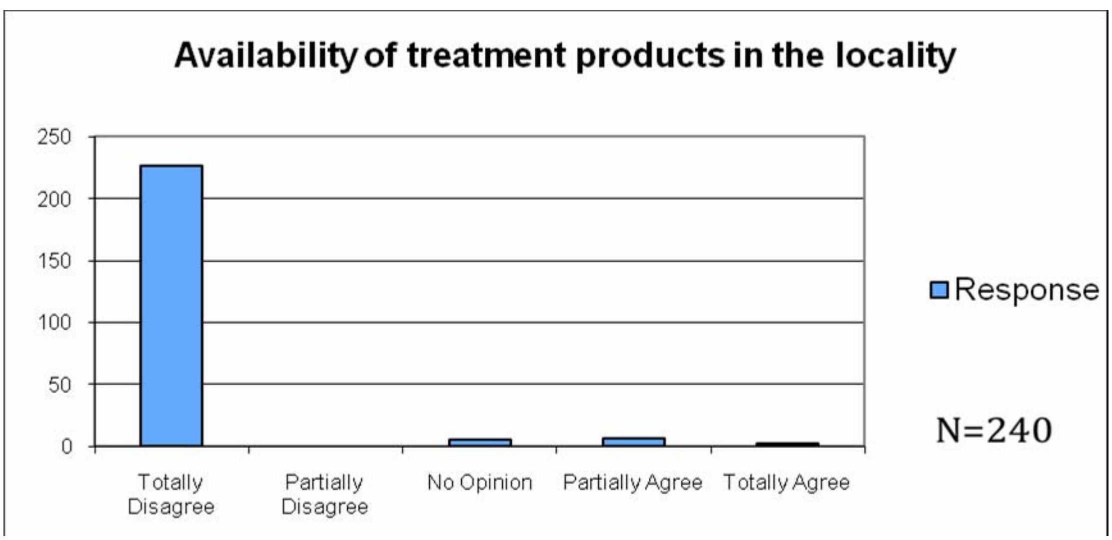


Figure 6.14: Availability of treatment products in the locality

The results from Figure 6.14 suggest that there were not many shops carrying water treatment products in Lucknow.

6.3.3 Drinking Water Treatment

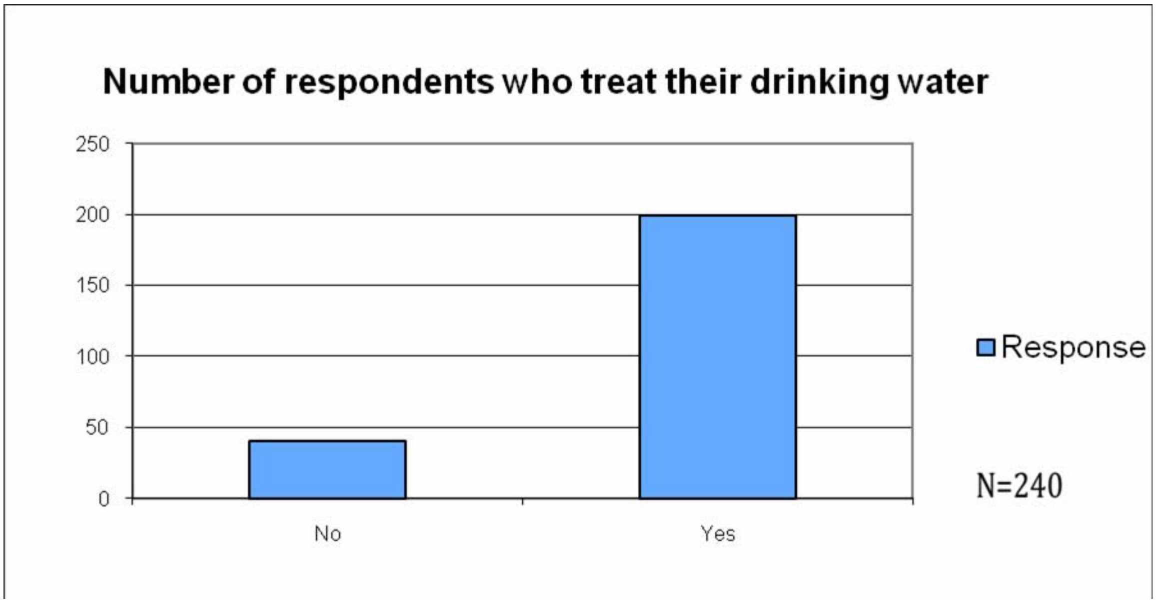


Figure 6.15: Number of respondents that treat their drinking water

Of the 240 households, 200 used some HWTS technology or the other to treat their drinking water (Figure 6.15). This makes sense because these communities had been specifically targeted by the NGO Pratinidhi, to encourage them to take up HWTS systems.

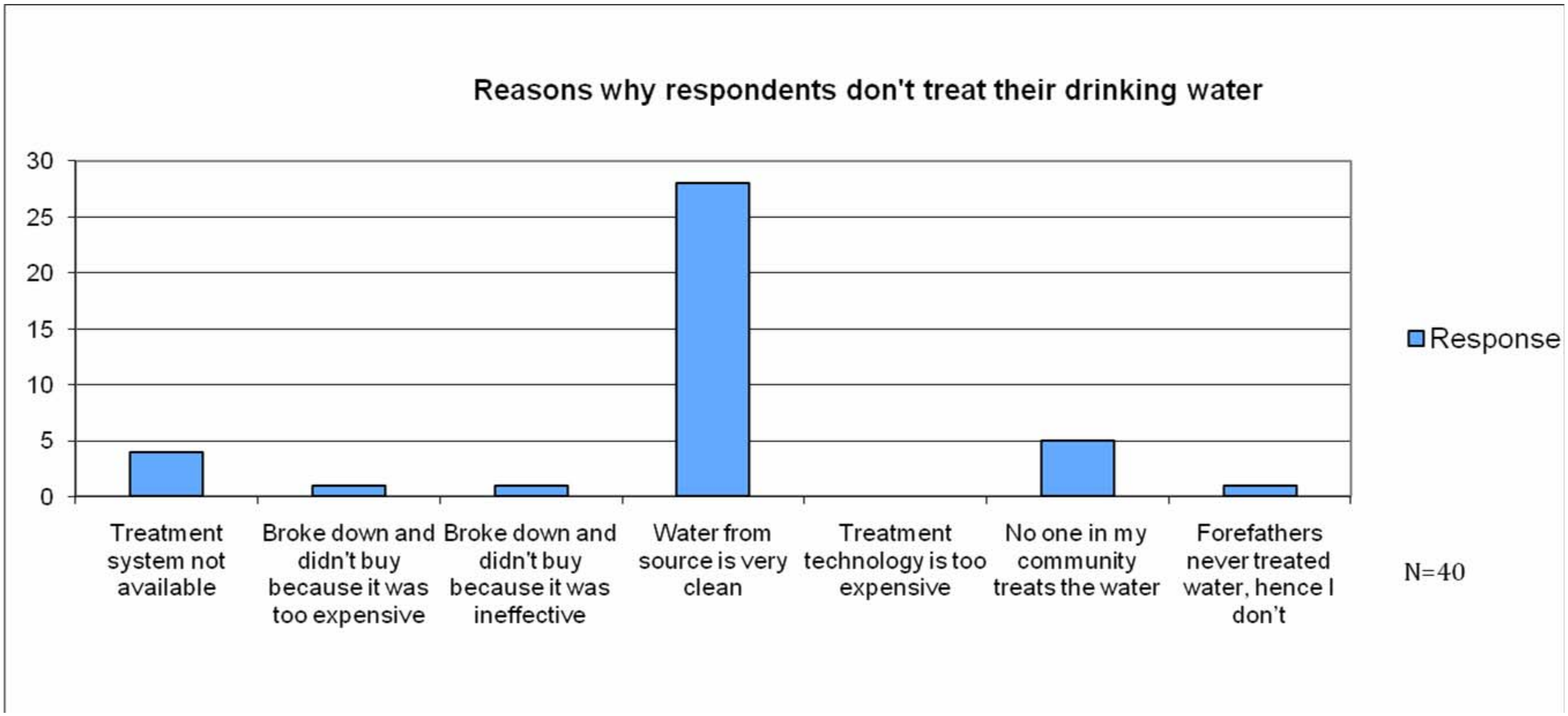


Figure 6. 16: Reasons why respondents don't treat their drinking water

From Figure 6.16 we see that about 27 of the 40 respondents who didn't treat their water, didn't do so because they felt that the water from their source was very clean. In fact, the author observed that households that had installed their own borehole rarely installed a treatment system.

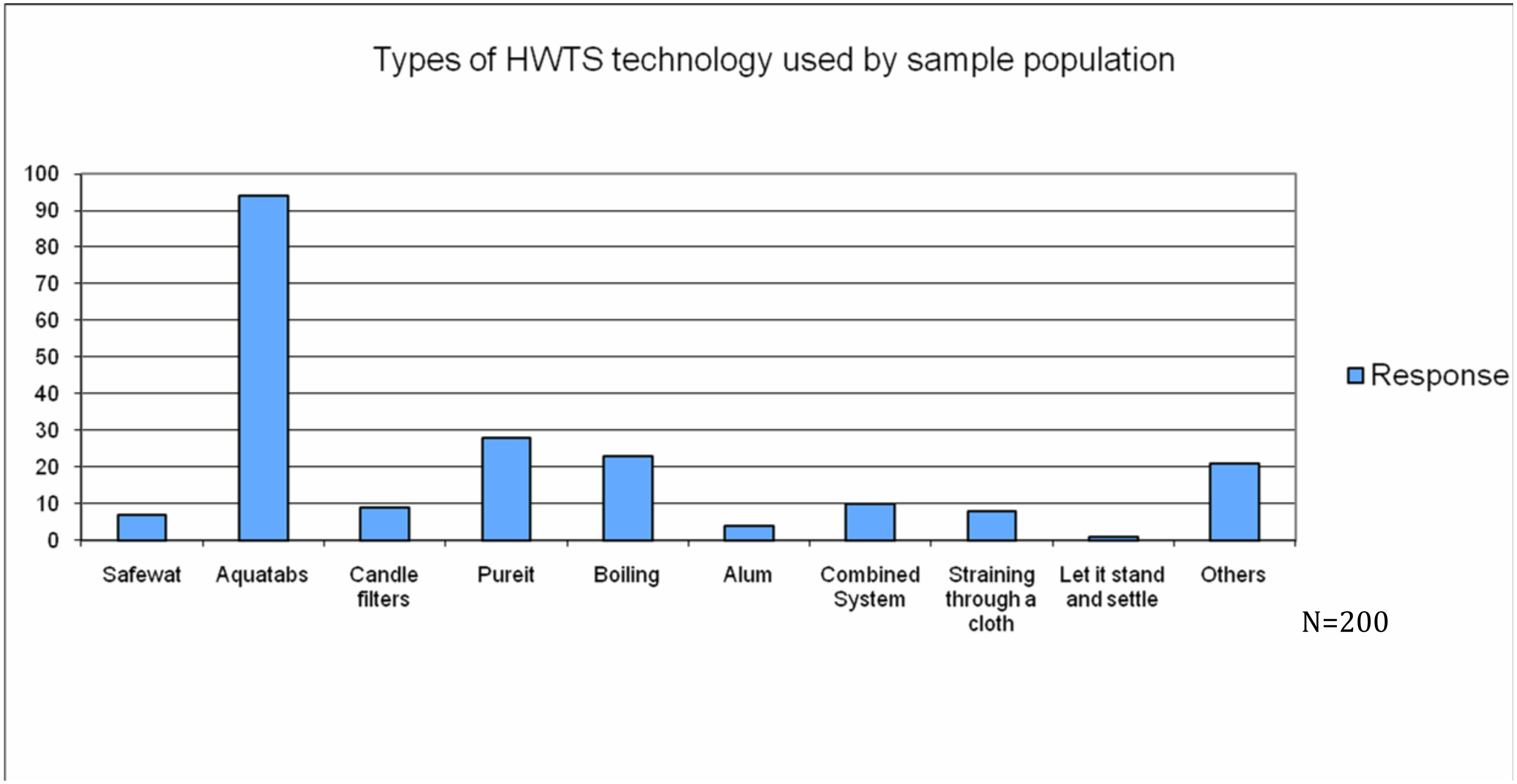


Figure 6.17: Types of HWTS technology used by sample population

Amongst the 200 households that used some HWTS technology, it was found that Aquatabs were most popular. This was probably observed due to the fact that Pratinidhi's campaign advocated the use of Aquatabs, Pureit and Safewat and because Aquatabs were the cheapest and the most longlasting of the three products.

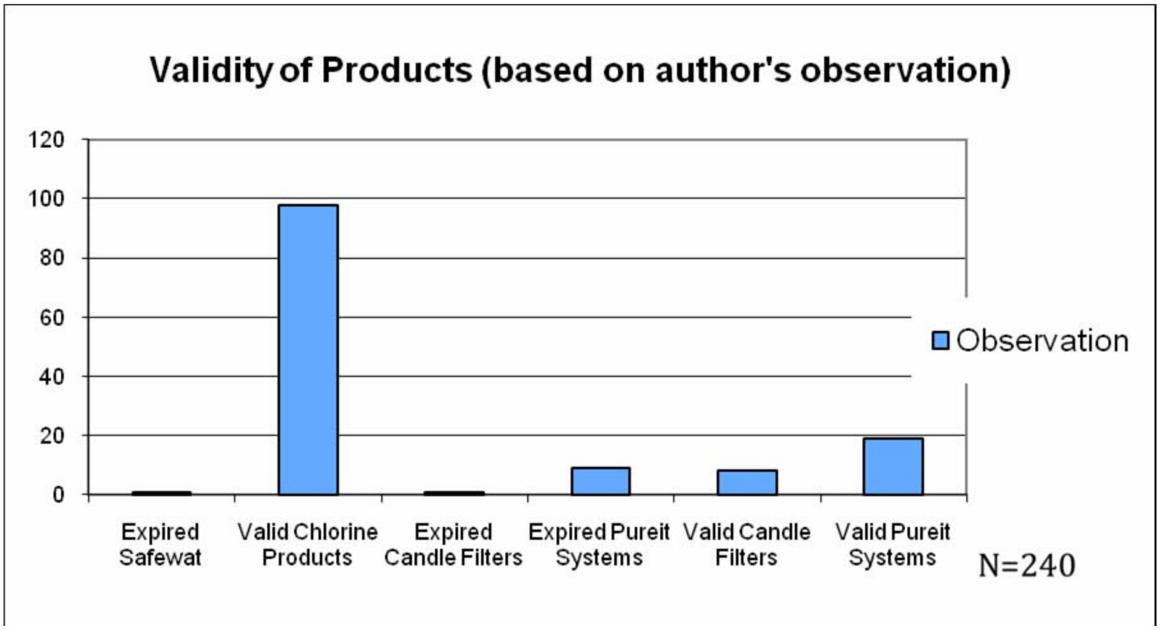


Figure 6.18: Validy of products (based on author's observation)

As shown in Figure 6.18, each product in every household was observed for its validity (i.e. it was not expired). It was observed that almost all chlorine products (Aquatabs and Safewat) were valid, however there was a significant number of Pureit systems that were being used in the field even after thy had expired. Most respondents at these households complained of poor after-sales service on the part of Hindustan Unilever.

6.3.4 Safe Storage

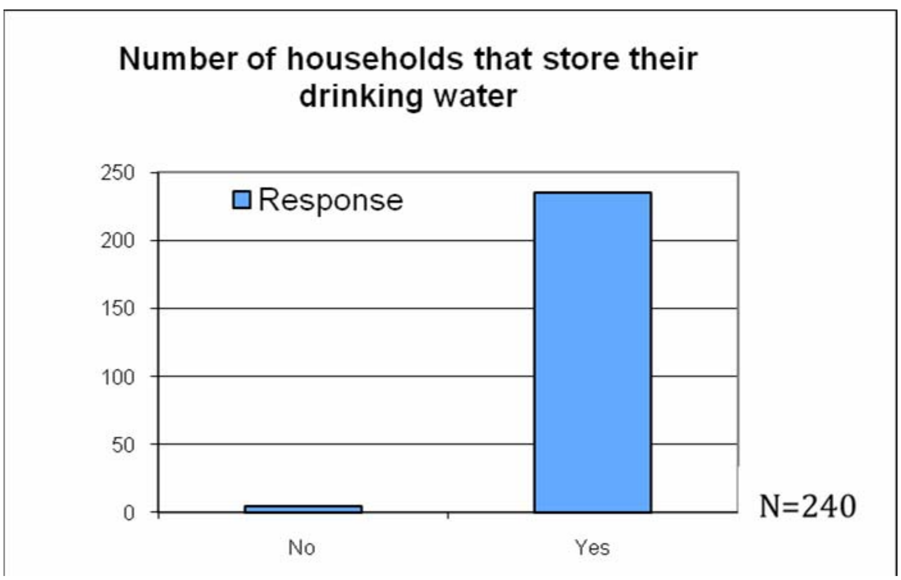
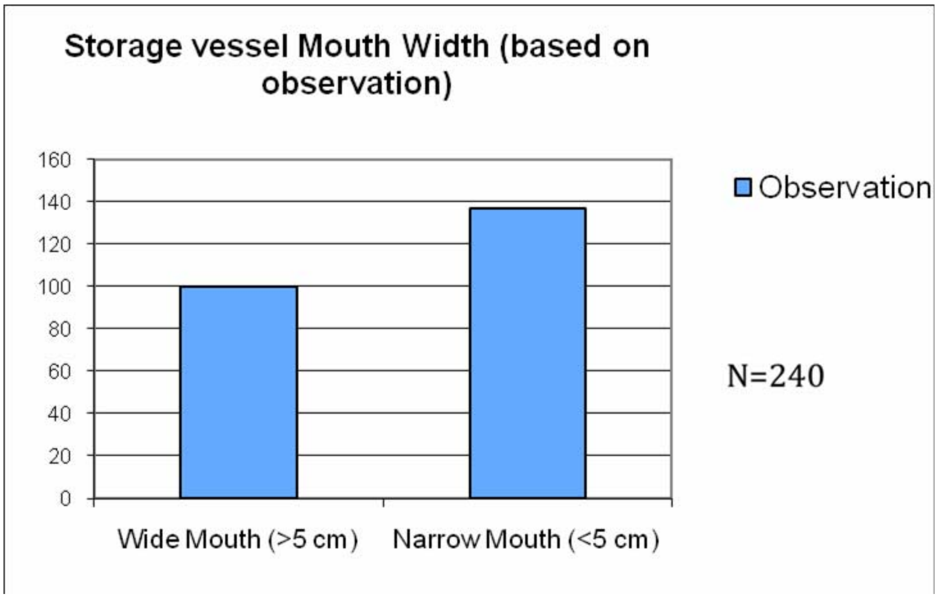


Figure 6.19: Number of households that store their drinking water

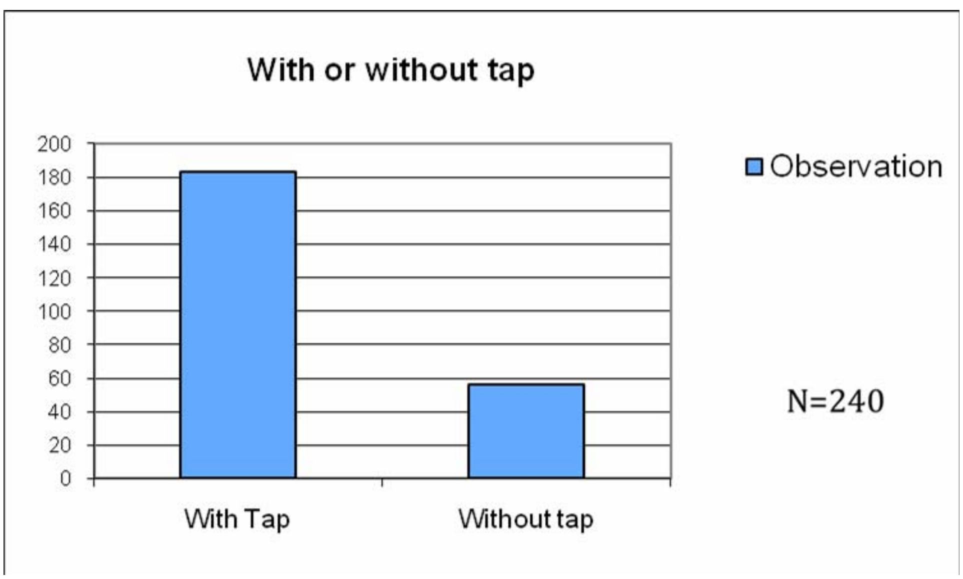
It can be verified from Figure 6.19 that more than 95% of the households store their drinking water.

