Household Water Use and Treatment Practices in Rural Nepal

BioSand Filter Evaluation and Considerations for Future Projects

By

Nathaniel Collingwood Gooch Paynter
BA English and American Literature, 1994
Brown University - Providence, RI

Submitted to the Department of Civil and Environmental Engineering
In Partial Fulfillment of the Requirements for the Degree of

MASTER OF ENGINEERING
in Civil and Environmental Engineering
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUNE 2001

Signature of Author ______________________________
Department of Civil and Environmental Engineering
May 11, 2001

Certified by ______________________________
Susan Murcott
Thesis Supervisor
Lecturer

Accepted by ______________________________
Oral Buyukozturk
Professor of Civil and Environmental Engineering
Chairman Departmental Committee on Graduate Studies

Dedicated to

Grenville Howard Paynter

5/20/31 ~ 3/9/97

He taught me what success meant.

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Abstract

Nepal suffers from severe microbial contamination of its water supplies. Because of its relative poverty and large rural population, Nepal cannot afford to install centralized water treatment systems to serve the majority of its population in the near future, and therefore treatment must be on a household point-of-use scale. For the past two years, the Massachusetts Institute of Technology Nepal Water Project Master of Engineering teams have traveled to Nepal to research the water situation and try to devise a water treatment solution. In January 2001, I traveled to Nepal as part of this year's Nepal Water Project to study the pilot project implementation of a water treatment system, the BioSand Water Filter (BSF). The purpose of my thesis has been to evaluate the water needs and supplies, sanitation, contaminated water – health connection, and local attitudes towards filtration. I found that while there was widespread use and acceptance of the BSF, there was not a corresponding improvement in health. Additionally, there did not appear to be a complete understanding of water contamination and its various pathways. However, with a basic education and technical monitoring program accompanying the BSF distribution, health improvements should become more pronounced.

Thesis Supervisor: Susan Murcott
Lecturer, Department of Civil and Environmental Engineering

ACKNOWLEDGEMENTS

I've leaned on a lot people in completing this project, and many others have been there to pick me up when I got home. Unfortunately, I don't think the words have been invented yet that can adequately express my gratitude to all those involved, but I'll stumble through best I can.

First, I'd like to thank my family – Sally Paynter; Brad, Betsy and Althea Paynter; Cameron, Mike, Hannah and Emma Paynter – for their boundless love and relentless encouragement. If doubt ever crossed their brows, they hid it damn well. I could always count on them for a bemused nod and a, "Well, that's great, Nat," whenever I got chatting too excitedly.

And then my dear friends. Sarah Braum, whose unshakable faith and love carried me through innumerable wide-eyed nights and hair-pulling-out days. David Kimball, my brilliant roommate, who knows the value of fine whiskey, deep aching laughter and all the colors of the meaty rainbow. Uncle Jim Stewart, who said to me three years ago, "That's the greatest thing I've heard – go for it!" – your approbation carried me through the dark times.

At MIT I had the good fortune to have Susan Murcott as my thesis advisor. She convinced me that engineering is not a realm beyond English majors, and that they have a need for us. Thank you, Susan, for your sage advice and faith. I'd also like to thank Dr. Eric Adams for his advice and guidance through the labyrinthine MIT officialdom. While I was in Nepal I benefited from the local knowledge and translating skills of Arjun Chettri. He guided me through the villages of Nepal, and introduced me to the wonderful people of Nepal. He and his brother Uttam Chettri run the NGO Hope for the Nation, and provided a great deal of support and information both in Nepal and once we returned. During our stay in Nepal Lincoln Lee and I met a very kind chemical engineer, Hari Krishna "Kanchu" Jayswal. Kanchu accompanied us on several interviews and gave invaluable insight into the Nepal Water Project. Also, I got a great deal of help from fellow Nepal researcher Rochelle Rainey, a doctoral candidate at Oregon State University. She consistently and cheerfully gave excellent advice, and guided me in extremely helpful directions.