Storage Vessel Characteristics:

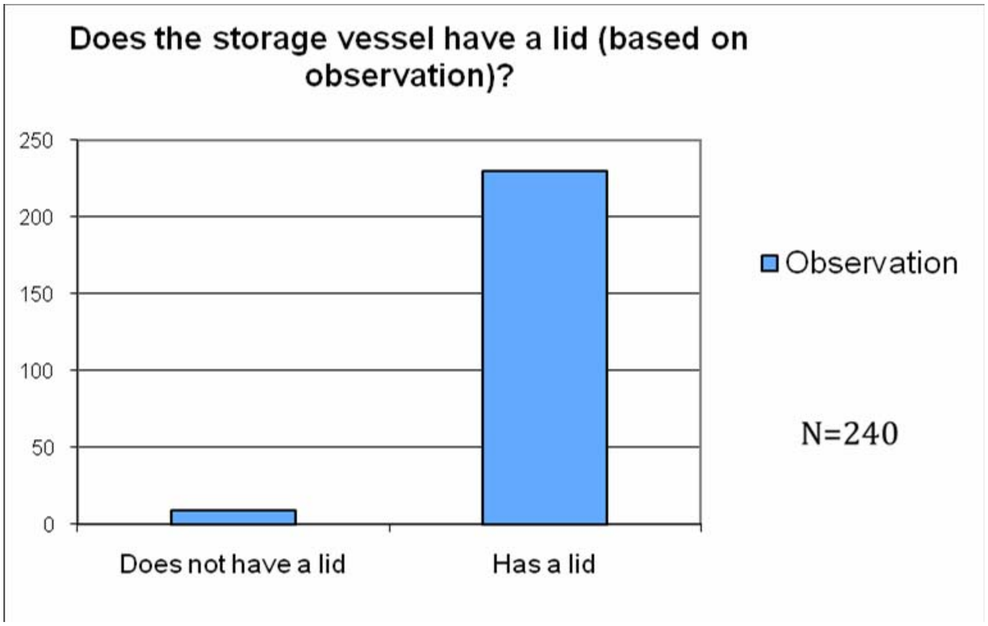
A safe storage container is defined here as a storage with a narrow mouth (< 5 cm), a tap and a lid.



(i)



(ii)



(iii)

Figure 6.20 Characteristics of the storage vessels

From the three figures depicted above, the following can be inferred about the storage vessels:

- The mouth of 60% of the storage containers was smaller than 5 cm while the other 40% had larger mouths. The author observed that many people used 1 or 2 liter plastic bottles to store their drinking water.
- Almost all vessels had a lid. [Author's Remark: Since the early 1990s, television in India has advertised the importance of keeping you drinking water covered] 180 of the 240 households were using storage vessels that had taps.

6.3.5 Demographics

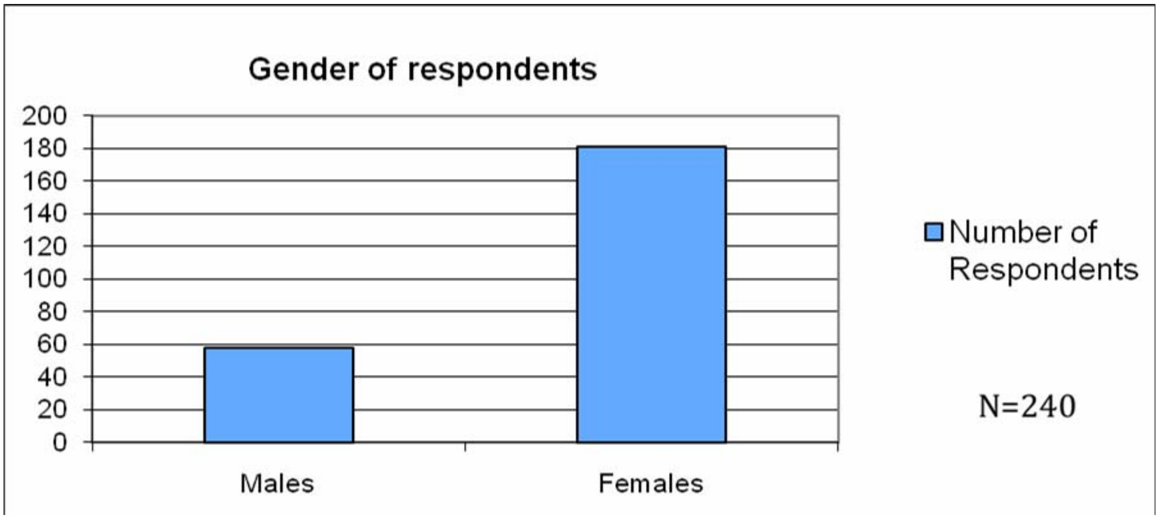


Figure 6.21: Gender of respondents

Since, most of these surveys were conducted through the working days of the week, the author found more women at home. Out of the 240 households surveyed, 188 were female respondents, while the rest were males (Figure 6.21).

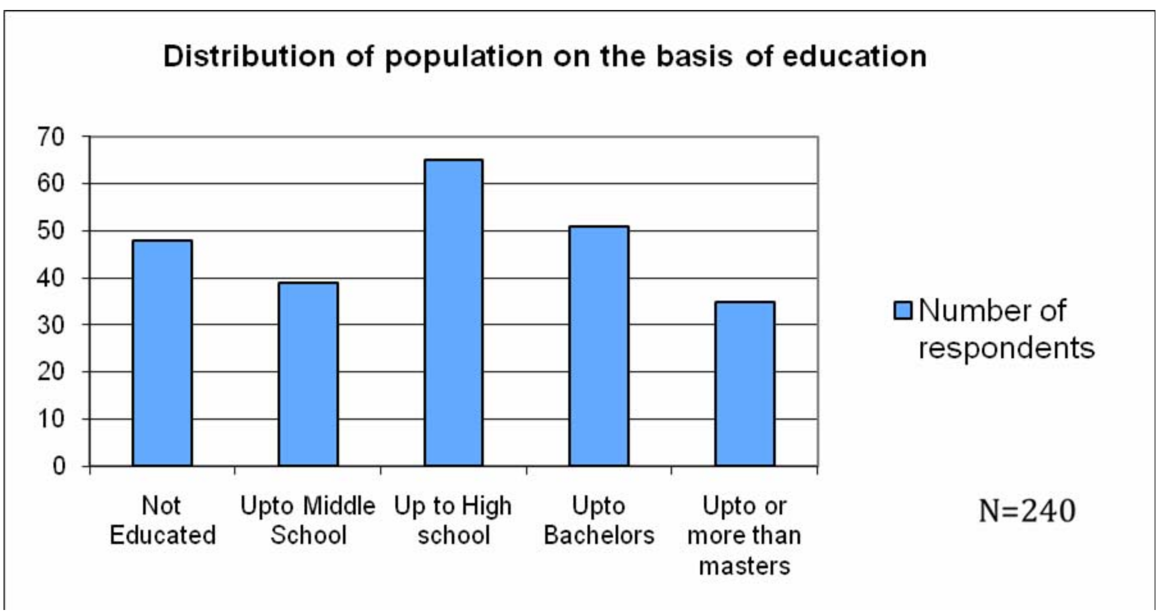


Figure 6.22: Distribution of sample population on the basis of level of education

As Figure 6.22 describes, 66% of the respondents were educated only up to high school. This when analyzed together with the Figure 6.21 implies that about 30% of the female population is uneducated.

CHAPTER 7: WATER QUALITY TEST RESULTS

7.1 Field Tests

The author collected water samples for 240 households in Lucknow and he performed a total of 276 bacteriological tests. Each sample was tested in the field by two methods: the enzyme substrate method using EC-Kit's 2 tests (the Colilert tube presence/absence test and the Petrifilm Test) and in the laboratory by the Multiple Tube Fermentation method. The approach followed for sampling and conducting these tests has been described in Chapter 5.

This chapter summarizes the water quality results from the field study and also the concurrent laboratory water quality tests. It must be made clear that unless mentioned, all results presented in this section correspond to *E.coli* contamination and not total coliform contamination.

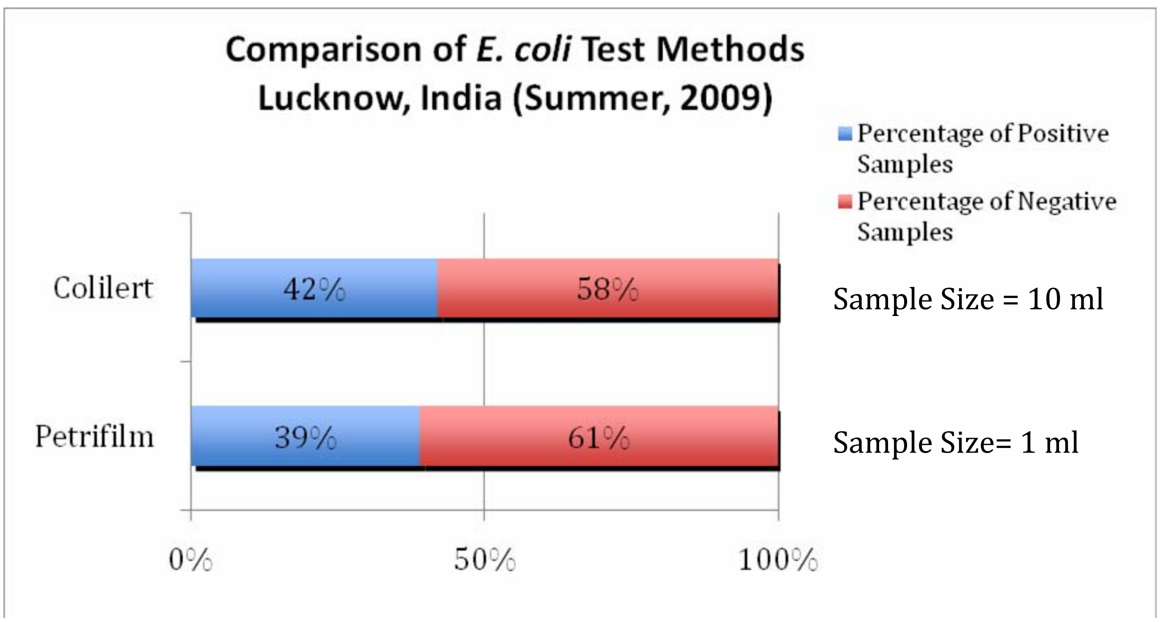


Figure 7.1: Comparison of percentage of positive and negative test results for the Colilert and Petrifilm Tests.

First, we wanted to make a comparision between the percentage of tests that turned out positive by either the Colilert or the Petrifilm methods. Figure 7.1 shows that the Colilert test gave positive results for 42% of the samples while the Petrifilm test gave positive results for 39% of the samples, thus there was a fairly close correspondence between the two results in terms of positive/negative.

The same data can qalso be analyzed using frequency distribution tables[1].

		Petrifilm	
		Number of positive samples	***Number of negative samples***
Colilert	***Number of positive samples***	**101**	**15**
	Number of negative samples	**7**	**153**

Table 7.1: 2x2 frequency distribution table of field test results for *E.coli* contamination (N=276)

From Table 7.1, it is can be seen that the two tests complied with one another 254 (101 +153) out of the 276 times. This table also shows that there were 22 samples where the two tests do not comply with each other. This can be explained statistically by means of the Type I and Type II errors. In this context the two maybe defined as:

Type I or False Positives: Samples where one of the tests (in our case, the Colilert test) gives a negative result, while the other (in our case, the Petrifilm test) gives a positive result are known as false positives or Type I errors. From Table 7.1 we can see that 7 out of the 22 outliers fall in this category. This means that for 7 of the 276 tests the Petrifilm test indicated the presence of *E.coli* in the water sample while the Colilert test did not. This is possible because the Petrifilm test utilizes a smaller sample size i.e. 1 mL whereas the Colilert test that utilizes a 10 mL sample for detection has a lower detection limit.

Type II or False Negatives: Samples where one of the tests (in our case, the Colilert test) gives a positive result, while the other (in our case, the Petrifilm test) gives a negative result. However, these results cannot be referred to as errors in the context of the EC-Kit because the Colilert test utilizes a 10 mL sample size as compared to the Petrifilm test, that utilizes a 1 mL sample, hence Colilert has a lower detection limit. It may be inferred that in the 15 of the 276 samples, the levels of contamination is between 10 – 99 CFU/100 mL, a range which can be detected by the Colilert test but not by the Petrifilm test.

[1] A Frequency Distribution table summarizes grouping of data divided into mutually exclusive classes and the number of occurrences in a class. Frequency distributions are used for both qualitative and quantitative data.

7.2 Comparison between the EC Kit and the Laboratory results

At the IIT laboratory, 42 samples were tested, together with concurrent split sample EC-Kit tests. Table 7.2 divides the 42 sets of test results on the basis of risk. The categorization of the low, medium, high and very high risk is based on risk table (Table 5.2) presented in Chapter 5.

		EC-Kit Field Test results			
MTF		Low	Medium	High	Very High
Laboratory results	Low	21	1	3	
	Medium	1		3	2
	High			2	5
	Very High			1	3

Table 7.2: 4x4 frequency distribution table categorizing samples based on risk (N=42)

We see that only 26 of the 42 samples show complete agreement with one another, i.e. low risk in field test= low risk in lab test, medium risk in field test= medium risk in lab test, high risk in field test= high risk in lab test, very high risk in field test= very high risk in lab test as highlighted in Table 7.2. In 14 of the 16 other samples, the EC-Kit consistently reports a higher risk level as compared to the laboratory method. In other words, the EC-Kit shows a higher detection level as compared with the MTF laboratory results performed at IIT.

Figures 7.2 and 7.3 summarise the linear regression analysis between the test results from the field and from the laboratory. The green line on the graphs predicts the 95% confidence level line for the regression, whereas, the black line on the graph depicts the prediction interval. The prediction interval is the band between which one would expect 95% of the points to lie. Hence, for a good corelation, one would expect the green line and the black line to be as close toone another as possible. However, in Figures 7.2 and 7.3, this is not the case, but rather, the data points are mainly scattered outside of these lines. Therefore, the corelation is low. Here it must be noted that while organizing the data to conduct this linear regression, all reported values of MTF Most Probable Number (MPN) tests that were more than 1600 were rounded off to 1700, while values of MPN where the count was reported to be less than 2 were rounded off to zero (see Table 5.1). This was done to facilitate the regression analysis[11].

The linear regression analysis for total coliform between the laboratory results and the field results yielded the following results:

R^2=0.5559

Equation: $y=1.186x+0.0406$

[2] Personal communication with Mr. Ezra Glenn, statistics instructor at MIT

On the other hand the linear regression analysis for *E.coli* between the laboratory results and the field results yielded the following results:

R^2=0.6287

Equation: y=1.1569x+0.05307

The low R^2 values means that there is no strict correlation between the two tests.

However, as mentioned earlier based on the analysis using the frequency tables one can conclude that the EC-Kit reports a consistently higher count as compared to the MTF test.

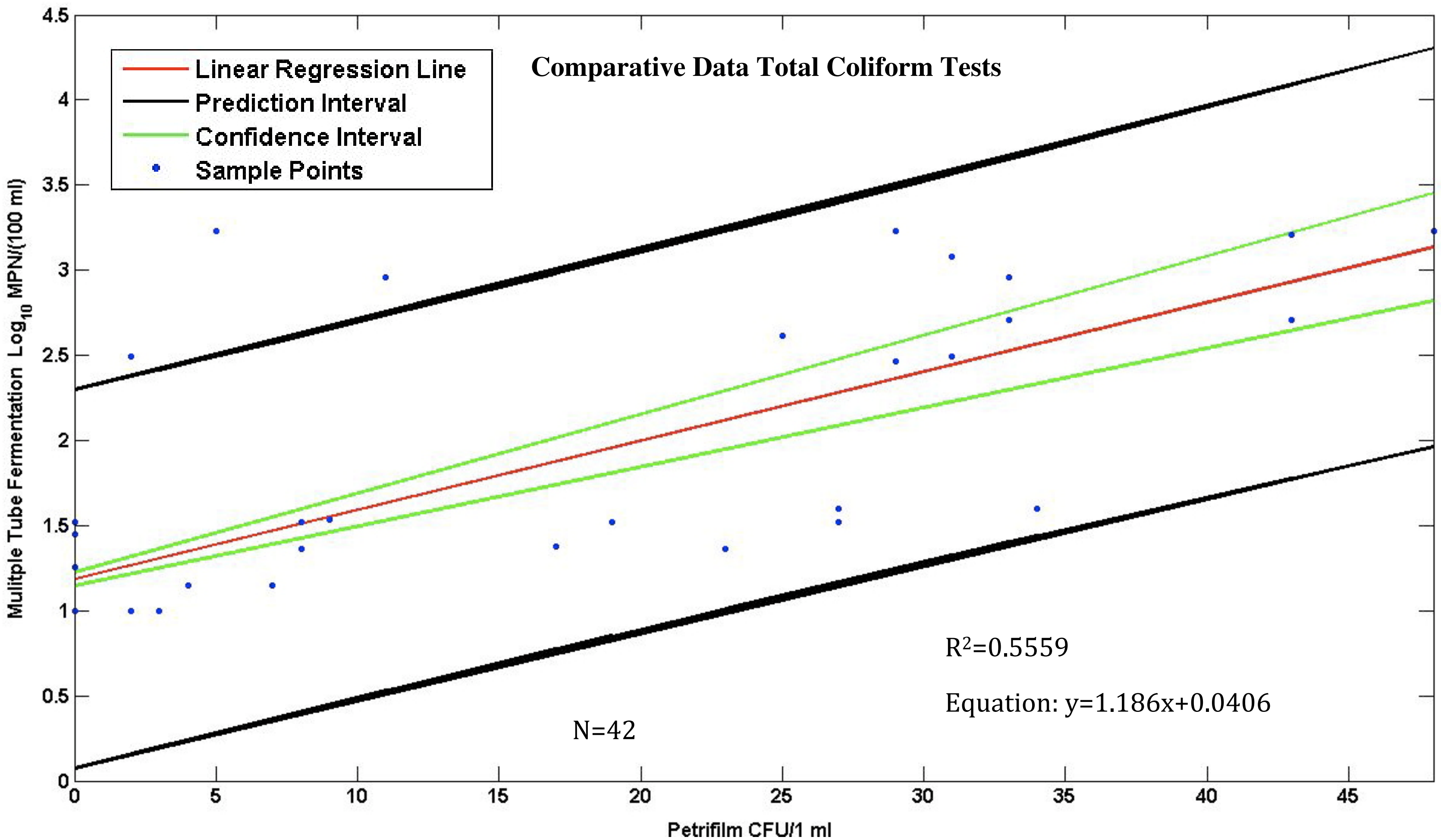


Figure 7.2: Graph representing the linear regression analysis of the results of the laboratory results (MTF technique) against the field results (EC-Kit) for total coliform.

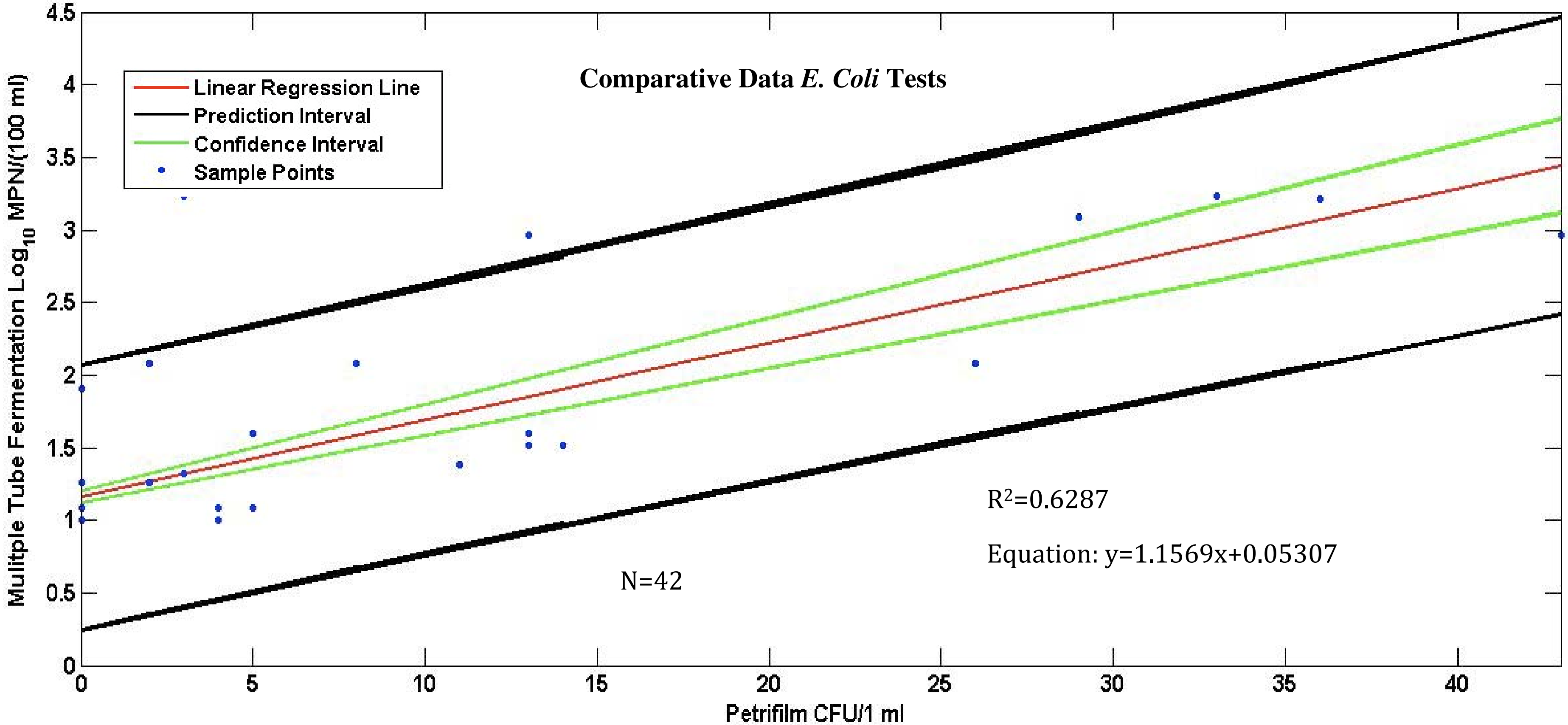


Figure 7.3: Graph representing the linear regression analysis of the results of the laboratory results (MTF technique) against the field results (EC-Kit) for *E.Coli* .

7.3 Risk level of water at the point of consumption

Microbial water quality directly affects the health of the consumer. Hence, this section focuses on the risk levels associated with water quality at the point of consumption. The point of consumption in this context refers to the container (cup or glass) that is used by the users to drink the water.

First, 35 out of the 276 water quality tests were samples collected from the source supplies. This sampling gave some idea of the contamination[3] levels of the supplies.

Type of Supply	Number of Samples	Average Contamination (In CFU/100 mL)[4]	Maximum Observed Contamination (In CFU/100 mL)
Piped into Dwelling	21	662	3700
Public Tap	2	0	0
Protected Well in Dwelling	3	1467	4300
Protected well in Yard/Plot	2	150	300
Protected Public Well	3	100	300
Borehole	4	525	1000

Table 7.3: Average and maximum contamination observed for different types of water supplies

Table 7.3 suggests that the water supplied at the public tap is the cleanest, although the sample size (N=2) is so small that no conclusion can be drawn out of it. It may also be observed that the maximum contamination levels are observed in the samples collected from the protected wells in the dwellings, however in this case also the sample size is very small (N=3). As far as the piped supply is concerned it is clear that the supply is contaminated, with an average CFU count of 662 CFU/100 mL and maximum observed CFU count of 3700 CFU/100 mL.

[3] Contamination refers to detectable *E.coli* count in the water sample

[4] Observed counts on the Petrifilm were reported in CFU/1mL. However, to reflect a more typical standard unit of CFU/100 mL, the Petrifilm test results have been multiplied by 100.

Type of Supply	Number of Samples	Low	Medium	High	Very High
Piped into Dwelling	21	6	2	9	4
Public Tap	2	2			
Protected Well in Dwelling	3	1		1	1
Protected well in Yard/Plot	2	1		1	
Protected Public Well	3	2	1		
Borehole	4	1		3	

Table 7.4: Risk levels for different types of water supplies

Table 7.4 presents the results for the 35 samples, classified on the basis of risk levels (based on the WHO and Metcalf classification, presented in Table 5.2). From Table 7.4 it can be inferred that both, the piped supplies and the boreholes are significantly contaminated and pose a higher health risk to consumers as compared to the other sources of supply.

For the second part of the analysis, the results from the remaining 240 water quality tests were examined. Here the samples were classified on the basis of the treatment they received and also on the basis of the risk levels associated with each of them. Tables 7.5 and 7.6 present these results.

Type of Supply	Number of Samples	Average Contamination in CFU/100 mL	Maximum Observed Contamination in CFU/100 mL
Chlorination	94	1295	8800
Pureit	26	786	1600
Aqua Guard	26	1084	3600
Reverse Osmosis	11	1150	3300
Boiling	23	412	1200

Table 7.5: Average and maximum contamination levels observed at the point of consumption, after treatment using different HWTS technologies

Table 7.5 suggests that the levels of contamination observed post-treatment are very high. This may be attributed to improper storage practices, inefficiency of HWTS treatment technology, lack of technical knowledge on the part of the user and/or on the part of the implementer, or due to improper servicing of the HWTS system.

Type of Supply	Number of Samples	Low	Medium	High	Very High
Chlorination	94	55	6	27	6
Pureit	26	14	4	5	3
Aqua Guard	26	17	2	5	2
Reverse Osmosis	11	5	3	2	1
Boiling	23	8	2	13	0
Others	16	5	2	8	1
None	44	15	4	17	8

Table 7.6: Risk levels for different types of water supplies

Table 7.6 presents the risk levels associated with the tested water samples. It was observed that 98 of the 240 water samples tested belong to the high or very high-risk level categories, while 23 samples belong to the medium risk category.

It was also observed that 17 of the 26 samples taken from households using Aqua Guard systems pose low risk to the consumer, while out of the 23 households practicing boiling 13 were exposed to high-risk levels.

CHAPTER 8: DISCUSSION

8.1 Survey Results

8.1.1 Water supply continuity

Based on the survey results it is apparent that all of the households that were surveyed have access to an 'improved' water source. However, the continuity of supply is not very good since 33% of the respondents did not have continuous access to water. Here it must be noted that the surveys were being conducted in the summer. In India, water supply and electricity are very closely interlinked. This is because, during the summer months the pressure of water in the piped network is very low, hence most people install underground water storage tanks to capture water from the supply, which they then pump up to overhead tanks. Moreover, the summer in India often brings with it long hours of power cuts which makes it hard for people to boost up water to their overhead tanks.

8.1.2 Water charges

Piped connections in Lucknow are all provided by the government municipal water supply, these supplies are charged a flat-water tax per year, which is calculated on the basis of the land area occupied by each household. The author observed that the water tax that was being charged a very low fee (Rs. 600/ year or USD 15/ year) and was fairly unevenly distributed, with the more affluent section of the society paying a very small chunk of their income for water, while the poor paying a relatively high portion of their income for water. In other big cities of India, like Delhi, there has been a shift from charging a flat water-tax to metering the water supplies. Such a change in Lucknow would help regulate the wastage of water and make the affluent pay their fair share.

8.1.3 User perceptions towards HWTS and implementing organizations

The perception of the general population towards HWTS was rather welcoming, although most users preferred that the treatment technology be provided by the government, or be sold in the proper consumer market as opposed to social-marketing schemes. When the author discussed this issue with a few respondents, it was apparent that they did not have too much confidence in the NGO workers that came to them to sell these products. There seems to have been distrust amongst people towards such social marketing schemes, which to them seemed more like profit-making ventures. In the same vein, it must be added that the workers from Pratinidhi were marketing only Pureit, Aquatabs and SafeWat in the communities that they were targeting. The author often observed that the workers were either ill-equipped to answer all questions of the user pertaining to other HWTS technologies, or in certain cases, some even ridiculed other treatment technologies that were in use.

8.1.4 Inadequate storage practices

Another problem that the survey data highlighted was of inadequate storage practices. While most people used vessels that had a lid to cover the mouth, very few people actually understood the importance of it. In many cases, the author saw people putting their hands into the storage vessel to draw water out of it. Pratinidhi's intervention program lacked the safe storage component. This meant that while users were made aware of the importance of safe drinking water and HWTS, they were not educated about the importance of safe storage.

8.1.5 Women's role

The primary water collectors in most households around Lucknow were the women of the house (75%). 30% of these women were not educated beyond primary school. Running a successful HWTS intervention in such areas would primarily entail educating this section of society so that they are aware of the dos and don'ts of water treatment. While many NGOs run intervention programs in schools in order to educate the children about proper water management and hygiene, very little is done at the household level, targeting the women.

8.1.6 Future research

Based on the results of the current study the author felt that future research should consider:

1. Conducting a similar study in a setting where,
    - The target group has been trained about the importance of safe storage
    - The user has access to more HWTS options.

2. Conducting a similar study in a rural setting in India to see how results differ, since this study was based out of a big city.

8.2 Water Quality Testing

Based on the results obtained in Chapter 7, it can be concluded that about 40% of the households are exposed of high-risk levels owing to contamination of drinking water while nearly 50% households are exposed to low-risk levels. It is hard to conclude whether the contamination being reported at the point of consumption is owing to the inefficiency in treatment or because of because of other factors. Although it is clear that each of the following reasons plays a part in adversely affecting the quality of water.

- Improper storage practices
- Inadequate maintenance and servicing of the system
- Using the system beyond its expiration date

Other than this, it is possible that, some contamination could have also occurred during the sampling process, although utmost care and attention was given while sampling.

8.2.1 Comparing test methods

The EC-Kit and the MTF matched up in their results for 26 of the 42 samples that were analyzed in the 4x4 frequency distribution table. In 14 of the remaining 16 samples it was observed that the risk levels being indicated by the EC-Kit were consistently higher than those indicated by the MTF. However, it should be noted that the sample size (N=42) was rather small to conduct such a comparison. In the future it would be useful to look at a larger set of data to check for trends. The linear regression analysis did not yield a good correlation between the two test methods – the EC-Kit and MTF. However, Vail et al (2003) got a strong correlation between their data sets for a similar study comparing the Petrifilms to other standard methods (Membrane Filtration and Quanti-tray). The reason for this could have been that Vail et al. sampled for both the tests at the same time. On the other hand, in the current study while the Petrifilm samples were conducted in the field the laboratory tests were conducted 24 hours later, since the samples had to be transported to the laboratory in Delhi. Even though the samples were kept in cooler bags through that time period, it could have affected the results and diminished the number of coliforms detected via the MTF technique in the laboratory.

8.3 Limitations of the study

- Time and resources did not permit the author to take samples from the inflow and outflow of the HWTS systems, instead he only tested water quality at the point of consumption, on the assumption that this was the most important result to know. However, it would have been valuable to also know the performance of the various HWTS based on directly testing influent/effluent water.

- Not cross checking the EC-Kit at the laboratory. Therefore, clearly not knowing the influence of the 24-hour delay, due to transportation, which could have affected the laboratory test results.

CHAPTER 9: CONCLUSION AND RECOMMENDATIONS

9.1 Relative to UNICEF and HWTS

Based on the response from various UNICEF country offices, it appears that scale-up of HWTS technologies has been rather slow. However, looking at the current scenario shift in India, many private sector enterprises like Bajaj, Hindustan Unilever and Eureka Forbes have started investing money into both research and development and marketing of low-cost HWTS systems. Such a shift, in the context of Figure 2.6, probably means that some countries are steadily moving up the S-shaped diffusion curve. In other cases, one must appreciate that the inefficient scale-up has occurred due to multi-faceted reasons such as lack of technical training and expertise, prevailing socio-economic conditions, instable political situations and in some cases also due to the lack of sufficient information.

Based on the responses received from UNICEF country offices, the author suggests that that it would be a good idea for the UNICEF headquarters to provide technical support to each country office. Given the constraints on the staffing, this could possibly be done by organizing regional workshops on good practices for HWTS implementation and scale-up. These regional forums could also be used by the country offices to share amongst themselves the information about their respective HWTS programs, which would help create the ideal forum for information sharing. Over and above this, there still might be some country offices that would have some specific problems in relation to implementation and scale-up. These should be communicated to the headquarters and the other member countries of the regional forum, who could then work together to find solutions.

Other problems to scale up put forth by the country offices included:

- The problem of reaching out to the poorest sections of society since HWTS technologies are still relatively expensive
- Difficulty in commercialization of HWTS technologies during non-emergency periods of the year, since these products are distributed for free during emergency events
- Lack of recognition of importance HWTS in providing safe water by local governments
- Lack of education which also leads to difficulties in the proper handling and use of any HWTS technology

9.2 Relative to field studies in Lucknow

9.2.1 Lack of technical expertise on the part of the implementer

In the current study the author worked with an NGO implementing the project at the field level. It was noted that most of the staff workers of the organization were not well versed with the portfolio of options available in the market. In the case observed by the author, the workers were marketing only three products Aquatabs, SafeWat and Pureit, and they were unversed and negative about other approaches. In fact, in a few cases it was also observed that the workers told the users that boiling water was an inefficient way to treat drinking water.

Hence, it is advisable that the staff of the implementing organizations is given adequate training, so that they are able to communicate a range of best practices to the user.

9.2.2 Inefficiencies occurring in the system

The author observed that some of the treatment systems were not functioning as per the prescribed standards. For instance, in many houses that were using Pureit systems it was observed a number of systems were past their expiration date. In addition, the author observed a physical gap had formed between the storage vessel and the filtration unit of the Pureit system. The possible explanation for this could be that different components of the Pureit filter are made with different plastics, which have different coefficients of thermal expansion because of which at higher temperatures the plastics expand unequally, thus creating a gap.

Higher standards of quality control testing coupled with better research and development could help avoid such problems.

9.2.3 Inadequacy in the after-sales service model of the implementer

This seemed to be a perennial problem with all implementing organizations. In case of both Hindustan Unilever and Eureka Forbes that manufacture Pureit and Aquaguard respectively, the after-sales service was very poor. Often the author came across users who had either been complaining to the companies over a faulty product or for a delayed bi-annual service or replacement.

9.2.4 Lack of knowledge on the part of the user

20% of the studied population were respondents that were uneducated and/or unaware. It was observed in many cases that people were not using the systems as prescribed by the implementer or manufacturer. For instance, some households were observed to be using a Pureit system whose chlorination unit had expired, or they were using one tablet of Aquatab in more than 10 liters of water, so as to dilute the taste of chlorine that the user did not like. In another case it was also observed that a household was using 2 tablets of chlorine to treat 10 liters of water, since they liked the taste of chlorine.

Problems of this nature are hardest to combat, since they involve changing the behavior of the user. However, establishing a good follow-up network, in the case of NGOs, or service practices, in the case of manufacturers, that educates the user in the appropriate manner could help solve some part of this problem.

9.2.5 Improper storage practices

Lack of training provided to the workers implementing these technologies leads to the problem of improper storage. It was unfortunate that none of Pratinidi's employees were trained on various aspects of safe storage. This coupled with the unhygienic practices at the user level contaminated treated water, as has been shown in Chapter 7.

The only way to effectively safeguard drinking water against problems of improper storage is by educating householders. It is essential that implementing organizations also realize the importance of safe storage. Safe storage must be advocated for parallel to setting up treatment technologies and not as a separate program. This is why the HWTS acronym is Household Water Treatment and Safe Storage.

9.3. Comparison of EC-Kit to lab method

The last aspect of this study involved comparing the EC-Kit in the field to the Multiple Tube Fermentation technique in the laboratory. The EC-Kit does a good job in predicting contamination in water supplies, however the accuracy of the test still requires further verification. A limitation of the study was that there was a time difference of about 18 hours between conducting the field test and the laboratory test, which may have affected the accuracy of the comparison results. Moreover, when transporting the samples from the field to the laboratory, sodium thiosulfate wasn't used (because of its interference with the Petrifilm test). This could have potentially changed the concentration of coliform contamination in the water. In the future, it is advisable to run concurrent EC-Kit and MTF tests, so as to get rid of the ambiguity that was caused in this study.

Given the constraints of time, distance and funding the author could only perform 42 comparative tests between the lab and the field. It is advisable that in future studies the sample size of the comparative set be larger.

9.4 Final comments

Critics of household water treatment technologies often complain that these systems have not been scaled up adequately or that they have not been successful in providing the promised health benefits based on blinded studies. However, after having studied various aspects of HWTS technology, from both the standpoint of the user and the implementer, the author believes that a focused effort towards provision of proper technical expertise to the staff at the implementing organizations would help take this effort forward. Moreover, a conscious effort towards empowering people by educating them about aspects of HWTS would help us reach the MDG targets for clean drinking water.

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ANNEX I: JOINT MONITORING PROGRAMME

WHO and UNICEF as a successor to the Water and Sanitation Decade organized the Joint Monitoring Programme. The purpose of this program is to:

- Monitor sector trends and programmes
- Build national sector monitoring capacity
- Inform national and global policymakers on the status of the sector

The JMP monitors and collects information, using the medium of the Multiple Indicator Cluster Survey (MICS)[1] programme that UNICEF conducts in approximately 100 countries. The MICS programme has been developed by UNICEF to assist countries in filling up data gaps for monitoring the situation of children and women through statistically sound, internationally comparable estimates of socioeconomic and health indicators. MICS uses three modular questionnaires that can be customized to meet the data needs of a country. MICS3, which began in 2005, was the first time when the UNICEF incorporated questions pertaining to HWTS within the questionnaire. The core questions incorporated in the questionnaire include the following (WHO, 2006):

Question 1. What is the main source of drinking water for the members of your family?

i. Piped water into dwelling
ii. Public tap/standpipe
iii. Tubewell/borehole
iv. Protected dug well
v. Unprotected dug well
vi. Protected spring
vii. Unprotected spring
viii. Rainwater collection
ix. Bottled water
x. Cart with small tank/ drum
xi. Tanker truck
xii. Surface water
xiii. Others

Question 2. How long does it take to go there, get water, and come back?

i. Number of minutes
ii. Water on premises
iii. Don't Know

Question 3. Who usually goes to this source to fetch water for your household?

i. Adult woman
ii. Adult man
iii. Female child (under 15 years)

[1] http://www.unicef.org/statistics/index_24302.html

iv. Male child (under 15 years)
v. Don't know

Question 4. Do you currently treat your water in any way to make it safer to drink?

i. Yes
ii. No
iii. Don't Know

Question 5. What do you usually do to the water to make it safer to drink?

i. Boil
ii. Add bleach/chlorine
iii. Strain it through a cloth
iv. Use a water filter (ceramic, sand, composite, etc.)
v. Solar disinfection
vi. Let it stand and settle
vii. Others
viii. Don't know

The responses for Questions 1 and 5 were categorized into “improved” and “unimproved” water supplies and “adequate” or “inadequate” treatment respectively by the JMP. JMP’s “improved water sources” is officially recognized as the indicator for the MDG water target too. The following water sources are considered to be “improved water sources”:

i. Piped water into dwelling
ii. Public tap/standpipe
iii. Tubewell/borehole
iv. Protected dug well
v. Protected spring
vi. Rainwater collection
vii. Bottled water

While all other options provided in Question 1 are classified as “unimproved”. The following treatment options are classified as “adequate” by the JMP:

i. Boil
ii. Add bleach/chlorine
iii. Use a water filter (ceramic, sand, composite, etc.)
iv. Solar disinfection

While all the other options enlisted in Question 5 are categorized as “inadequate”.