And of course, my fellow Nepal team: Tim Harrison – I have to admit that I was annoyed that he's taller than I am, until I watched him smack his head into doors, ceilings, cars, monasteries, etc. Jessie Hurd, who, as far as I can tell, never has a bad day, and that's contagious. "9.5-Fingered" Lincoln Lee, my traveling companion, who made me laugh at least once a day and was only intimidated by fried goat marrow. Meghan Smith, who allegedly came down with the complete complement of Nepali diseases, especially Crammed-in-a-"bus"-for-fifteen-hours-with-twelve-breeding-goats-itis. Never got her down, though.

Thank you, all. I am deeply and happily in your debt.

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There is no truer sign of civilization and culture than good sanitation.
-J. C. Stobert, 1935

1.0 INTRODUCTION

It has often been noted that water is one of our most basic needs. The great civilizations of history have thrived in part because of their ability to find, transport and deliver potable water to their growing urban populations and agricultural centers. The Roman aqueducts are the most visible monuments of sophisticated water engineering, but others exist in various cradles of early civilizations. They're found around the great Persian cities, along the banks of the Nile and among the Greek city-states, spreading dendritically from the Indus and Ganges, connecting the ancient cities of China, and serving as the backbone of several Meso-American empires.

Our need for fresh water has historically also been our vulnerability, easily exploited by invading armies and occasionally changing the course of history. Alexander the Great was killed in his 34th year by water-borne disease along the Euphrates near Babylon (Renault, 1975). Besieged cities could only hold out as long as their freshwater supply lasted. When confronted with the unstoppable army of Sweden's Charles XII, Peter the Great befouled with corpses all the wells within a hundred-mile radius of the invading army, forcing the Swedish king to retreat for lack of safe drinking water (Massie, 1980). The examples continue well into the 20th Century.

The spread and development of a civilization is often tied or hampered by its ability to deliver fresh water and remove waste. Within the United States, New York City struggled for a hundred years to overcome its natural paucity of potable water and sanitation. The shallow wells of Manhattan Island had been depleted or fouled by the early 18th Century, and the city suffered annual epidemics of cholera and yellow fever due to poor sanitation. Without an adequate water supply and proper sanitation, the economic, political, cultural, and social future of the city was severely impeded. With the opening of the Croton aqueduct in 1842, the city had a reliable water source which allowed it to pursue its development and prosperity (Koeppel, 2000).

The supply of potable water and the safe disposal of wastewater continue to be a great challenge for the world today. While it is difficult to conduct a cost-benefit analysis of the benefits of improving water and sanitation, it is easier to determine the cost of *not* providing them: in the early 1990s Peru suffered a cholera outbreak. In the first ten weeks of the epidemic economic losses due to drops in agricultural exports and revenues from tourism where *three times* the total amount Peru invested in sanitation and water supply in the whole of the 1980s (World Bank, 1992).

1.1 WORLD WATER BACKGROUND

On November 10th, 1980 the United Nations officially declared the 1980s as the UN International Drinking Water Supply and Sanitation Decade (IDWSSD), with a goal of providing clean water and adequate sanitation for all by 1990 (Schiller, 1982). At the time approximately 1.6 billion people worldwide were without clean water and about 2 billion were without adequate sanitation. Ten years after the IDWSSD ended, the situation remains dire. 28% of the world's population, or 1.7 billion people, are without access to clean water and 2.4 billion are without adequate sanitation (WHO, 2001). When population growth over that time period is taken into account, the program is just keeping ahead of the 1980 conditions, and is still far short of the goal of clean water for all.

The effects of poor water supply and sanitation are various and widespread. They range from the estimated ten-million person-hours annually spent predominantly by women and children gathering water from distant, often polluted, sources to economic hardship caused by lost labor and medical expenses to appalling health statistics:

- Every eight seconds a child dies of water-related diseases
- Contaminated drinking water and improper sewerage are tied with five million deaths annually.
- Today, approximately half of all peoples in the developing world are suffering from diarrhea, ascaris, dracunculiasis, hookworm, schistosomiasis or trachoma.
  (WHO, 1996).