ANNEX II: UNICEF and the WASH Program

The three support services offered by UNICEF (http://www.unicef.org/wash/index_43084.html#comp), as an agency, are:

1. The Comprehensive Package for the 60-priority countries.

2. Support offered during Emergencies

3. Support to the WASH programs of all 201-member countries

1 Comprehensive package for priority countries

1. Promoting a balanced national WASH programming framework:

UNICEF encourages a three-pillar approach to the WASH program, this includes the provision of water supply and sanitation services that are complemented by the promotion of improved hygiene behavior and supported by an enabling environment.

2. Supporting inter-sectoral approaches:

Maximum benefits can be drawn out for children by integrating the hygiene, sanitation and water programs with other sectoral programs such as education, health and nutrition.

3. Providing catalytic and continuous support for scaling up sustainable WASH programs:

UNICEF believes that targets can be met only when national service delivery programs are significantly scaled-up. Hence, it prioritizes and supports activities that contribute to this end. Thoroughly understanding the dynamics of the WASH sector the organization has positioned itself in a manner that UNICEF can be instrumental in increasing coverage while upholding the sustainability of the WASH services.

4. Supporting community management through effective decentralization processes:

UNICEF helps support measures and create strong institutions at the intermediate level (municipal, district, province, etc.), since they are critical to supporting community managed service provision, which is in turn essential to the sustained scaling up of WASH coverage.

5. Promoting safe and sustainable water supplies through improved water resources management:

The freshwater resource base is considered to be one that needs to be protected and promoted when implementing programs within the WASH group.

6. Focusing on sanitation, water quality and hygiene at the household level:

UNICEF believes that with a greater focus on the household level interventions one could increases the effectiveness of sectoral programs, especially in the areas of sanitation, water quality and hygiene promotion. UNICEF continues to promote affordable, safe household latrines; technology development in the area of household water treatment and safe storage, and programs that seek to improve key household hygiene practices.

7. Addressing a child's right to health and education through the provision of WASH in schools:

The organization is committed to ensuring that all children have access to high quality water and sanitation services at school, and the benefit of hygiene education. Such programs give UNICEF an opportunity to directly address a child's right to both education and health.

2 In Emergencies

UNICEF has defined four key strategies to guide WASH programming in countries in crisis and transition:

1. Support to national emergency preparedness planning

2. Coordinating UN and NGO emergency response programs

3. Acceleration and adaptation of existing programs to rapidly and efficiently respond in emergency situations

4. Ensuring that the emergency response inputs during emergencies reinforce the best practices in the sector and contribute to national priorities as defined by government, UNICEF and partners.

3 In all other member countries

UNICEF has 201-member countries. In these countries it has adopted the following strategy:

1. Advocacy and technical support for improving hygiene awareness and promoting behavior change

2. Technical support for water quality

3. Development of emergency preparedness plans for WASH

4. Support to national monitoring for achievement of MDG target 10

ANNEX III: Sample Questionnaire of the survey conducted in Lucknow

Assessment of the status of HWTS in villages in Northern India

For respondents consent:

You are being asked to participate in a research study. The purpose of this study is to determine the status of household level water treatment systems in your village. Please ask questions, if there is anything you do not understand. Your participation is voluntary and will have no effect on the quality of your water supply or treatment if you choose not to participate. You may refuse to answer any or all questions on the survey. The data collected on the basis of these surveys is strictly confidential and we will not record any of your personal information (including name, telephone number and address).

Household Survey on the Status of HWTS in villages in Northern India

Section I:

1. What is the main source of drinking water for members of your household?
Piped into dwelling…………. …………………..1
Piped into yard/plot…………. …………………..2
Public tap………………….. ……………………...3
Open well in dwelling……… ……………………..4
Open well in yard/plot……… ……… …………… 5
Open public well………………………………….6
Protected well in dwelling………………….……..7
Protected well in yard/plot………………….……….8
Protected public well…… …………………………9
Borehole…..…………………... ……………….…10
Spring……… ……………………………… …...11
Protected spring……………………………….….12
Surface water……………………………….….13
Cart with drum…………………………….….14
Tanker trucks…………………………….….15
Rainwater…………………………………….….16

2. Is water normally available from this source?
Yes……………………………………………………1
No……………………………………………………..0

3. In the last two weeks, was water unavailable from this source for a day or longer?
Yes……………………………………………………1
No……………………………………………………..0

4. Was the water connection to your house done by an agency authorized by the government to do so?
No…… ………….…… ………….0
Yes………………………………… 1
Not applicable…… ………………. 9
(If source of drinking water is piped water into dwelling, yard or plot, a public tap/standpipe/kiosk or a borehole, ask:)

5. Who is providing water at your main source?
Government authority… ………….1
CBO/NGO………………………….2
Private operator…………………...3
Other (specify) _______________4

6. How much time does it take on average to go there, get water and come back?

30 minutes or less …… …….1
31 to 60 minutes…………….2
61-180 minutes……………...3
More than 3 hours…………..4
Does not know ………………9

7. Could I see the vessel you use to collect water

Yes………………….. 1
No…………………….0

7 a. Type of vessel:

7 b. Approximate Volume:

8. How many times do you go to collect water?

9. Who typically collects the water for the household?

1. Women
2. Children (girls only)
3. Children (boys only)
4. Children (all)
5. Women and children (girl)
6. Women and Children (boy)
7. Women and Children (all)
8. Men
9. Men and Children
10. Men and Women
11. Entire family, anyone may go to fetch water

10. Do you pay for your water?

Yes………………….. 1
No…………………….0

11. If yes, how is it charged?

0. Water Tax
1. Per liter
2. Per jerry can
3. Per bucket
4. Per earthen pot

12. What is the cost (in rupees per unit)?

13. It is necessary to treat at home my family's drinking water?

Totally disagree 1

Partially disagree 2
No opinion 3
Partially agree 4
Totally agree 5

14. Most of my friends take some action at home to treat their water to make it safer to drink?
Totally disagree 1
Partially disagree 2
No opinion 3
Partially agree 4
Totally agree 5

15. My neighbors take some action at home to treat their water to make it safer to drink.
Totally disagree 1
Partially disagree 2
No opinion 3
Partially agree 4
Totally agree 5

16. The majority of people in my village take some action at home to treat their water to make it safer to drink?
Totally disagree 1
Partially disagree 2
No opinion 3
Partially agree 4
Totally agree 5

17. I feel confident that I can correctly treat water to make it safer for drinking.
Totally disagree 1
Partially disagree 2
No opinion 3
Partially agree 4
Totally agree 5

18. Where I live there are shops that sell water treatment products
Totally disagree 1
Partially disagree 2
No opinion 3
Partially agree 4
Totally agree 5

19. Shops near my house always carry water treatment products that I may need.

Totally disagree 1
Partially disagree 2
No opinion 3
Partially agree 4
Totally agree 5

20. Do you currently treat your drinking water?
Yes……………………………………………………1
No……………………………………………………..0

21. If no, then why don't you treat your water?

1. Treatment systems are not available
2. I had a treatment system but it broke down, after which I never bothered to buy one since it was too expensive
3. I had a treatment system but it broke down, after which I never bothered to buy one because I feel that it is ineffective
4. The water from the source is very clean
5. Treatment technology is too expensive
6. No one in my community treats water, hence I don't treat it too
7. My forefathers never treated the water from this source hence why do I need to?

22. If you use chlorination, which of the three do you use?
1. Hypochlorite Solution
2. Aquatabs
3. PuR

23. **May I see the packaging of the product used?**
Yes……………………………………………………1
No……………………………………………………..0
24. (Based on observation), is the product still valid?
Yes……………………………………………………1
No……………………………………………………..0

25. If you use filtration, which of the three do you use?
1. Bio-sand
2. Candle
3. Purit

26. May I see the filter?
Yes……………………………………………………1
No……………………………………………………..0

27. (Based on observation), is the product still valid

Yes……………………………………………………1
No……………………………………………………..0

28. Solar Disinfection
Yes……………………………………………………1
No……………………………………………………..0

29. May I see the bottles exposed to the sun?
Yes……………………………………………………1
No……………………………………………………..0

30. How long do you expose them before drinking the water?

1. 6 hours during 1 day when sunny
2. 6 hours per day during 2 days when cloudy
3. Shorter periods than indicated in responses 1 and 2
4. Other, Specify

31. Boiling
Yes……………………………………………………1
No……………………………………………………..0

32. How long did you let the water boil?
Until it was smoking………………………………….1
Until it came to a rolling boil…………………………2
Several Minutes……………………………………….3

33. Where did you store the boiled water?
Same container where it boiled……………………...1
Transferred it to a different container than where it boiled….2

34. Other methods
0. Not applicable
1. Aluminum salt coagulant
2. Iron salt coagulant
3. Polymers (natural or synthetic)
4. Combined system (e.g., PuR, Aquasure, Pure-it, Family Lifestraw, etc.)
5. Chemical removal system (arsenic, fluoride, other)
6. Straining through a cloth
7. Let is stand and settle
8. Other. Specify______________________-

35. Do you store your drinking water?
Yes……………………………………………………1

No………………………………………………………..0

36. May I see the main container(s) where you store it?

Allowed……………………………………………………1

Not Allowed...……………………………………………..0

37. Has wide or narrow mouth

Wide Mouth (>5 cms)………………………………..1

Narrow Mouth (< 5 cms)……………………………2

Not Observed…………………………………………3

38. Has Tap

Yes……………………………………………………1

No………………………………………………………..0

39. Has a lid or fitted cover

Yes……………………………………………………1

No………………………………………………………..0

40. Is covered filtration reservoir with tap

Yes……………………………………………………1

No………………………………………………………..0

41. May I take a sample of your drinking water?

Allowed……………………………………………………1

Not Allowed...……………………………………………..0

Section 2: Demographics

Q 42 A: Month of interview:

Q 42 B: Year of Interview:

Q 43 Gender of respondent:

Male……………………………1

Female…………………………..2

Q 44 Study Area:

1. Lucknow

Q 45 Name of Locality:

Vijay Khera	1
Ghadi Kanura	2
Abharanpur	3
Jankipuram	4
Vikas Nagar (Slum Vin Palace)	5
Kalyanpur	6
Lal Bagh	
Gaitri Nagar	
Sabhouli	
Faizullah Ganj	
Aliganj/ Sultanpur	
Khadra	
New Madhey Ganj	
Rajajipuram	
Shahadatganj	
Gomti Nagar	

Q 46 Age of respondent:

Q. 47 How many people live permanently in the household?

Q 48 How many of those are boys under the age of 5 years?

Q 49 How many of those are girls under the age of 5 years?

Q 50 Who in the household is responsible for taking care of the children less than 5 years?

Respondent 1

Respondent's wife 2

Respondent's mother 3

Respondent's mother in-law 4

Siblings	**5**
Others (please specify)	**6**

Q 51 Did your ever attend school?

Yes	1
No	0

Q 52 If yes, what was the last grade of school you completed?

None	0
Grade 1-8	1
High School	2
Bachelors	3
Masters or greater	4

Q 53 How many members in the family are educated?

Q 54 What is the highest grade of school to which a family member is educated?

None	0
Grade 1-8	1
High School	2
Bachelors	3
Masters or greater	4

Q 55 Occupation of the earning member/members: (need options for this)

Unemployed	0
Business	1
Government Service	2
Private Service	3

Q 56 Monthly/Annual income of the family (in rupees)

ANNEX IV: Data from household surveys in Lucknow

Survey No.	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 7 a	Q 7 b	Q 8	Q 9	Q 10
001	10	1	0	1	1	1	1	1	20		4	1
002	1	1	1	1	1	1	1	1	20		5	1
003	1	1	1	1	1	1	1	1	20		4	1
004	1	1	1	1	1	1	1	1	20		1	1
005	1	1	1	1	1	1	1	1	20		7	1
006	1	1	1	1	1	1	1	1	20		1	1
007	1	1	1	1	1	1	1	5	20		1	1
008	3	1	1	1	1	2	1	1	20	10	11	0
009	1	1	1	1	1	1	1	1	20		11	1
010	1	1	1	1	1	1	1	1	20		1	1
011	1	1	0	1	1	1	1	3	25	2	3	1
012	1	1	0	1	1	1	1	1	15		5	1
013	1	1	0	1	1	1	1	1	20		9	0
014	1	1	0	1	1	1	1	1	10		1	1
015	3	1	1	0	3	2	1	5	10	3	11	1
016	3	1	0	0	3	3	1	5	5	3	11	0
017	3	1	0	1	1	2	1	5	5	4	7	1
018	10	1	0	1	1	2	1	1	20		7	0
019	10	1	1	0	4	1	1	2	15		1	0
020	10	1	1	1	4	1	1	1	20		1	0
021	1	1	0	1	1	1	1	2	20		7	1
022	1	1	1	1	1	1	1	2	10		1	1
023	1	1	1	1	1	2	1	3	25		1	1
024	1	1	0	1	1	2	1	3	35		1	1

025	1	1	1	1	1	1	1	3	20		1	1
026	1	1	1	1	1	2	1	1	10		1	1
027	1	1	1	1	2	1	1	4	2		10	1
028	2	1	0	1	1	2	1	2	12		10	1
029	1	1	0	1	1	1	1	3	15		1	1
030	1	1	0	1	1	1	1	2	12		1	1
031	1	1	0	1	1	1	1	2	10		1	1
032	1	1	0	1	1	1	1	1	10		1	1
033	1	1	0	1	1	1	1	2	12		1	1
034	1	1	0	1	1	1	1	2	12		1	1
035	1	1	0	1	1	1	0				1	1
036	2	1	0	0	3	1	1	4	1		1	0
037	10	1	0	0	3	1	1	2	10		1	0
038	10	1	0	0	3	1	1	2	10		1	0
039	10	1	0	0	3	1	1	2	10		1	0
040	8	1	0	0	3	1	1	1	10	3	1	0
041	10	1	0	0	3	1	1	1	12		1	0
042	1	1	0	1	1	1	1	1	12		1	1
043	1	1	0	1	1	1	1	2	5		1	1
044	1	1	0	1	1	1	1	1	10		1	1
045	1	1	0	1	1	1	1	1	10		1	1
Survey No.	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 7 a	Q 7 b	Q 8	Q 9	Q 10
046	1	1	0	1	1	2	1	6	12	1	1	0
047	1	1	0	1	1	2	1	2	10		1	1
048	1	1	0	1	1	2	1	3	10		1	1
049	1	1	0	1	1	2	1	2	12		1	1
050	1	1	0	1	1	2	1	4	2		1	1
051	1	1	1	1	1	2	1	6	7		1	1

052	1	1	0	1	1	2	1	1	10		1	1
053	1	1	0	1	1	1	1	6	10		1	1
054	1	1	0	1	1	1	1	1	12		1	1
055	1	1	0	1	1	1	1	5	10		1	1
056	1	1	0	1	1	1	1	6	10		1	1
057	10	1	1	0	3	1	1	1	10		1	0
058	10	1	0	0	3	1	1	1	10		1	0
059	10	1	0	0	3	1	1	1	10		1	0
060	11	1	0	0	3	1	1	1	10		1	0
061	10	1	0	0	1	1	1	1	10		1	0
062	10	1	0	0	3	1	1	1	10		1	0
063	10	1	0	1	1	1	1	3	10		1	0
064	9	1	0	1	1	1	1	1	10	2	10	1
065	1	1	0	1	1	1	1	6	10		5	1
066	1	1	1	1	1	1	1	2	12		1	1
067	1	1	1	1	1	1	1	1	10		1	1
068	9	1	1	1	1	1	1	2	6	3	1	0
069	1	1	0	1	1	1	1	2	10		1	1
070	1	1	0	1	1	1	1	1	10		1	1
071	1	1	0	1	1	1	1	1	10		1	1
072	2	1	0	1	1	1	1	6	6		1	1
073	1	1	0	1	1	1	1	2	6		5	1
074	1	1	1	1	1	1	1	6	10		1	1
075	1	1	1	1	1	1	1	3	15		1	1
076	10	1	0	0	3	1	1	4	2		1	0
077	10	1	0	0	3	1	1	6	8		1	0
078	8	1	0	0	3	1	1	1	10	3	1	0
079	10	1	0	0	3	1	1	1	12	2	1	0

080	10	1	0	0	3	1	1	2	20	3	10	0
081	10	1	1	0	3	1	1	6	8		1	0
082	10	1	0	0	3	1	1	1	10	2	1	0
083	1	1	1	1	1	1	1	6	6		1	1
084	1	1	1	1	1	1	1	6	8		1	1
085	1	1	1	1	1	1	1	6	5		1	1
086	1	1	0	1	1	1	1	2	20		8	1
087	1	1	1	1	1	1	1	6	10		1	1
088	1	1	1	1	1	2	1	6	10		1	1
089	1	1	0	1	1	1	1	6	2		8	1
090	1	1	1	1	1	1	1	6	7		1	1
091	1	1	1	1	1	1	1	6	10		1	1
092	1	1	0	1	1	1	1	2	15		1	1
093	1	1	0	1	1	1	1	2	5		1	1
Survey No.	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 7 a	Q 7 b	Q 8	Q 9	Q 10
094	1	1	1	1	1	1	1	1	10		1	1
095	1	1	1	1	1	1	1	6	5		1	1
096	3	1	0	0	3	1	1	1	10	3	5	0
097	9	1	1	1	1	2	1	5	16	4	11	0
098	9	1	1	1	1	2	1	5	10	2	1	0
099	1	1	0	1	1	1	1	2	10		1	1
100	9	1	1	1	1	1	1	2	10	2	10	1
101	1	1	1	1	1	1	1	2	10		1	1
102	1	1	0	1	1	1	1	3	10		1	1
103	10	1	0	1	1	2	1	1	7	3	8	1
104	10	1	0	1	1	1	1	2	15	2	1	0
105	10	1	0	1	1	2	1	1	20	4	1	0
106	7	1	0	0	3	1	1	1	10		1	0

107	9	1	0	1	1	1	1	1	10	3	8	0
108	9	1	0	1	1	1	1	5	15		6	0
109	8	1	0	0	3	1	1	2	10	1	1	0
110	7	1	0	0	3	1	1	2	12		1	0
111	9	1	1	1	1	2	1	5	12	3	1	0
112	9	1	0	1	1	2	1	1	12	1	1	0
113	10	1	0	0	3	1	1	1	15		1	0
114	7	1	0	0	3	1	1	1	15		1	0
115	1	1	1	1	1	1	1	5	12		1	1
116	9	1	0	1	1	2	1	5	5	4	6	0
117	1	1	0	1	1	1	1	2	10		1	0
118	1	1	1	1	1	1	1	3	15		1	1
119	1	1	1	1	1	1	1	2	10		1	0
120	10	1	0	0	3	1	1	1	15		1	0
121	9	1	0	1	1	1	1	2	15	3	10	0
122	9	1	0	1	1	1	1	1	12	3	7	0
123	1	1	0	1	1	1	1	6	10		1	1
124	9	1	0	1	1	1	1	5	5	1	1	0
125	9	1	0	1	1	1	1	5	5	1	1	0
126	9	1	0	1	1	1	1	4	1		1	0
127	9	1	0	1	1	2	1	6	16	2	7	0
128	9	1	0	9	1	2	1	1	8	2	8	0
129	10	1	0	0	3	1	1	2	10	2	4	0
130	7	1	0	0	3	1	1	6	10		1	0
131	1	1	0	1	1	1	1	5	10		11	0
132	9	1	0	1	1	2	1	2	10	2	1	0
133	9	1	0	1	1	1	1	5	10	2	11	0
134	3	1	1	9	1	1	1	2	12	3	11	0

135	1	1	1	1	1	1	1	2	10	2	1	0
136	9	1	0	1	1	2	1	5	5	3	10	0
137	3	1	1	1	1	1	1	1	8	3	1	0
138	9	1	0	1	1	1	1	1	15	2	11	0
139	1	1	0	1	1	1	1	6	10		1	1
140	1	1	1	1	1	1	1	3	10		1	1
141	1	1	0	1	1	1	1	3	10		1	1
Survey No.	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 7 a	Q 7 b	Q 8	Q 9	Q 10
142	9	1	0	1	1	1	1	1	10	3	1	0
143	9	1	0	1	1	1	1	5	5	3	1	0
144	9	1	0	1	1	2	1	2	10	2	8	0
145	9	1	0	1	1	1	1	5	5	4	11	0
146	1	1	1	1	1	1	1	2	20		1	1
147	9	1	0	1	1	2	1	2	10	3	4	0
148	1	1	1	1	1	1	1	2	20		1	1
149	1	1	1	1	1	1	1	3	20		11	1
150	1	1	1	1	1	1	1	1	15		1	1
151	1	1	0	1	1	1	1	2	10		1	0
152	1	1	0	1	1	1	1	1	15		1	0
153	1	1	1	1	1	1	1	2	15		1	1
154	1	1	0	1	1	1	1	1	10		1	1
155	1	1	0	1	1	1	1	1	10		1	1
156	1	1	0	1	1	1	1	1	15		1	1
157	1	1	0	1	1	1	1	6	10		1	1
158	1	1	1	1	1	1	1	2	10		1	1
159	1	1	1	1	1	1	1	3	10		1	1
160	1	1	0	1	1	1	1	1	10		1	1
161	7	1	0	0	3	1	1	5	10		1	0

162	9	1	0	1	1	2	1	2	12	4	11	1
163	1	1	0	1	1	9	1	5	5		1	0
164	9	1	0	1	1	1	1	6	10	2	5	0
165	7	1	0	0	3	1	1	2	10	3	1	0
166	9	1	0	1	1	1	1	2	10	2	1	0
167	1	1	1	1	1	1	1	1	10		1	1
168	1	1	1	1	1	1	1	2	10		1	1
169	1	1	1	1	1	1	1	1	10		1	1
170	9	1	0	1	1	1	1	2	12	3	1	0
171	9	1	0	1	1	1	1	2	12	3	1	0
172	1	1	1	1	1	1	1	6	15		1	1
173	1	1	1	1	1	1	1	2	10		1	1
174	9	1	0	1	1	1	1	2	10	4	4	0
175	9	1	0	1	1	2	1	2	4	2	1	0
176	9	1	0	1	1	1	1	2	15	1	4	0
177	9	1	0	1	1	1	1	2	12	2	1	0
178	1	1	1	1	1	1	1	1	15		1	1
179	9	1	0	1	1	1	1	1	10	8	1	0
180	1	1	0	1	1	1	1	1	12		1	1
181	1	1	1	1	1	1	1	6	10		1	1
182	1	1	1	1	1	1	1	6	10		1	1
183	1	1	1	1	1	1	1	6	10		1	1
184	1	1	1	1	1	1	1	1	10		10	1
185	1	1	1	1	1	1	1	6	15		10	1
186	1	1	1	1	1	1	1	1	12		5	1
187	7	1	0	0	3	1	1	6	10		1	0
188	9	1	1	1	1	2	1	5	12	3	1	0
189	9	1	0	1	1	2	1	1	12	1	1	0

Survey No.	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 7 a	Q 7 b	Q 8	Q 9	Q 10
190	10	1	0	0	3	1	1	1	15		1	0
191	7	1	0	0	3	1	1	1	15		1	0
192	1	1	1	1	1	1	1	5	12		1	1
193	9	1	0	1	1	2	1	5	5	4	6	0
194	1	1	0	1	1	1	1	2	10		1	0
195	1	1	1	1	1	1	1	3	15		1	1
196	1	1	1	1	1	1	1	2	10		1	0
197	10	1	0	0	3	1	1	1	15		1	0
198	9	1	0	1	1	1	1	6	10	3	10	0
199	9	1	0	1	1	1	1	1	12	3	7	1
200	9	1	0	1	1	1	1	2	12	3	1	0
201	9	1	1	1	1	1	1	1	15	3	4	0
202	9	1	0	1	1	1	1	2	10	3	1	0
203	1	1	0	1	1	1	1	6	3		1	1
204	1	1	0	1	1	1	1	1	12		1	1
205	1	1	0	1	1	1	1	6	10		1	1
206	7	1	0	0	3	1	1	4	2		1	0
207	1	1	0	1	1	1	1	2	10		1	1
208	7	1	0	0	3	1	1	1	15		8	0
209	8	1	0	0	3	1	1	1	20		7	0
210	7	1	0	0	3	1	1	1	10		8	0
211	7	1	0	0	3	1	1	1	10		11	0
212	8	1	0	1	1	1	1	4	2		1	1
213	1	1	0	1	1	1	1	2	10		1	1
214	1	1	0	1	1	1	1	4	2		1	1
215	7	1	0	1	1	1	1	3	15		1	1
216	7	1	0	1	3	1	1	1	12		1	0

217	1	1	0	1	1	1	1	2	20		7	1
218	1	1	1	1	1	1	1	2	10		1	1
219	1	1	1	1	1	2	1	3	25		1	1
220	1	1	0	1	1	2	1	3	35		1	1
221	1	1	1	1	1	1	1	3	20		1	1
222	1	1	1	1	1	2	1	1	10		1	1
223	1	1	1	1	2	1	1	4	2		10	1
224	2	1	0	1	1	2	1	2	12		10	1
225	1	1	0	1	1	1	1	3	15		1	1
226	1	1	0	1	1	1	1	2	12		1	1
227	1	1	0	1	1	1	1	2	10		1	1
228	1	1	0	1	1	1	1	1	10		1	1
229	1	1	0	1	1	1	1	2	12		1	1
230	1	1	1	1	1	1	1	2	10	2	1	0
231	9	1	0	1	1	2	1	5	5	3	10	0
232	3	1	1	1	1	1	1	1	8	3	1	0
233	9	1	0	1	1	1	1	1	15	2	11	0
234	1	1	0	1	1	1	1	6	10		1	1
235	1	1	1	1	1	1	1	3	10		1	1
236	1	1	0	1	1	1	1	3	10		1	1
237	9	1	0	1	1	1	1	1	10	3	1	0
Survey No.	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 7 a	Q 7 b	Q 8	Q 9	Q 10
238	9	1	0	1	1	1	1	5	5	3	1	0
239	9	1	0	1	1	2	1	2	10	2	8	0
240	9	1	0	1	1	1	1	5	5	4	11	0

Survey No.	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20
001	0	2	5	4	5	4	5	1	1	1
002	0	2	1	1	1	2	3	1	1	0
003	0	2	1	1	1	1	1	1	1	0
004	0	2	5	5	2	3	5	1	1	1
005	0	2	5	1	1	1	1	1	1	0
006	0	2	4	1	1	1	3	1	1	0
007	0	3	3	1	1	1	3	1	1	0
008		0	4	1	1	1	1	1	1	0
009	0	3	3	3	1	1	3	1	1	1
010	0	1	1	1	1	1	1	1	1	0
011	0	2	5	5	5	3	5	1	1	0
012	0	2	1	1	2	1	1	1	1	1
013		0	5	5	2	3	1	1	1	1
014	0	3	1	3	5	3	1	1	1	1
015	0	1	1	3	1	2	1	1	1	1
016		0	2	4	3	2	5	1	1	1
017	0	1	3	1	1	1	5	1	1	1
018		0	3	5	5	3	3	1	1	1
019		0	5	3	5	3	1	1	1	1
020		0	1	1	1	1	5	1	1	1
021	0	2	5	1	2	3	5	1	1	1
022	0	2	5	5	5	5	4	1	1	1
023	0	2	5	5	5	5	4	1	1	1
024	0	2	5	5	5	4	5	1	1	1
025	0	2	5	5	5	5	2	1	1	1

026	0	2	5	5	5	5	5	4	5	1
027	0	3	5	5	5	4	5	4	4	1
028	0	2	5	5	2	3	5	1	5	1
029	0	3	5	5	5	3	5	1	1	1
030	0	2	4	4	3	3	3	1	1	1
031	0	2	5	5	5	3	4	1	1	1
032	0	2	5	5	4	3	4	1	1	1
033	0	3	5	5	5	3	3	1	1	1
034	0	3	5	3	3	3	5	1	1	1
035	0	2	2	2	3	3	4	1	1	1
036		0	1	1	1	1	1	1	1	0
037		0	1	1	1	1	3	1	1	0
038		0	3	3	3	3	4	1	1	1
039		0	4	3	4	3	4	3	3	1
040		0	5	3	3	3	5	1	1	1
041		0	5	3	3	3	4	1	1	1
042	0	2	2	1	2	3	3	1	1	1
043	0	2	5	4	3	3	4	3	3	1
044	0	2	4	3	4	3	4	3	3	1
045	0	3	4	3	3	3	4	1	1	1
046		0	4	4	4	3	5	1	1	1
Survey No.	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20
047	0	2	5	4	4	3	5	1	1	1
048	0	2	5	5	4	3	5	1	1	1
049	0	2	5	5	4	3	4	1	1	1
050	0	3	4	4	3	3	4	1	1	1
051	0	3	5	2	2	3	4	1	1	1
052	0	2	4	4	2	3	4	1	1	1

053	0	2	4	4	4	3	4	1	1	1
054	0	2	4	4	3	3	5	1	1	1
055	0	2	4	4	4	3	5	1	1	1
056	0	2	4	2	2	3	4	1	1	1
057		0	5	1	1	3	3	1	1	0
058		0	4	1	1	3	4	1	1	1
059		0	5	1	4	3	5	1	1	1
060		0	4	1	4	3	4	1	1	1
061		0	1	1	1	1	4	1	1	0
062		0	4	2	3	3	4	1	1	1
063		0	5	4	3	3	4	1	1	1
064	0	2	4	4	4	3	4	1	1	1
065	0	2	5	5	1	3	5	1	1	1
066	0	2	4	3	2	3	4	1	1	1
067	0	2	2	2	1	3	2	1	1	0
068		0	4	3	3	3	4	1	1	1
069	0	2	5	5	3	3	5	1	1	1
070	0	2	4	1	2	3	4	1	1	1
071	0	2	4	4	4	3	4	1	1	1
072	0	2	5	3	3	3	4	1	1	1
073	0	2	5	3	4	3	4	1	1	1
074	0	2	4	4	5	4	5	1	1	1
075	0	2	4	4	3	3	4	1	1	1
076		0	1	4	4	3	5	1	1	0
077		0	5	2	2	3	5	1	1	1
078		0	4	2	2	3	4	1	1	1
079		0	4	4	3	3	4	1	1	1
080		0	5	1	2	4	4	1	1	1

081		0	5	4	4	4	5	1	1	1
082		0	3	4	3	3	3	1	1	1
083	0	2	5	4	4	4	4	1	1	1
084	0	2	5	5	1	3	4	1	1	1
085	0	2	4	4	3	3	4	1	1	1
086	0	2	4	4	4	3	5	1	1	1
087	0	2	4	3	3	3	4	1	1	1
088	0	2	4	5	5	3	5	1	1	1
089	0	2	1	4	2	3	4	1	1	1
090	0	2	4	4	4	3	4	1	1	1
091	0	2	5	3	3	3	4	1	1	1
092	0	2	4	4	3	3	4	1	1	1
093	0	2	4	3	3	3	4	1	1	1
094	0	2	5	3	3	3	5	1	1	1
Survey No.	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20
095	0	2	5	2	2	3	4	1	1	1
096		0	1	1	1	1	1	1	1	1
097		0	4	2	2	3	2	1	1	1
098		0	5	5	4	3	5	1	1	1
099	0	2	4	4	2	2	4	1	1	1
100	0	2	4	3	3	3	5	1	1	1
101	0	2	5	5	5	5	5	4	4	1
102	0	2	5	5	4	2	5	1	1	1
103	0	2	4	4	4	4	5	1	1	1
104		0	5	1	4	3	5	1	1	1
105		0	4	4	4	3	5	1	1	1
106		0	2	3	3	3	5	1	1	0
107		0	5	5	4	3	5	1	1	1

108		0	2	2	3	3	3	1	1	0
109		0	4	4	3	3	5	1	1	1
110		0	5	3	2	2	5	1	1	1
111		0	2	2	3	3	5	1	1	0
112		0	4	1	3	3	5	1	1	1
113		0	1	1	1	3	3	1	1	0
114		0	1	1	1	3	3	1	1	0
115	0	2	4	4	4	3	5	1	1	1
116		0	5	5	4	4	5	1	1	1
117		0	5	5	5	4	5	1	1	1
118	0	3	4	4	4	4	5	1	1	1
119		0	4	2	3	3	3	1	1	0
120		0	1	2	2	2	5	1	1	0
121		0	5	4	3	3	4	1	1	0
122		0	5	4	3	3	5	1	1	1
123		2	5	4	3	3	2	1	1	1
124		0	1	1	1	1	3	1	1	0
125		0	3	2	2	3	3	1	1	0
126		0	1	1	1	1	3	1	1	0
127		0	5	1	1	3	3	1	1	0
128		0	5	3	3	3	5	1	1	1
129		0	1	1	1	3	3	1	1	0
130		0	5	3	1	1	3	5	1	1
131		0	4	4	4	4	4	1	1	1
132		0	5	1	2	3	4	1	1	1
133		0	4	4	4	4	4	1	1	1
134		0	4	3	3	3	5	1	1	1
135		0	4	3	3	3	5	1	1	1

136		0	5	5	4	4	5	1	1	1
137		0	5	5	5	4	5	1	1	1
138		0	4	3	3	3	5	1	1	1
139	0	2	5	5	5	5	5	1	1	1
140	0	2	5	4	4	4	5	1	1	1
141	0	2	4	3	3	3	5	1	1	1
142		0	5	4	4	4	5	1	1	1
Survey No.	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20
143		0	5	3	3	3	5	1	1	1
144		0	4	2	2	2	3	1	1	0
145		0	5	2	2	3	5	1	1	1
146	0	2	5	5	3	3	3	1	1	1
147		0	5	3	3	3	4	1	1	1
148	0	2	5	4	4	3	5	1	1	1
149	0	2	4	3	3	3	3	1	1	0
150	0	3	5	5	4	4	5	1	1	1
151		0	1	1	1	1	3	1	1	0
152		0	4	3	3	3	4	1	1	1
153	0	2	5	3	3	3	5	1	1	1
154	0	2								
155	0	2	5	5	4	4	3	1	1	1
156	0	2	5	4	4	3	3	1	1	0
157	0	2	5	5	3	3	5	1	1	1
158	0	2	5	4	3	3	4	1	1	1
159	0	2	4	3	3	3	3	1	1	1
160	0	2	5	4	3	3	5	3	1	1
161		0	4	4	3	3	3	1	1	0
162	0	2	4	4	3	3	3	1	1	0

163		0	4	4	3	3	4	1	1	1
164		0	5	3	3	3	5	1	1	1
165		0	5	3	3	3	4	1	1	1
166		0	5	3	3	3	5	1	1	1
167		2	5	3	4	3	5	1	1	1
168	0	2	5	4	4	3	5	1	1	1
169	0	2	4	4	3	4	5	1	1	1
170		0	5	5	5	3	5	1	1	1
171		0	5	3	3	3	4	1	1	1
172	0	2	5	5	5	3	5	1	5	1
173	0	2	5	4	4	3	5	1	1	1
174		0	5	3	3	3	5	1	1	1
175		0	4	4	4	3	4	1	1	1
176		0	5	5	3	3	5	1	1	1
177		0	5	4	3	3	5	1	1	1
178	0	2	5	3	3	3	5	1	1	1
179		0	4	2	2	2	5	1	1	1
180	0	3	5	5	3	3	5	1	1	1
181	0	2	5	4	4	3	5	1	1	1
182	0	2	5	3	4	3	5	1	1	1
183	0	2	5	4	4	3	5	1	1	1
184	0	2	5	5	4	3	4	1	1	1
185	0	2	5	3	3	3	2	1	1	1
186	0	2	5	5	3	3	5	1	1	1
187		0	5	3	2	2	5	1	1	1
188		0	2	2	3	3	5	1	1	1
189		0	4	1	3	3	5	1	1	1
190		0	1	1	1	3	3	1	1	1

Survey No.	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20
191		0	1	1	1	3	3	1	1	1
192	0	2	4	4	4	3	5	1	1	1
193		0	5	5	4	4	5	1	1	1
194		0	5	5	5	4	5	1	1	1
195	0	3	4	4	4	4	5	1	1	1
196		0	4	2	3	3	3	1	1	1
197		0	1	2	2	2	5	1	1	1
198		0	5	4	3	3	4	1	1	1
199	0	2	5	4	3	3	5	1	1	1
200		0	5	5	5	3	5	1	1	1
201		0	5	5	4	4	5	1	1	1
202		0	2	1	1	1	3	1	1	0
203	0	2	5	2	1	3	5	1	1	1
204	0	2	5	4	4	3	5	1	1	1
205	0	2	5	5	5	3	5	1	1	1
206		0	5	4	4	3	5	1	1	1
207	0	2	5	4	2	3	5	1	1	1
208		0	5	4	1	1	1	1	1	1
209		0	4	3	3	3	4	1	1	0
210		0	4	4	3	3	2	1	1	0
211		0	1	4	3	3	3	1	1	0
212	0	3	5	4	4	4	5	1	1	1
213	0	3	5	4	4	3	5	1	1	1
214	0	3	5	4	4	4	5	3	3	1
215	0	3	5	5	4	4	5	5	5	1
216		0	5	4	4	4	4	4	4	0
217	0	2	5	1	2	3	5	1	1	1

218	0	2	5	5	5	5	4	1	1	1
219	0	2	5	5	5	5	4	1	1	0
220	0	2	5	5	5	4	5	1	1	1
221	0	2	5	5	5	5	2	1	1	1
222	0	2	5	5	5	5	5	4	5	1
223	0	3	5	5	5	4	5	4	4	1
224	0	2	5	5	2	3	5	1	5	1
225	0	3	5	5	5	3	5	1	1	1
226	0	2	4	4	3	3	3	1	1	1
227	0	2	5	5	5	3	4	1	1	1
228	0	2	5	5	4	3	4	1	1	1
229	0	3	5	5	5	3	3	1	1	1
230		0	4	3	3	3	5	1	1	1
231		0	5	5	4	4	5	1	1	1
232		0	5	5	5	4	5	1	1	1
233		0	4	3	3	3	5	1	1	1
234	0	2	5	5	5	5	5	1	1	1
235	0	2	5	4	4	4	5	1	1	1
236	0	2	4	3	3	3	5	1	1	1
237		0	5	4	4	4	5	1	1	1
238		0	5	3	3	3	5	1	1	1
Survey No.	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20
239		0	4	2	2	2	3	1	1	0
240		0	5	2	2	3	5	1	1	1

Survey No.	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26	Q 27	Q 28	Q 29	Q 30
001		2	1	1						
002	6									
003	6									
004					3	1	1			
005	4									
006	4									
007	7									
008	1									
009										
010	4									
011	1									
012					3	1	1			
013					3	1	0			
014					3	1	1			
015		2	1	1						
016		2	1	1						
017		2	1	1						
018		2	1	1						
019										
020					2	1	0			
021					2	1	1			
022		2	1	1						
023										
024										
025										

026										
027										
028		2	1	1						
029		2	1	1						
030		2	1	1						
031		2	1	1						
032										
033		2	1	1						
034		2	1	1						
035		2	1	1						
036	4									
037	6									
038										
039					2	1	1			
040		1	1	1						
041		2	1	1						
042		2	1	1						
043										
044		2	1	1						
045		2	1	1						
046		2	1	1						
Survey No.	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26	Q 27	Q 28	Q 29	Q 30
047		2	1	1						
048		2	1	1						
049		2	1	1						
050										
051		2	1	1						
052										

053										
054					2	1	1			
055		2	1	1						
056					3	1	1			
057	1									
058		2	1	1						
059		2	1	1						
060		2	1	1						
061	4									
062										
063										
064		2	1	1						
065					3	1	1			
066		2	1	1						
067	4									
068		2	1	1						
069		2	1	1						
070		2	1	1						
071		2	1	1						
072		2	1	1						
073		2	1	1						
074					3	1	1			
075		2	1	1						
076	4									
077										
078		2	1	1						
079		2	1	1						
080		2	1	1						

081										
082										
083		2	1	1						
084										
085										
086										
087		2	1	1						
088					3	1	0			
089		1	1	1						
090					3	1	1			
091		2	1	1	2	1	1			
092										
093										
094										
Survey No.	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26	Q 27	Q 28	Q 29	Q 30
095										
096	4									
097		2	1	1						
098		2	1	1						
099										
100										
101		2	1	1						
102					3	1	1			
103					3	1	0			
104		1	1	0						
105					3	1	0			
106	2									
107					3	1	0			