1.2 NEPAL BACKGROUND, PROJECT PURPOSE AND LOCATIONS

1.2.1 NEPAL BACKGROUND

Landlocked between India and China, the Kingdom of Nepal covers 147,181 square kilometers, approximately the same size as Michigan (Britannica, 2001). Within this small area, Nepal has been folded and compressed into three distinctive regions: the flat Terai in the south, the mountainous Himalayas in the north, and the mid-land hill region between them. The highly varied terrain has spawned an astonishing array of cultures and societies: sixty according to the Nepalese census and over 100 according to ethnologists (Bista, 1991). Because Nepal did not gain political unity until the 18th-Century, and national unity in 1950, these ethnicities retain many of their individual identities, which makes for a rich society, but difficult for generalizations. However, one common denominator is religion. Most of the Nepali population practices one of four major religions: Hinduism, Buddhism, Islam, or Christianity. The country has a vast Hindu majority of 86%, while 8% are Buddhists, and less then 4% are Muslim. Although Christians are forbidden from directly proselytizing in Nepal, they are allowed to work on development projects, and now there are approximately 60,000 practicing Christians in the Kingdom (Moran, 1999).

While the terrain makes for innumerable micro-climates, two seasons dominate the nation: the wet and the dry. Like much of southern Asia, Nepal receives an annual monsoon drenching between May and mid-October that replenishes the rivers and aquifers and saturates the fields. The country starts drying out in November, and by April water supplies are running low, and the heat and dust become oppressive. Although the monsoon rains alleviate droughts and heat, the water quality frequently deteriorates under the elevated sediment load from extensive run-off (Moran, 1999).

1.2.2 PROJECT PURPOSE AND LOCATIONS

Although previous Nepal Water Project studies have focused on water treatment systems, there has been little research that examines the appropriateness of these systems. It is clear that any development project, including household water treatment, must be combined with a thorough understanding of social and practical considerations in order to be successful. The necessity of this becomes obvious when one considers that a well-engineered project is useless if the target population does not, will not, or cannot use it. There are numerous examples of well-meaning projects that ultimately backfired or exacerbated the problem they were meant to address because their appropriateness was not taken into account. For example, a sanitation program was implemented in a poor area. The new latrines were well-built, of bricks and mortar, and had locks on their doors. Houses in the region, however, did not have locks, so people used the latrines to store their valuables, such as bicycles and chickens. As far as the people were concerned the sanitation program was a great success - for storing valuables (Feuerstein, 1986).

The purpose of my research has been to investigate the appropriateness of one type of water treatment system, the BioSand Water Filter (BSF), to examine the BSF pilot program, and to identify other considerations that should be addressed when implementing a water treatment program. The term *appropriateness* incorporates many diverse concerns. For this paper, *appropriateness* can be defined as the technical efficacy of the treatment system, specifically its ability to meet the World Health Organization's guidelines regarding microbial contamination - zero *coliform* forming units (cfu) per 100ml - and turbidity - less than five Nephelometric Turbidity Units (NTU) (WHO, 1996). Simultaneously, the development program must take into account the social acceptability of the treatment system, i.e. it must not conflict with any significant cultural mores nor can it place any additional burden on the families. The system should be both easily understood and maintained by the target population, and fulfill the four criteria of *appropriate technology*:

1) The technology must be of simple design and easily produced.
2) It must be low cost.
3) It must use local, easily accessible materials.
4) It must have a rural focus.

(Schumacher, 1973)

In studying appropriateness, several other important issues came to my attention along the way. For example, it was not clear whether the Nepalis were using and maintaining the BSF properly, if at all. Additionally, sanitation availability and effectiveness needed to be evaluated to find possible sources of contamination. One also needed to identify practices that lead to re-contamination. Another critical part of the study and the development of effective household-level filtration is an evaluation of the population's understanding of water and health. If they do not understand the connection between contaminated water - even when it appears clear - and ill health, any water treatment project is doomed to failure.

From these parameters, a tripartite focus to this study emerged. First, I evaluated the use of the BSF - was it being used properly, was it reducing microbial contamination and turbidity, did people like it, and what reservations did they have. Second, I studied the water practices and needs of the rural Nepalese - where did they get their water from, where was their latrine and what kind was it, who got the water and how many trips did they make, etc. Finally, I attempted to evaluate the Nepali understanding of water and public health - why did they filter water, what other water purification do they practice, etc.