108	4									
109		2	1	1						
110					3	1	1			
111	4									
112										
113	4									
114	4									
115		2	1	1						
116		2	1	1						
117					3	1	0			
118					3	1	1			
119	4									
120	4									
121	4									
122					3	1	1			
123		2	1	1						
124	4									
125										
126	4									
127	6									
128		2	1	1						
129	4									
130	1				3	1	1			
131		2	1	1						
132		2	1	1						
133		2	1	1						
134		2	1	1						
135		2	1	1						

136		2	1	1						
137		2	1	1						
138		2	1	1						
139										
140		2	1	1						
141										
142		2	1	1						
Survey No.	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26	Q 27	Q 28	Q 29	Q 30
143		2	0							
144	4									
145										
146		2	1	1						
147										
148										
149	4									
150										
151	4									
152										
153										
154										
155		2	1	1						
156	4									
157										
158										
159										
160										
161	4									
162	3									

163										
164										
165		2	1	1						
166		2	1	1						
167										
168		2	1	1						
169		2	1	1						
170		2	1	1						
171		1	1	1						
172		2	1	1						
173		1	1	1						
174		2	1	1						
175		1	1	1						
176		2	1	1						
177		2	1	1						
178		2	1	1						
179		2	1	1						
180					3	1	1			
181					3	1	0			
182					3	1	1			
183					3	1	1			
184					2	1	1			
185					3	1	1			
186		2	1	1						
187					3	1	1			
188										
189		2	1	1						
190		2	1	1						

Survey No.	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26	Q 27	Q 28	Q 29	Q 30
191		1	1	1						
192		2	1	1						
193										
194		2	1	1						
195		2	1	1						
196		2	1	1						
197		2	1	1						
198					3	1	0			
199										
200		2	1	1						
201		2	1	1						
202	6									
203					3	1	1			
204										
205					2	1	1			
206										
207										
208					2	1	1			
209	4									
210	4									
211	4									
212										
213										
214										
215										
216	4									
217										

218					2	1	1			
219										
220					3	1	1			
221										
222										
223										
224					3	1	0			
225		2	1	1						
226		2	1	1						
227		2	1	1						
228										
229		2	1	1						
230		2	1	1						
231		2	1	1						
232		2	1	1						
233		2	1	1						
234										
235		2	1	1						
236										
237		2	1	1						
238		2	0							
Survey No.	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26	Q 27	Q 28	Q 29	Q 30
239	4									
240										

Survey No.	Q 31	Q 32	Q 33	Q 34	Q35	Q 36	Q 37	Q 38	Q 39	Q 40
001					1	1	1	0	1	0
002					1	1	1	0	1	0
003					1	1	1	0	1	0
004					1	1	1	1	1	1
005					1	1	1	0	1	0
006					1	1	1	0	1	0
007					1	1	1	0	1	0
008					1	1	1	0	1	0
009				6	1	1	1	0	1	0
010					1	1	1	0	1	0
011					1	1	2	0	1	0
012					1	1	2	1	1	1
013					1	1	2	1	1	1
014					0			1	1	1
015					1	1	2	0	0	0
016					1	1	1	0	1	0
017					1	1	1	0	1	0
018					1	1	1	0	1	0
019				8	1	1	1	0	1	0
020					1	1	2	0	1	1
021					1	1	2	1	1	1
022					1	1	2	1	1	0
023				8	1	1	2	1	1	1
024				8	1	1	1	0	1	0
025				8	1	1	1	0	1	0
026				8	1	1	2	0	1	0

027				8	1	1	2	1	1	1
028					1	1	1	0	0	0
029					1	1	1	0	1	0
030					1	1	2	0	1	0
031					1	1	2	0	1	0
032				8	1	1	2	0	1	0
033					1	1	1	0	1	0
034					1	1	1	0	1	0
035					1	1	2	0	1	0
036					1	1	2	0	1	0
037					0	1	2	0	1	0
038				1	1	1	0	0	1	0
039					1	1	2	1	1	1
040					1	1	1	0	1	0
041					1	1	2	0	1	0
042					1	1	2	0	1	0
043	1	3	2		1	1	2	0	1	0
044					1	1	2	0	0	1
045					1	1	1	0	1	0
046					1	1	2	0	1	0
047					1	1	2	0	1	0
Survey No.	Q 31	Q 32	Q 33	Q 34	Q35	Q 36	Q 37	Q 38	Q 39	Q 40
048					1	1	2	0	1	0
049					1	1	2	0	1	0
050				4	1	1	2	0	1	0
051					1	1	1	0	1	0
052	1	2	2		1	0	2	0	1	0

053				5	1	1	2	1	1	1
054					1	1	2	1	1	1
055					1	1	1	0	1	0
056					1	1	2	1	1	1
057					1	1	1	0	1	0
058					1	1	2	0	1	0
059					1	1	2	0	1	0
060					1	1	2	0	1	0
061					1	1	1	0	1	0
062	1	2	2		1	1	2	0	1	0
063	1	2	2	6	1	1	2	0	1	0
064					1	1	2	0	1	0
065					1	1	2	1	1	1
066					1	1	1	0	1	0
067					1	1	1	0	1	0
068					1	1	1	0	1	0
069					1	1	1	0	1	0
070					1	1	2	0	1	0
071					1	1	1	0	1	0
072					1	1	1	0	1	0
073					1	1	2	0	1	0
074					1	1	2	1	1	1
075					1	1	1	0	1	0
076					1	1	2	0	1	0
077				8	1	1	2	0	1	0
078					1	1	2	0	0	0
079					1	1	2	0	1	0
080					1	1	22	0	1	0

081				8	1	1	2	1	1	1
082	1	2	2		1	1	2	0	1	0
083					1	1	2	0	1	0
084				8	1	1	2	0	1	1
085	1	2	2		1	1	2	0	0	0
086				7	1	1	1	0	1	0
087					1	1	1	1	1	1
088					1	1	2	1	1	1
089					1	1	1	0	1	0
090					1	1	2	1	1	1
091					1	1	2	1	1	1
092				8	1	1	2	0	1	0
093	1	2	2	6	1	1	2	0	1	0
094	1	2	2		1	1	2	0	1	0
095	1	2	2	6	1	1	1	0	1	0
Survey No.	Q 31	Q 32	Q 33	Q 34	Q35	Q 36	Q 37	Q 38	Q 39	Q 40
097					1	1	1	0	1	0
098					1	1	1	1	1	1
099				1	1	1	2	0	1	0
100				1	1	1	2	1	1	1
101					1	1	2	1	1	0
102					1	1	2	1	1	1
103					1	1	2	1	1	1
104					1	1	1	0	1	0
105					1	1	2	1	1	1
106					1	1	2	0	1	0
107					1	1	2	1	1	1

108					1	1	2	1	1	1
109					1	1	1	0	1	0
110					1	1	2	1	1	1
111					1	1	1	0	1	0
112	1	2	2	6	1	1	1	0	1	0
113					0	1	1	0	1	0
114					1	1	1	0	1	0
115					1	1	2	0	1	0
116					1	1	1	0	1	0
117					1	1	2	1	1	1
118					1	1	2	1	1	1
119					1	1	2	0	1	0
120					1	1	2	0	1	0
121					1	1	1	0	1	0
122					1	1	2	1	1	1
123					1	1	2	1	1	1
124					1	1	1	0	1	0
125					1	1	2	0	1	0
126					1	1	2	0	1	0
127					1	1	2	1	1	1
128					1	1	2	1	1	1
129					1	1	1	0	1	0
130					1	1	2	1	1	1
131					1	1	1	0	1	0
132					1	1	1	0	0	0
133					1	1	1	0	1	0
134					1	1	2	0	1	0
135					1	1	2	0	1	0

136					1	1	2	0	1	0
137					1	1	1	0	1	0
138					1	1	1	0	1	0
139				8	1	1	2	1	1	1
140					1	1	1	0	1	0
141				8	1	1	2	0	1	0
142					1	1	2	0	1	0
143					1	1	1	0	0	0
144					1	1	1	0	1	0
Survey No.	Q 31	Q 32	Q 33	Q 34	Q35	Q 36	Q 37	Q 38	Q 39	Q 40
145	1	1	2	6	1	1	2	0	1	0
146					1	1	2	1	1	1
147	1	2	2		1	1	1	0	1	0
148	1	2	2		1	1	1	0	1	0
149					1	1	1	0	1	0
150	1	3	2		1	1	1	0	1	0
151					1	1	1	0	1	0
152	1	1	2		1	1	2	0	1	0
153	1	2	2		1	1	2	0	1	0
154										
155					1	1	2	0	1	0
156					1	1	2	1	1	1
157	1	2	2	6	1	1	2	0	1	0
158	1	2	2		1	1	1	0	1	0
159	1	1	2		1	1	2	0	1	0
160				4	1	1	2	0	1	0
161					1	1	1	0	1	0

162					1	1	1	0	1	0
163	1	2	2		1	1	2	0	1	0
164	1	2	2		1	1	2	1	1	1
165					1	1	2	1	1	1
166					1	1	1	0	1	0
167				4	1	1	2	0	1	0
168					1	1	1	0	1	0
169					1	1	1	0	1	0
170					1	1	2	0	1	0
171					1	1	1	0	1	0
172					1	1	1	1	1	1
173					1	1	2	0	1	0
174					1	1	1	0	1	0
175					1	1	1	0	1	0
176					1	1	1	0	1	0
177					1	1	1	0	1	0
178					1	1	2	0	1	0
179					1	1	1	0	1	0
180					1	1	2	1	1	1
181					1	1	2	1	1	1
182					1	1	2	1	1	1
183					1	1	2	1	1	1
184					1	1	2	0	1	0
185					1	1	2	1	1	1
186					1	1	1	0	1	0
187					1	1	2	1	1	1
188				8	1	1	1	0	1	0
189					1	1	1	0	1	0

190					0	1	1	0	1	0
191					1	1	1	0	1	0
192					1	1	2	0	1	0
193	1	2	2		1	1	1	0	1	0
Survey No.	Q 31	Q 32	Q 33	Q 34	Q35	Q 36	Q 37	Q 38	Q 39	Q 40
194					1	1	2	1	1	1
195					1	1	2	1	1	1
196					1	1	2	0	1	0
197					1	1	2	0	1	0
198					1	1	1	0	1	0
199				8	1	1	2	1	1	1
200					1	1	2	0	1	0
201					1	1	2	0	1	0
202					1	1	1	0	1	0
203					1	1	2	0	1	1
204				4	1	1	2	0	1	0
205					1	1	2	0	1	0
206				8	1	1	2	0	1	0
207				8	1	1	1	0	1	0
208					1	1	2	1	1	1
209					1	1	1	0	1	0
210					1	1	1	0	1	0
211					1	1	1	0	1	0
212				4	1	1	1	0	1	0
213				4	1	1	2	0	1	0
214					1	1	2	0	1	0
215				4	1	1	2	0	1	0
216					1	1	2	0	1	0

217				8	1	1	2	1	1	1
218					1	1	2	1	1	0
219					1	1	2	1	1	1
220					1	1	1	0	1	0
221				4	1	1	1	0	1	0
222				4	1	1	2	0	1	0
223				4	1	1	2	1	1	1
224					1	1	1	0	0	0
225					1	1	1	0	1	0
226					1	1	2	0	1	0
227					1	1	2	0	1	0
228				8	1	1	2	0	1	0
229					1	1	1	0	1	0
230					1	1	2	0	1	0
231					1	1	2	0	1	0
232					1	1	1	0	1	0
233					1	1	1	0	1	0
234				8	1	1	2	1	1	1
235					1	1	1	0	1	0
236				8	1	1	2	0	1	0
237					1	1	2	0	1	0
238					1	1	1	0	0	0
239					1	1	1	0	1	0
240	1	1	2	6	1	1	2	0	1	0

Survey No.	Q 41	Q 42 A	Q 42 B	Q 43	Q 44	Q 45	Q 46	Q 47	Q 48	Q 49	Q 50
001	1	7	9	2	1	1	48	11	1	1	1
002	1	7	9	2	1	2	60	10	0	0	
003	1	7	9	2	1	2	46	5	0	0	
004	1	7	9	1	1	2	24	7	0	0	
005	1	7	9	1	1	2	32	9	3	0	2
006	1	7	9	2	1	3	40	6	0	0	1
007	1	7	9	1	1	3	19	5	0	2	2
008	1	7	9	2	1	3	20	6	0	0	1
009	1	7	9	1	1	3	45	8	3	1	2
010	1	7	9	2	1	3	35	7	0	0	1
011	1	7	9	2	1	4	35	6	2	0	1
012	1	7	9	2	1	4	35	4	0	0	1
013	1	7	9	2	1	4	54	2	0	0	
014	1	7	9	1	1	4	35	4	0	0	2
015	1	7	9	1	1	5	20	4	0	1	2
016	1	7	9	2	1	5	40	14	2	1	1
017	1	7	9	2	1	5	12	7	1	0	5
018	1	7	9	2	1	6	23	6	1	0	1
019	1	7	9	2	1	6	50	2	0	0	
020	1	7	9	1	1	6	60	4	0	1	6
021	1	7	9	2	1	6	45	8	0	0	
022	1	7	9	2	1	6	30	1	0	1	1
023	1	7	9	2	1	7	44	6	0	0	
024	1	7	9	2	1	7	27	9	0	1	1
025	1	7	9	2	1	7	42	5	0	0	

026	1	7	9	1	1	7	40	5	0	0	2
027	1	7	9	2	1	7	35	4	1	0	1
028	1	7	9	2	1	4	36	5	1	0	1
029	1	7	9	2	1	4	35	4	0	0	1
030	1	7	9	2	1	4	42	4	0	0	1
031	1	7	9	2	1	4	50	4	0	0	1
032	1	7	9	2	1	4	33	6	0	1	1
033	1	7	9	2	1	4	40	5	0	0	1
034	1	7	9	2	1	4	32	4	0	0	
035	1	7	9	1	1	4	29	3	0	0	
036	1	7	9	1	1	8	32	4	1	0	2
037	1	7	9	1	1	8	42	4	0	0	
038	1	7	9	1	1	8	55	12	0	2	2
039	1	7	9	1	1	8	50	5	0	0	
040	1	7	9	2	1	8	29	4	0	0	
041	1	7	9	2	1	4	28	9	0	1	1
042	1	7	9	1	1	4	60	2	0	0	
043	1	7	9	2	1	4	34	4	1	1	1
044	1	7	9	2	1	4	40	5	0	0	1
045	1	7	9	2	1	4	46	8	0	1	`
Survey No.	Q 41	Q 42 A	Q 42 B	Q 43	Q 44	Q 45	Q 46	Q 47	Q 48	Q 49	Q 50
046	1	7	9	2	1	4	40	4	0	0	1
047	1	7	9	2	1	9	38	2	0	0	
048	1	7	9	2	1	9	27	5	2	1	1
049	1	7	9	2	1	9	42	6	0	0	
050	1	7	9	1	1	9	32	4	0	1	2
051	1	7	9	2	1	9	18	5	0	0	
052	1	7	9	2	1	9	23	4	0	0	

053	1	7	9	2	1	9	36	5	1	0	1
054	1	7	9	1	1	9	62	6	0	2	2
055	1	7	9	2	1	9	20	6	0	0	
056	1	7	9	2	1	9	7	0	0		1
057	1	7	9	2	1	9	25	7	1	0	1
058	1	7	9	2	1	9	32	6	1	0	1
059	1	7	9	2	1	9	30	5	1	0	1
060	1	7	9	2	1	9	35	6	0	0	
061	1	7	9	1	1	9	5	0	0	0	
062	1	7	9	1	1	9	21	5	0	1	2
063	1	7	9	2	1	9	38	5	0	0	
064	1	7	9	1	1	4	45	5	0	0	
065	1	7	9	2	1	10	19	5	0	0	3
066	1	7	9	2	1	10	4	0	0	1	1
067	1	7	9	2	1	10	21	6	0	1	1
068	1	7	9	2	1	10	55	3	0	0	1
069	1	7	9	2	1	10	18	6	0	0	3
070	1	7	9	1	1	10	15	7	0	1	3
071	1	7	9	2	1	10	60	6	1	0	1
072	1	7	9	2	1	10	25	8	0	1	1
073	1	7	9	2	1	10	19	8	0	1	3
074	1	7	9	2	1	10	24	8	1	2	1
075	1	7	9	2	1	10	25	7	0	0	1
076	1	7	9	1	1	10	42	5	0	0	2
077	1	7	9	2	1	10	33	5	1	0	1
078	1	7	9	2	1	10	45	8	2	0	1
079	1	7	9	2	1	4	44	4	0	0	
080	1	7	9	1	1	4	29	2	0	0	

081	1	7	9	1	1	11	31	4	0	0	2
082	1	7	9	2	1	11	40	5	0	0	1
083	1	7	9	2	1	11	40	5	0	0	
084	1	7	9	2	1	11	32	3	0	0	1
085	1	7	9	2	1	11	34	5	0	0	1
086	1	7	9	1	1	11	22	2	0	0	
087	1	7	9	2	1	11	45	4	0	0	1
088	1	7	9	1	1	11	48	6	0	0	
089	1	7	9	1	1	11	60	10	0	0	
090	1	7	9	2	1	11	50	2	0	0	
091	1	7	9	2	1	11	24	5	0	1	1
092	1	7	9	1	1	4	68	3	0	0	2
Survey No.	Q 41	Q 42 A	Q 42 B	Q 43	Q 44	Q 45	Q 46	Q 47	Q 48	Q 49	Q 50
093	1	7	9	2	1	4	38	1	0	0	1
094	1	7	9	2	1	4	24	2	0	0	
095	1	7	9	2	1	4	27	5	1	0	1
096	1	7	9	1	1	4	39	6	1	0	2
097	1	7	9	1	1	4	25	21	2	1	2
098	1	7	9	2	1	4	35	6	1	1	1
099	1	7	9	2	1	4	32	5	0	0	1
100	1	7	9	1	1	4	33	6	0	1	2
101	1	7	9	2	1	4	24	5	1	0	1
102	1	8	9	2	1	12	30	12	3	1	1
103	1	8	9	2	1	12	29	4	0	0	1
104	1	8	9	2	1	12	25	5	2	0	1
105	1	8	9	2	1	12	30	8	0	1	1
106	1	8	9	2	1	12	35	6	0	0	1
107	1	8	9	1	1	12	32	4	1	0	2

108	1	8	9	2	1	12	40	7	0	0	1
109	1	8	9	2	1	12	35	8	0	1	1
110	1	8	9	2	1	12	30	5	0	0	1
111	1	8	9	2	1	12	36	6	0	0	1
112	1	8	9	2	1	12	30	6	0	1	1
113	1	8	9	1	1	12	24	6	0	0	3
114	1	8	9	2	1	12	20	5	1	1	1
115	1	8	9	2	1	12	54	6	0	0	1
116	1	8	9	2	1	12	30	6	2	0	1
117	1	8	9	2	1	12	48	7	0	1	1
118	1	8	9	2	1	12	24	7	0	1	1
119	1	8	9	1	1	12	19	5	0	0	3
120	1	8	9	1	1	12	23	7	0	1	2
121	1	8	9	1	1	12	30	4	2	0	2
122	1	8	9	2	1	12	29	6	0	1	1
123	1	8	9	2	1	13	27	4	2	0	1
124	1	8	9	2	1	13	51	3	0	0	1
125	1	8	9	1	1	13	60	7	2	0	2
126	1	8	9	2	1	13	45	3	0	0	1
127	1	8	9	2	1	13	50	3	0	0	1
128	1	8	9	2	1	13	55	7	0	1	1
129	1	8	9	2	1	13	30	5	0	1	1
130	1	8	9	1	1	13	26	8	1	1	2
131	1	8	9	2	1	12	30	6	0	0	1
132	1	8	9	2	1	12	21	3	1	0	1
133	1	8	9	2	1	13	17	8	1	1	1
134	1	8	9	1	1	13	45	5	0	1	2
135	1	8	9	2	1	13	21	3	0	1	1