While in Nepal from January 4th to the 21st, 2001, Tse Luen Lee and I traveled to two regions and I interviewed the owners of the BSFs while he examined its technical aspects. First we went to the Palpa region near Tansen in the middle hills for a week, and then we traveled south to the Nawalparasi region in the Terai, as shown in Figure 1.1. The areas were chosen because these were the two locations of BSFs in Nepal.

FIGURE 1.1 MAP OF NEPAL, SHOWING PROJECT LOCATIONS

1.3 CASTE IN NEPAL

The caste system in Nepal is somewhat different from the caste system practiced by Orthodox Hindus in India. Under the orthodox system, there are five rigid castes - Brahmin, Khastriya, Vaishya, Shudra, and Untouchable - and it is impossible to move from one caste to another. However, as Hinduism and its caste system were adopted in Nepal they had to incorporate the many strong ethnicities that were flourishing throughout the area at the time. Therefore, the Nepali caste system is considerably more complicated. Topping the system are still the Brahmins, followed by the Thakuris and the Chettris. Under the Chettri is the Shrestha caste, which is composed of all the various Nepali ethnicities: Bhotia, Gurung, Lepcha, Limbu, Magar, Mithili, Newar, Rajbansi, Rai, Sherpa, Sunwa, Tamang, Tharu, and Thakali. While many of the rigid structures, including intercaste movement, and legal barriers of the caste system have been outlawed, they remain in practice and continue to be an important part of Nepali society. (Bista, 1991). Table 1.1 illustrates the respective caste systems, with the perforated lines indicating possible inter-caste movement.

TABLE 1.1 CASTE SYSTEMS

Orthodox Hindu
Brahmin
Khastriya
Vaishya
Shudra
↓
Untouchable

Nepali Caste Heirarchy	
Brahmin	
Thakuri	
Chhetri	
Shrestha	
Bhotia	Gurung
Lepcha	Limbu
Magar	Mithili
Newar	Rajbansi
Rai	Sherpa
Sunwar	Tamang
Tharu	Thakali
Untouchable	

(Adapted from Bista, 1991)

2.0 BACKGROUND

2.1 WATER QUALITY IN NEPAL

Despite its freshwater wealth, Nepal shares in the developing world's water quality problems described in Section 1.1,. Unfortunately this freshwater is unequally distributed around the country, a situation exacerbated by droughts during the dry season and flooding during the monsoons. Additionally, Nepal is the seventh poorest nation in the world with an average annual income of US$220 (World Bank, 2001), and this poverty may also be the cause of some of the worst national health statistics in the world:

- Life expectancy is 58 years, as compared to 77 years in the United States (World Bank, 2001).
- Estimates of infant mortality are 79 per 1000 births, over ten times the American rate of 5 per 1000 (World Bank, 2001).
- 11% of children die before the age of five (UNICEF, 2001).
- 25% of infant deaths are due to diarrhea (UNDP, 1998).
- 48% of the population is stunted due to an inability during infancy and childhood to retain essential nutrients during diarrheic episodes (UNDP, 1998).

The extreme poverty mentioned above combined with a de-centralized, rural population precludes the government from installing centralized water treatment and sewerage systems. Therefore, if public health is to be protected in the near-term, water treatment systems must be implemented on a community or household-by-household basis. The rural population relies on a variety of water sources, depending on their region, and water is carried from these sources in *gagris*. A *gagri*, or *gagro* if it is ceramic, is the standard water container in Nepal, with a volume between 14 and 17L. It is typically made out of aluminum, copper, brass, and sometimes plastic. Three gagris are shown in Figure 2.1 with a BioSand Water Filter. In the hill district, most of the water is collected from spring-fed streams that are piped to a local standpipe, or "stonetaps" (in villages), or to the yard (in remote areas). In the flatlands of the Terai, water is collected either from a private hand-dug well, local stream, tubewells or piped from distant sources. In examining water collected from these sources, Lee found that 93% of the random water samples had microbial contamination (Lee, 2001).