136	1	8	9	2	1	13	35	7	2	1	1
137	1	8	9	2	1	13	24	5	2	0	1
138	1	8	9	2	1	13	30	4	1	0	1
139	1	8	9	2	1	13	24	8	2	0	1
Survey No.	Q 41	Q 42 A	Q 42 B	Q 43	Q 44	Q 45	Q 46	Q 47	Q 48	Q 49	Q 50
140	1	8	9	2	1	13	25	4	1	1	1
141	1	8	9	2	1	13	18	7	0	0	3
142	1	8	9	2	1	13	14	7	0	0	3
143	1	8	9	2	1	13	18	7	0	1	3
144	1	8	9	1	1	13	28	5	2	0	2
145	1	8	9	2	1	13	18	19	0	2	1
146	1	8	9	1	1	13	32	7	1	1	2
147	1	8	9	2	1	13	19	5	0	0	5
148	1	8	9	2	1	13	16	3	0	0	3
149	1	8	9	2	1	13	52	4	0	0	1
150	1	8	9	1	1	13	45	14	3	2	2
151	1	8	9	2	1	13	40	4	0	0	1
152	1	8	9	2	1	13	24	8	2	0	1
153	1	8	9	2	1	13	17	6	0	0	3
154											
155	1	8	9	2	1	13	26	4	0	0	1
156	1	8	9	2	1	13	45	4	0	0	1
157	1	8	9	2	1	13	40	5	0	0	1
158	1	8	9	2	1	13	55	7	1	1	1
159	1	8	9	2	1	13	34	5	0	0	1
160	1	8	9	2	1	13	30	5	0	1	1
161	1	8	9	2	1	14	18	6	0	1	3
162	1	8	9	2	1	14	15	5	0	0	3

163	1	8	9	2	1	14	27	24	0	1	1
164	1	8	9	2	1	14	35	5	0	0	1
165	1	8	9	2	1	14	30	4	0	0	1
166	1	8	9	2	1	14	40	4	0	1	1
167	1	8	9	2	1	14	45	11	0	0	1
168	1	8	9	2	1	13	35	8	1	0	1
169	1	8	9	1	1	13	21	5	0	0	3
170	1	8	9	2	1	13	35	2	0	0	1
171	1	8	9	2	1	13	26	3	1	0	1
172	1	8	9	2	1	13	28	8	0	0	1
173	1	8	9	2	1	13	35	7	0	1	1
174	1	8	9	2	1	13	26	8	1	0	1
175	1	8	9	2	1	13	60	3	0	0	1
176	1	8	9	2	1	13	40	4	0	1	1
177	1	8	9	2	1	13	30	6	0	0	1
178	1	8	9	1	1	13	35	5	0	0	2
179	1	8	9	2	1	13	35	20	0	1	1
180	1	8	9	1	1	13	22	4	1	0	2
181	1	8	9	1	1	13	40	4	0	0	2
182	1	8	9	2	1	13	45	4	0	0	1
183	1	8	9	2	1	13	42	6	0	0	1
184	1	8	9	1	1	13	50	4	0	0	2
185	1	8	9	1	1	13	40	5	0	0	2
186	1	8	9	2	1	13	18	9	0	0	3
Survey No.	Q 41	Q 42 A	Q 42 B	Q 43	Q 44	Q 45	Q 46	Q 47	Q 48	Q 49	Q 50
187	1	8	9	2	1	13	26	5	0	0	1
188	1	8	9	2	1	13	33	6	0	0	1
189	1	8	9	2	1	13	30	6	0	1	1

190	1	8	9	1	1	13	27	6	0	0	3
191	1	8	9	2	1	13	25	5	1	1	1
192	1	8	9	2	1	13	45	6	0	0	1
193	1	8	9	2	1	13	33	6	2	0	1
194	1	8	9	2	1	13	49	7	0	1	1
195	1	8	9	2	1	13	27	7	0	1	1
196	1	8	9	1	1	13	21	5	0	0	3
197	1	8	9	1	1	13	25	7	0	1	2
198	1	8	9	1	1	13	30	4	2	0	2
199	1	8	9	2	1	13	29	6	0	1	1
200	1	8	9	2	1	15	35	2	0	0	1
201	1	8	9	2	1	15	45	5	0	0	1
202	1	8	9	2	1	15	35	4	0	0	1
203	1	8	9	1	1	15	25	15	2	0	2
204	1	8	9	2	1	15	53	8	0	1	6
205	1	8	9	2	1	15	32	10	0	2	1
206	1	8	9	2	1	15	28	10	1	1	1
207	1	8	9	1	1	15	37	7	1	0	2
208	1	8	9	1	1	16	32	9	0	1	2
209	1	8	9	2	1	16					
210	1	8	9	1	1	16	27	3	0	0	
211	1	8	9	2	1	16	45	5	0	0	1
212	1	8	9	2	1	16	38	4	0	0	1
213	1	8	9	2	1	16	40	6	0	0	1
214	1	8	9	2	1	16	55	5	0	1	6
215	1	8	9	1	1	16	30	5	0	0	
216	1	8	9	2	1	16	52	5	0	0	
217	1	7	9	2	1	16	45	8	0	0	

218	1	7	9	2	1	16	30	1	0	1	1
219	1	7	9	2	1	16	44	6	0	0	
220	1	7	9	2	1	16	27	9	0	1	1
221	1	7	9	2	1	16	42	5	0	0	
222	1	7	9	1	1	16	40	5	0	0	2
223	1	7	9	2	1	16	35	4	1	0	1
224	1	7	9	2	1	16	36	5	1	0	1
225	1	7	9	2	1	16	35	4	0	0	1
226	1	7	9	2	1	16	42	4	0	0	1
227	1	7	9	2	1	16	50	4	0	0	1
228	1	7	9	2	1	16	33	6	0	1	1
229	1	7	9	2	1	16	40	5	0	0	1
230	1	8	9	2	1	16	21	3	0	1	1
231	1	8	9	2	1	16	35	7	2	1	1
232	1	8	9	2	1	16	24	5	2	0	1
233	1	8	9	2	1	16	30	4	1	0	1
Survey No.	Q 41	Q 42 A	Q 42 B	Q 43	Q 44	Q 45	Q 46	Q 47	Q 48	Q 49	Q 50
234	1	8	9	2	1	16	24	8	2	0	1
235	1	8	9	2	1	16	25	4	1	1	1
236	1	8	9	2	1	16	18	7	0	0	3
237	1	8	9	2	1	16	14	7	0	0	3
238	1	8	9	2	1	16	18	7	0	1	3
239	1	8	9	1	1	16	28	5	2	0	2
240	1	8	9	2	1	16	18	19	0	2	1

Survey No.	Q 51	Q 52	Q 53	Q 54	Q 55	Q 56
001	1	2	10	3	1	7000
002	0	0	9	3	1	11000
003	1	4	5	4	2	16000
004	1	3	7	4	2	20000
005	1	1	5	2	1	6000
006	0	0	5	3	3	2500
007	1	1	2	1	3	2000
008	1	1	4	1	1	2500
009	1	4	8	4	3	7000
010	1	2	7	2	1	2000
011	1	3	6	3	1	12500
012	1	2	4	2	1	10000
013	0	0	1	3	2	15000
014	1	4	4	4	3	15000
015	1	1	1	1	3	2000
016	0	0	0	0	3	4500
017	1	1	3	1	1	5000
018	1	1	5	1	3	4500
019	1	4	2	4	2	15000
020	1	3	3	3	2	20000
021	1	2	8	4	2	10000
022	1	4	3	4	3	15000
023	1	4	5	4	2	45000
024	1	4	8	4	2	45000
025	1	4	5	4	2	35000

026	1	4	5	4	2	35000
027	1	4	4	4	2	30000
028	1	4	5	4	3	4000
029	1	1	4	3	3	6000
030	1	2	4	3	2	20000
031	1	3	4	4	2	30000
032	1	4	5	4	2	15000
033	1	2	5	3	2	20000
034	1	3	4	4	1	5000
035	1	3	2	3	1	20000
036	1	2	3	2	1	2000
037	1	1	2	1	3	2500
038	1	2	8	2	0	8000
039	1	3	4	3	2	15000
040	1	2	4	2	3	3000
041	1	3	8	3	3	40000
042	1	2	2	2	1	5000
043	1	3	3	4	3	18000
044	0	0	4	4	1	4000
045	0	0	6	3	2	8000
Survey No.	Q 51	Q 52	Q 53	Q 54	Q 55	Q 56
046	1	1	4	2	1	2500
047	1	3	2	3	3	2000
048	1	3	2	3	3	5000
049	0	0	3	3	1	2000
050	1	3	3	4	3	20000
051	1	2	5	3	3	5000
052	1	4	4	4	1	5000

053	1	3	4	3	2	12000
054	1	2	4	3	3	6000
055	1	3	3	3	1	3000
056	1	4	7	4	3	10000
057	1	2	6	3	3	4000
058	1	1	5	2	1	2000
059	1	3	4	3	2	18000
060	1	2	4	4	3	7000
061	0	0	4	3	3	5000
062	1	3	4	3	2	11000
063	1	2	5	3	0	0
064	1	2	5	2	3	4000
065	1	3	5	4	2	30000
066	1	1	3	2	3	3000
067	1	4	5	4	2	15000
068	0	0	1	2	1	2000
069	1	3	3	3	1	1800
070	1	2	3	2	2	3000
071	0	0	4	1	1	2500
072	1	2	7	2	1	3000
073	1	2	7	4	2	8000
074	1	1	6	4	3	8000
075	1	1	7	2	1	4000
076	1	4	5	4	3	23000
077	1	2	5	4	3	15000
078	0	0	4	2	2	10000
079	1	1	4	3	2	15000
080	1	2	2	2	1	8000

081	1	3	4	3	1	10000
082	0	0	4	3	2	10000
083	0	0	1	1	1	2000
084	1	3	3	3	2	7000
085	1	3	5	4	2	10000
086	1	4	2	4	0	0
087	0	0	3	3	3	2000
088	1	1	6	3	3	3500
089	1	2	10	2	1	5000
090	1	3	2	4	3	15000
091	1	3	3	3	3	5000
092	1	4	3	4	1	5000
Survey No.	Q 51	Q 52	Q 53	Q 54	Q 55	Q 56
093	1	2	3	4	1	4000
094	1	2	2	2	1	3000
095	1	1	4	2	1	3000
096	0	0	4	1	3	3000
097	0	0	7	2	1	8000
098	1	1	4	1	3	3000
099	1	1	5	2	1	10000
100	1	2	4	2	1	5000
101	1	2	3	2	1	6000
102	1	3	7	4	1	40000
103	1	3	3	3	2	4000
104	1	1	3	2	3	2000
105	1	1	6	3	1	4000
106	0	0	5	3	1	8000
107	1	2	3	2	1	2500

108	1	1	4	3	1	2000
109	0	0	4	1	3	3000
110	1	3	5	3	3	3500
111	1	1	6	2	1	1500
112	1	2	4	3	3	3000
113	1	3	6	4	2	30000
114	0	0	3	2	3	2000
115	1	3	6	4	3	5000
116	1	2	3	2	1	3000
117	0	0	5	2	1	2250
118	1	3	6	3	2	6000
119	1	2	4	2	2	5000
120	1	3	5	3	2	10000
121	1	4	2	4	0	0
122	1	3	5	3	3	3500
123	1	2	2	2	3	4500
124	0	0	2	2	1	3000
125	1	1	5	3	2	10000
126	0	0	2	2	1	3000
127	0	0	0	0	1	3000
128	1	1	6	3	2	20000
129	0	0	0	0	1	2000
130	0	0	1	2	1	3000
131	0	0	3	2	1	2500
132	1	2	2	3	1	2500
133	1	2	6	2	3	4000
134	1	1	2	1	3	2000
135	1	2	2	2	3	3000

136	0	0	3	1	1	2000
137	1	1	2	1	1	2000
138	0	0	2	2	1	2000
139	1	2	6	2	2	20000
Survey No.	Q 51	Q 52	Q 53	Q 54	Q 55	Q 56
140	1	3	2	3	2	10000
141	1	1	7	3	1	20000
142	1	2	6	2	3	6000
143	1	2	6	2	3	4000
144	0	0	1	1	3	3000
145	1	3	19	3	2	10000
146	0	0	2	2	3	2000
147	1	1	5	2	1	4000
148	1	3	1	3	3	3000
149	1	2	4	2	2	6000
150	1	2	14	3	3	10000
151	0	0	2	2	1	3000
152	0	0	4	2	1	4000
153	1	2	4	2	1	50000
154						
155	1	2	4	2	1	2500
156	1	1	3	1	3	6000
157	0	0	4	3	2	4000
158	1	1	5	4	3	8000
159	1	2	5	3	2	4000
160	1	2	4	2	1	5000
161	1	1	4	1	2	5000
162	1	2	4	2	3	5000

163	1	2	20	2	1	4500
164	1	2	5	2	1	3000
165	1	2	4	3	1	4000
166	1	2	3	2	3	3000
167	1	2	11	3	2	17000
168	0	0	5	2	2	5000
169	1	2	5	4	1	6000
170	1	1	2	1	2	1500
171	0	0	1	2	1	3000
172	1	1	8	3	3	4000
173	0	0	5	1	1	3000
174	0	0	5	1	3	3000
175	0	0	1	2	1	2000
176	0	0	0	0	1	4000
177	0	0	4	1	3	5000
178	1	1	4	1	1	3500
179	0	0	8	2	1	8000
180	1	2	3	2	1	4000
181	1	4	4	4	1	10000
182	1	4	4	4	2	7000
183	1	3	6	4	2	5000
184	1	3	4	3	2	18000
185	1	3	5	3	1	5000
186	1	2	4	3	1	3000
Survey No.	Q 51	Q 52	Q 53	Q 54	Q 55	Q 56
187	1	3	5	3	3	4500
188	1	1	6	2	1	2500
189	1	2	4	3	3	3000

190	1	3	6	4	2	10000
191	0	0	3	2	3	2500
192	1	3	6	4	3	4000
193	1	2	3	2	1	3000
194	0	0	5	2	1	2500
195	1	3	6	3	2	7000
196	1	2	4	2	2	6000
197	1	3	5	3	2	7000
198	1	4	2	4	1	4000
199	1	3	5	3	3	6000
200	1	1	2	1	2	1500
201	1	3	5	3	1	8000
202	1	2	4	3	2	5000
203	0	0	10	3	1	5000
204	1	2	7	4	1	10000
205	1	2	7	2	1	5000
206	1	3	6	4	1	6000
207	1	3	6	3	3	10000
208	1	4	8	4	1	36000
209						
210	1	4	3	4	2	10000
211	0	0	4	4	2	12000
212	1	3	4	3	3	15000
213	1	4	6	4	3	40000
214	1	3	4	4	2	32000
215	1	4	4	4	2	80000
216	1	4	5	4	6	35000
217	1	2	8	4	2	10000

218	1	4	3	4	3	15000
219	1	4	5	4	2	45000
220	1	4	8	4	2	45000
221	1	4	5	4	2	35000
222	1	4	5	4	2	35000
223	1	4	4	4	2	30000
224	1	4	5	4	3	4000
225	1	1	4	3	3	6000
226	1	2	4	3	2	20000
227	1	3	4	4	2	30000
228	1	4	5	4	2	15000
229	1	2	5	3	2	20000
230	1	2	2	2	3	3000
231	0	0	3	1	1	2000
232	1	1	2	1	1	2000
233	0	0	2	2	1	2000
Survey No.	Q 51	Q 52	Q 53	Q 54	Q 55	Q 56
234	1	2	6	2	2	20000
235	1	3	2	3	2	10000
236	1	1	7	3	1	20000
237	1	2	6	2	3	6000
238	1	2	6	2	3	4000
239	0	0	1	1	3	3000
240	1	3	19	3	2	10000

ANNEX V: Water Quality Test Results from Lucknow

Survey Number	Water Quality Test Done (Y/N)	Colilert test tube (yellow or colourless)	e-coli (present/ absent)	No. of blue colonies	No. of red colonies	Total no. of colonies
001	Yes	Yellow	Absent	1	17	18
001 Source	Yes	Yellow	Present	8	31	39
002	Yes	Yellow	Absent	0	13	13
003	Yes	Yellow	Absent	0	7	7
004	Yes	Colorless	Absent	0	1	1
004 Source	Yes	Yellow	Present	4	15	19
005	Yes	Yellow	Present	3	26	29
006	Yes	Yellow	Present	4	32	36
007	Yes	Yellow	Present	8	57	65
008	Yes	Yellow	Present	35	27	62
009	Yes	Colorless	Absent	0	43	43
010	Yes	Yellow	Present	2	63	65
010, Source (home)	Yes	Yellow	Absent	0	2	2
010, Source (Main)	Yes	Colorless	Absent	0	0	0
011	Yes	Yellow	Present	47	33	80
012	Yes	Colorless	Absent	0	8	8
013 (Expired Purit)	Yes	Yellow	Present	13	43	56
013, Source	Yes	Yellow	Present	37	41	78

014	Yes	Colorless	Absent	0	4	4
015	Yes	Yellow	Present	7	15	22
016	Yes	Yellow	Absent	0	7	7
017	Yes	Yellow	Present	5	29	34
SOURCE	Yes	Yellow	Absent	0	2	2
018	Yes	Colorless	Absent	0	6	6
019	Yes	Yellow	Present	4	33	37
Survey Number	**Water Quality Test Done (Y/N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present/ absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**
020	Yes	Yellow	Absent	0	17	17
021	Yes	Yellow	Absent	0	5	5
022	Yes	Colorless	Absent	0	1	1
023	Yes	Yellow	Absent	0	23	23
024	Yes	Yellow	Absent	0	31	31
025	Yes	Yellow	Present	0	8	8
025, Source	Yes	Yellow	Present	5	27	32
026	Yes	Yellow	Absent	0	8	8
027	Yes	Colorless	Absent	0	2	2
028	Yes	Colorless	Absent	0	1	1
029	Yes	Colorless	Absent	0	0	0
030	Yes	Colorless	Absent	0	0	0
031	Yes	Colorless	Absent	0	0	0
032, Source	Yes	Yellow	Present	2	65	67
032	Yes	Yellow	Absent	0	28	28
033	Yes	Colorless	Absent	0	0	0
034	Yes	Yellow	Absent	0	4	4

035	Yes	Yellow	Absent	0	1	1
036	Yes	Yellow	Present	1	6	7
037	Yes	Yellow	Absent	0	3	3
038	Yes	Colorless	Absent	0	0	0
039	Yes	Yellow	Absent	0	44	44
040	Yes	Colorless	Absent	0	0	0
041	Yes	Colorless	Absent	0	0	0
042	Yes	Colorless	Absent	0	0	0
043	Yes	Yellow	Absent	0	2	2
044	Yes	Yellow	Absent	0	9	9
045	Yes	Yellow	Absent	0	7	7
046	Yes	Yellow	Absent	0	15	15
047, Source	Yes	Yellow	Present	5	102	107
Survey Number	**Water Quality Test Done (Y/N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present/ absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**
047	Yes	Yellow	Absent	0	7	7
048	Yes	Yellow	Absent	0	100	100
049	Yes	Yellow	Absent	0	2	2
050, Source	Yes	Yellow	Absent	0	440	440
050	Yes	Yellow	Absent	0	400	400
051	Yes	Yellow	Absent	0	63	63
052	Yes	Colorless	Absent	0	0	0
053	Yes	Yellow	Absent	0	3	3
054	Yes	Yellow	Absent	0	6	6
055	Yes	Yellow	Absent	0	15	15
056	Yes	Colorless	Absent	0	0	0

057	Yes	Yellow	Present	1	3	4
058, Source	Yes	Colorless	Absent	0	0	0
058	Yes	Colorless	Absent	0	0	0
059	Yes	Colorless	Absent	0	0	0
060	Yes	Colorless	Absent	0	0	0
061	Yes	Yellow	Present	2	28	30
062	Yes	Colorless	Absent	0	1	1
063, Source	Yes	Yellow	Present	10	100	110
063	Yes	Yellow	Present	3	15	18
064, Source	Yes	Yellow	Present	80	156	236
064	Yes	Yellow	Present	3	29	32
065	Yes	Yellow	Present	3	7	10
066	Yes	Colorless	Absent	0	0	0
067	Yes	Yellow	Present	4	9	13
068	Yes	Yellow	Absent	0	2	2
069 WHITE FLOATING MATTER IN COLILERT	Yes	Yellow	Absent	0	1	1
Survey Number	**Water Quality Test Done (Y/N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present/ absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**
070	Yes	Colorless	Absent	0	0	0
071	Yes	Colorless	Absent	0	0	0
072	Yes	Yellow	Absent	0	4	4
073	Yes	Colorless	Absent	0	0	0
074	Yes	Colorless	Absent	0	0	0
075,	Yes	Yellow	Present	1	6	7

Source						
075	Yes	Colorless	Absent	0	0	0
076	Yes	Yellow	Absent	0	80	80
077	Yes	Colorless	Absent	0	0	0
078, Source	Yes	Yellow	Absent	0	15	15
078	Yes	Yellow	Absent	0	4	4
079	Yes	Colorless	Absent	0	0	0
080	Yes	Colorless	Absent	0	0	0
081	Yes	Yellow	Present	0	180	180
082	Yes	Colorless	Absent	0	0	0
083	Yes	Colorless	Absent	0	0	0
084	Yes	Yellow	Absent	0	8	8
085	Yes	Yellow	Absent	0	20	20
086, Community Source	Yes	Yellow	Present	5	33	38
086	Yes	Yellow	Present	4	8	12
087	Yes	Yellow	Present	15	120	135
088	Yes	Yellow	Absent	0	2	2
089	Yes	Colorless	Absent	0	0	0
090	Yes	Yellow	Absent	0	140	140
091	Yes	Colorless	Absent	0	0	0
092	Yes	Yellow	Present	4	29	33
093, Source	Yes	Yellow	Present	8	43	51
093	Yes	Yellow	Present	2	9	11
094	Yes	Colorless	Absent	0	0	0
Survey Number	**Water Quality Test Done**	**Colilert test tube (yellow or**	**e-coli (present / absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**

	(Y / N)	colourless)				
095	Yes	Yellow	Present	2	25	27
096, Source	Yes	Colorless	Absent	0	0	0
096	Yes	Yellow	Absent	0	4	4
097	Yes	Colorless	Absent	0	0	0
098	Yes	Colorless	Absent	0	0	0
099, Source	Yes	Yellow	Present	13	11	24
099	Yes	Yellow	Present	4	7	11
100	Yes	Yellow	Present	3	2	5
101, Source	Yes	Yellow	Present	5	33	38
101	Yes	Colorless	Absent	0	0	0
102	Yes	Yellow	Absent	0	8	8
103, Source	Yes	Yellow	Present	3	9	12
103	Yes	Yellow	Absent	0	2	2
104	Yes	Yellow	Present	12	80	92
105	Yes	Yellow	Present	16	220	236
106	Yes	Yellow	Absent	0	3	3
107	Yes	Yellow	Absent	0	43	43
108	Yes	Yellow	Present	5	97	102
109	Yes	Yellow	Absent	0	24	24
SOURCE, 110	Yes	Yellow	Present	1	15	16
110	Yes	Yellow	Present	2	4	6
111	Yes	Yellow	Present	5	19	24
112	Yes	Yellow	Present	3	16	19
113	Yes	Yellow	Present	7	6	13
114	Yes	Yellow	Present	4	18	22

115	Yes	Yellow	Present	1	4	5
116	Yes	Colorless	Absent	0	1	1
117	Yes	Yellow	Absent	0	1	1
Source, 118	Yes	Yellow	Present	0	2	2
Survey Number	**Water Quality Test Done (Y/N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present/ absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**
118	Yes	Yellow	Absent	0	1	1
119	Yes	Yellow	Present	0	1	1
120	Yes	Yellow	Absent	0	0	0
121	Yes	Yellow	Present	4	9	13
122	Yes	Yellow	Absent	0	5	5
123	Yes	Yellow	Present	3	7	10
Source, 124	Yes	Yellow	Absent	0	1	1
124	Yes	Yellow	Absent	0	2	2
125	Yes	Yellow	Present	0	16	16
126	Yes	Yellow	Present	3	18	21
127	Yes	Yellow	Absent	0	3	3
Source, 128	Yes	Colorless	Absent	0	1	1
128	Yes	Colorless	Absent	0	0	0
129	Yes	Yellow	Absent	0	2	2
130	Yes	Colorless	Absent	0	0	0
Source, 131	Yes	Yellow	Absent	0	3	3
131	Yes	Colorless	Absent	0	0	0
132	Yes	Colorless	Absent	0	0	0
133	Yes	Yellow	Absent	1	5	6

134	Yes	Colorless	Absent	0	0	0
135	Yes	Yellow	Present	2	24	26
136	Yes	Yellow	Present	6	18	24
137	Yes	Yellow	Present	3	8	11
138	Yes	Yellow	Absent	0	5	5
Source, 139 and 140	Yes	Yellow	Present	19	8	27
139	Yes	Yellow	Present	1	4	5
140	Yes	Yellow	Present	88	129	217
141	Yes	Yellow	Present	17	14	31
142	Yes	Colorless	Absent	0	0	0
Survey Number	**Water Quality Test Done (Y / N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present / absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**
143	Yes	Yellow	Present	2	6	8
144	Yes	Yellow	Absent	0	3	3
145	Yes	Yellow	Present	1	5	6
146	Yes	Yellow	Present	4	7	11
147	Yes	Yellow	Present	7	9	16
148	Yes	Yellow	Absent	0	2	2
149	Yes	Yellow	Present	0	1	1
150	Yes	RED	Present	1	9	10
151	Yes	Yellow	Present	1	6	7
152	Yes	Yellow	Absent	0	3	3
153	Yes	Yellow	Present	6	5	11
154	Yes	Colorless	Absent	0	0	0
155	Yes	Colorless	Absent	0	1	1
156	Yes	Yellow	Present	2	8	10

157	Yes	Yellow	Present	1	9	10
158	Yes	Colorless	Absent	0	0	0
159	Yes	Yellow	Absent	0	3	3
Source, 160	Yes	Yellow	Absent	0	7	7
160	Yes	Yellow	Present	5	18	23
Source, Jalalpur	Yes	Yellow	Present	5	7	12
161	Yes	Yellow	Present	13	4	17
162	Yes	Yellow	Present	7	9	16
163	Yes	Yellow	Absent	0	6	6
164	Yes	Yellow	Absent	0	3	3
165	Yes	Colorless	Absent	0	9	9
166	Yes	Yellow	Absent	0	8	8
167	Yes	Yellow	Present	3	11	14
168	Yes	Yellow	Present	7	9	16
169	Yes	Yellow	Absent	0	8	8
170	Yes	Colorless	Absent	0	0	0
171	Yes	Yellow	Absent	0	17	17
Survey Number	**Water Quality Test Done (Y/N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present/ absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**
172	Yes	Yellow	Present	6	9	15
173	Yes	Yellow	Absent	0	6	6
174	Yes	Colorless	Absent	2	8	10
175	Yes	Yellow	Present	9	10	19
176	Yes	Colorless	Absent	0	0	0
177	Yes	Yellow	Absent	0	11	11
178	Yes	Colorless	Present	0	8	8

179	Yes	Colorless	Absent	0	0	0
180	Yes	Yellow	Absent	0	3	3
181	Yes	Yellow	Present	8	13	21
Source, 182	Yes	Yellow	Present	4	12	16
182	Yes	Yellow	Absent	0	3	3
183	Yes	Yellow	Absent	0	5	5
184	Yes	Yellow	Present	3	8	11
Source, 185	Yes	Yellow	Present	7	27	34
185	Yes	Yellow	Present	2	8	10
186	Yes	Yellow	Absent	0	5	5
187	Yes	Colorless	Absent	0	0	0
188	Yes	Colorless	Absent	0	0	0
189	Yes	Yellow	Absent	0	4	4
190	Yes	Yellow	Present	8	65	73
191	Yes	Yellow	Present	0	13	13
192	Yes	Colorless	Absent	0	0	0
193	Yes	Yellow	Absent	0	36	36
194	Yes	Yellow	Absent	1	17	18
195	Yes	Yellow	Absent	0	6	6
196	Yes	Yellow	Present	3	12	15
197	Yes	Yellow	Absent	0	2	2
198	Yes	Colorless	Absent	0	0	0
199	Yes	Colorless	Absent	0	0	0
200	Yes	Yellow	Present	13	15	28
Survey Number	**Water Quality Test Done (Y/N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present/ absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**

201	Yes	Yellow	Present	3	7	10
202	Yes	Yellow	Absent	0	2	2
203	Yes	Yellow	Present	0	11	11
204	Yes	Yellow	Absent	0	3	3
205	Yes	Yellow	Present	16	19	35
206	Yes	Yellow	Absent	0	4	4
207	Yes	Colorless	Absent	0	0	0
Source, 208	Yes	Yellow	Present	43	48	91
208	Yes	Yellow	Present	26	33	59
209, School Handpump	Yes	Yellow	Absent	0	3	3
209, School Bucket	Yes	Yellow	Present	14	27	41
210	Yes	Yellow	Present	13	34	47
211	Yes	Yellow	Absent	0	2	2
Source, 212	Yes	Yellow	Absent	0	0	0
212	Yes	Colorless	Present	3	5	8
213	Yes	Yellow	Present	36	43	79
214	Yes	Yellow	Present	33	29	62
215	Yes	Colorless	Absent	0	0	0
Source, 216	Yes	Yellow	Absent	0	0	0
216	Yes	Yellow	Present	11	17	28
217	Yes	Colorless	Absent	0	0	0
218	Yes	Yellow	Absent	0	0	0
219	Yes	Yellow	Present	29	31	60
220	Yes	Colorless	Absent	0	0	0
221	Yes	Colorless	Absent	0	0	0

Source, 222	Yes	Yellow	Absent	0	0	0
222	Yes	Colorless	Absent	0	0	0
223	Yes	Colorless	Absent	0	0	0
Survey Number	**Water Quality Test Done (Y/N)**	**Colilert test tube (yellow or colourless)**	**e-coli (present/ absent)**	**No. of blue colonies**	**No. of red colonies**	**Total no. of colonies**
224	Yes	Yellow	Present	13	19	32
225	Yes	Yellow	Present	5	4	9
226	Yes	Yellow	Present	4	7	11
227	Yes	Yellow	Present	2	14	16
228	Yes	Yellow	Present	0	13	13
229	Yes	Yellow	Present	0	3	3
230	Yes	Yellow	Present	7	3	10
231	Yes	Yellow	Present	9	6	15
232	Yes	Yellow	Absent	0	0	0
233	Yes	Yellow	Present	3	7	10
234	Yes	Yellow	Present	0	4	4
235	Yes	Yellow	Absent	2	8	10
236	Yes	Colorless	Absent	0	0	0
237	Yes	Yellow	Present	12	0	12
238	Yes	Colorless	Absent	0	1	1
239	Yes	Yellow	Present	0	5	5
240	Yes	Yellow	Present	0	8	8

Survey Number	E-coli (CFU/100 ml)	Total coliform (CFU/100 ml)	Lab test done (Y/N)
001	100	1800	N
001 Source	800	3900	N
002	0	1300	N
003	0	700	N
004	0	100	N
004 Source	400	1900	N
005	300	2900	N
006	400	3600	N
007	800	6500	N
008	3500	6200	N
009	0	4300	N
010	200	6500	N
010, Source (home)	0	200	N
010, Source (Main)	0	0	N
011	4700	8000	N
012	0	800	N
013 (Expired Purit)	0	5600	N
013, Source	3700	7800	N
014	0	400	N
015	700	2200	N
016	0	700	N

Survey Number	E-coli (CFU/100 ml)	Total coliform (CFU/100 ml)	Lab test done (Y/N)
017	500	3400	N
SOURCE	0	200	N
018	0	600	N
019	400	3700	N
020	0	1700	N
021	0	500	N
022	0	100	N
023	0	2300	Y
Survey Number	**E-coli (CFU/100 ml)**	**Total coliform (CFU/100 ml)**	**Lab test done (Y/N)**
024	0	3100	Y
025	0	800	Y
025, Source	500	3200	Y
026	0	800	Y
027	0	200	Y
028	0	100	N
029	0	0	N
030	0	0	N
031	0	0	N
032, Source	200	6700	N
032	0	2800	N
033	0	0	N
034	0	400	N
035	0	100	N
036	100	700	N
037	0	300	N
038	0	0	N

039	0	4400	N
040	0	0	N
041	0	0	N
042	0	0	N
043	0	200	N
044	0	900	N
045	0	700	N
046	0	1500	N
047, Source	500	10700	N
047	0	700	N
048	0	10000	N
049	0	200	N
050, Source	0	44000	N
050	0	40000	N
Survey Number	**E-coli (CFU/100 ml)**	**Total coliform (CFU/100 ml)**	**Lab test done (Y/N)**
051	0	6300	N
052	0	0	N
053	0	300	N
054	0	600	N
055	0	1500	N
056	0	0	N
057	100	400	N
058, Source	0	0	
058	0	0	N
059	0	0	N

060	0	0	N
061	200	3000	N
062	0	100	N
063, Source	1000	11000	N
063	300	1800	N
064, Source	8000	23600	N
064	300	3200	N
065	300	1000	N
066	0	0	N
067	400	1300	N
068	0	200	N
069 WHITE FLOATING MATTER IN COLILERT	0	100	N
070	0	0	N
071	0	0	N
072	0	400	N
073	0	0	N
074	0	0	N
075, Source	100	700	N
Survey Number	**E-coli (CFU/100 ml)**	**Total coliform (CFU/100 ml)**	**Lab test done (Y/N)**
075	0	0	N
076	0	8000	N
077	0	0	N
078, Source	0	1500	N

078	0	400	N
079	0	0	N
080	0	0	N
081	0	18000	N
082	0	0	N
083	0	0	N
084	0	800	N
085	0	2000	N
086, Community Source	500	3800	N
086	400	1200	N
087	1500	13500	N
088	0	200	N
089	0	0	N
090	0	14000	N
091	0	0	N
092	400	3300	Y
093, Source	800	5100	Y
093	200	1100	Y
094	0	0	Y
095	200	2700	Y
096, Source	0	0	Y
096	0	400	Y
097	0	0	Y
098	0	0	Y
099, Source	1300	2400	Y

Survey Number	E-coli (CFU/100 ml)	Total coliform (CFU/100 ml)	Lab test done (Y/N)
099	400	1100	Y
100	300	500	Y
101, Source	500	3800	Y
101	0	0	Y
102	0	800	N
103, Source	300	1200	N
103	0	200	N
104	1200	9200	N
105	1600	23600	N
106	0	300	N
107	0	4300	N
108	500	10200	N
109	0	2400	N
SOURCE, 110	100	1600	N
110	200	600	N
111	500	2400	N
112	300	1900	N
113	700	1300	N
114	400	2200	N
115	100	500	N
116	0	100	N
117	0	100	N
Source, 118	0	200	N
118	0	100	N

119	0	100	N
120	0	0	N
121	400	1300	N
122	0	500	N
123	300	1000	N
Source, 124	0	100	N
Survey Number	**E-coli (CFU/100 ml)**	**Total coliform (CFU/100 ml)**	**Lab test done (Y/N)**
124	0	200	N
125	0	1600	N
126	300	2100	N
127	0	300	N
Source, 128	0	100	N
128	0	0	N
129	0	200	N
130	0	0	N
Source, 131	0	300	N
131	0	0	N
132	0	0	N
133	100	600	N
134	0	0	N
135	200	2600	N
136	600	2400	N
137	300	1100	N
138	0	500	N
Source, 139 and	1900	2700	N

140			
139	100	500	N
140	8800	21700	N
141	1700	3100	N
142	0	0	N
143	200	800	N
144	0	300	N
145	100	600	N
146	400	1100	N
147	700	1600	N
148	0	200	N
149	0	100	N
150	100	1000	N
Survey Number	**E-coli (CFU/100 ml)**	**Total coliform (CFU/100 ml)**	**Lab test done (Y/N)**
151	100	700	N
152	0	300	N
153	600	1100	N
154	0	0	N
155	0	100	N
156	200	1000	N
157	100	1000	N
158	0	0	N
159	0	300	N
Source, 160	0	700	N
160	500	2300	N

Source, Jalalpur	500	1200	N
161	1300	1700	
162	700	1600	N
163	0	600	N
164	0	300	N
165	0	900	N
166	0	800	N
167	300	1400	N
168	700	1600	N
169	0	800	N
170	0	0	N
171	0	1700	N
172	600	1500	N
173	0	600	N
174	200	1000	N
175	900	1900	N
176	0	0	N
177	0	1100	N
178	0	800	N
179	0	0	N
180	0	300	N
Survey Number	**E-coli (CFU/100 ml)**	**Total coliform (CFU/100 ml)**	**Lab test done (Y/N)**
181	800	2100	N
Source, 182	400	1600	N
182	0	300	N
183	0	500	N

184	300	1100	N
Source, 185	700	3400	N
185	200	1000	N
186	0	500	N
187	0	0	N
188	0	0	N
189	0	400	N
190	800	7300	N
191	0	1300	N
192	0	0	N
193	0	3600	N
194	100	1800	N
195	0	600	N
196	300	1500	N
197	0	200	N
198	0	0	N
199	0	0	N
200	1300	2800	N
201	300	1000	N
202	0	200	N
203	0	1100	N
204	0	300	N
205	1600	3500	N
206	0	400	N
207	0	0	N
Source, 208	4300	9100	Y
208	2600	5900	Y

Survey Number	E-coli (CFU/100 ml)	Total coliform (CFU/100 ml)	Lab test done (Y/N)
209, School Handpump	0	300	Y
209, School Bucket	1400	4100	Y
210	1300	4700	Y
211	0	200	Y
Source, 212	0	0	Y
212	300	800	Y
213	3600	7900	Y
214	3300	6200	Y
215	0	0	Y
Source, 216	0	0	Y
216	1100	2800	Y
217	0	0	Y
218	0	0	Y
219	2900	6000	Y
220	0	0	Y
221	0	0	Y
Source, 222	0	0	Y
222	0	0	Y
223	0	0	Y
224	1300	3200	Y
225	500	900	N
226	400	1100	N

227	200	1600	N
228	0	1300	N
229	0	300	N
230	700	1000	N
231	900	1500	N
232	0	0	N
233	300	1000	N
234	0	400	N
235	200	1000	N
236	0	0	N
237	1200	1200	N
238	0	100	N
239	0	500	N
240	0	800	N

ANNEX VI: Table Enlisting Available HWTS Technologies in the 45 respondent countries

	Types of Treatment Technologies that are used						
Country	Boiling	Flocculation / Disinfection	Bleach/ Chlorine	Water Filters	SODIS	Let it stand and settle	Others
Afghanistan	√		√				
Angola	√		√	√		√	
Burkina Faso	√	√	√	√		√	√
Burundi	√	√	√				
Cambodia	√	√	√	√	√	√	
Central African Republic (CAR)	√	√	√	√			
China	√	√	√	√		√	
Congo/Brazzavill e		√	√	√			
Côte d'Ivoire		√		√		√	√
DPR Korea	√	√					
Democratic Republic of Congo (DRC)	√	√	√	√	√		
Djibouti	√	√		√			
Eritrea				√		√	
Ethiopia	√	√	√	√	√		
Gambia	√		√			√	√
Guatemala	√		√	√	√		

Guinea-Bissau	√		√				√
Haiti	√	√	√	√		√	
Honduras	√	√	√	√	√		
India	√	√	√	√	√	√	
Iraq	√	√	√	√		√	√
Kenya	√	√	√	√	√	√	√
Madagascar	√	√	√	√	√	√	
Malawi	√	√	√	√		√	
Republic of Maldives	√	√	√	√			
Mali	√	√	√				√
Mauritania	√	√	√	√		√	√
Mongolia	√	√	√	√			
Mozambique	√	√	√	√	√	√	√
Myanmar	√	√	√	√		√	√
Nepal	√		√	√	√	√	√
Nicaragua	√	√	√	√	√	√	√
Niger	√		√	√			√
Sudan	√	√	√	√		√	
Pakisan	√	√	√	√	√	√	
Philippines	√	√	√	√	√		
Rwanda	√		√	√		√	
Senegal	√		√	√	√		
Central & Southern Zone (CSZ)- Somalia		√	√	√		√	
Somalia / North West Zone (Puntland)	√		√		√	√	

Somalia (North West Zone - Somaliland)	√		√	√		√	√
Sierra Leone				√	√		
Sri Lanka	√	√	√	√	√	√	√
Tanzania	√	√	√	√	√	√	
Thailand	√		√	√	√	√	
Uganda	√	√	√				
Vietnam	√	√	√		√	√	√