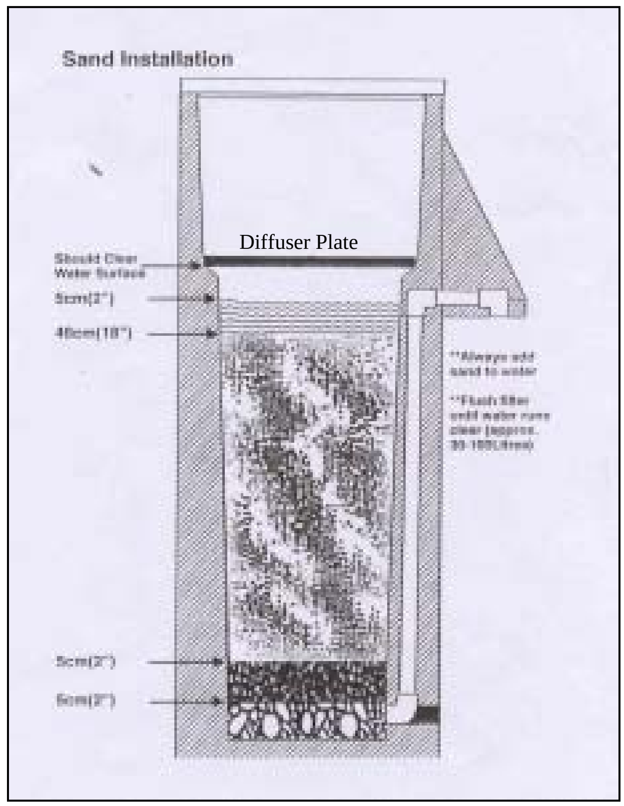
FIGURE 2.1 BSF WITH THREE TYPES OF GAGRIS

2.2 BIOSAND FILTER BACKGROUND

The filter examined was the BioSand Water Filter (BSF), also referred to as the Canadian Water Filter. Dr. David Manz of the University of Calgary, Canada, developed the BSF in 1988, and it was designed to address several issues that had cropped up during the implementation of previous water treatment projects. In particular, the BSF was supposed to have a high flow-rate, effective microbial reduction, improve the taste and clarity of water, accommodate intermittent flow, as well as being an appropriate technology (Manz, 1998).

The BSF works in a similar manner to a slow-sand filter. A slow-sand filter removes pathogens through two processes, adsorption and bacterivory. As organic contaminants travel through the sand, they collide with and adsorb onto sand particles. The organisms and particles collect in the greatest density in the top layer of the sand, gradually forming a biofilm. The biofilm is not a true "film" as it does not exist in a cohesive layer, but instead refers to the dense population that develops within the top layer of the sand. Within the biofilm is an active food chain that consumes the pathogens as they deposit on the sand's surface (Schulz and Okun, 1984). There are two drawbacks to the slow-sand filter with regards to household level treatment: 1) it requires a constant flow, and 2) it is usually built on a municipal scale, and so requires a centralized water and sanitation system.

FIGURE 2.2 SCHEMATIC OF BSF (Ritenour, 1998)



2.2.1 BSF DESIGN

Dr. Manz made several modifications to the traditional slow-sand filter to allow for intermittent flow and point-of-use treatment. The BSF, as illustrated in Figure 2.1, is essentially a rectangular, concrete box, with a gradual tapering of the sides from the top to the bottom. The BSF is filled with carefully graded layers of sand, from coarse grains on the bottom to fine sand on the top. The fine sand has a higher surface area, which promotes the number of collisions for a given volume. Above the sand is a *diffuser plate*, a piece of perforated metal or plastic that sits on a ledge over the sand, protecting it and the biofilm from the scouring effect of pouring water directly onto the sand. Below the diffuser plate, but above the sand, is the resting level of the water. Dr. Manz discovered that the biofilm could survive for extended periods of time if the water level is 5cm above the biofilm. The biofilm requires both an aquatic environment and a constant influx of O_2, so should the resting water level rise above 5cm, the O_2 will not diffuse to the biofilm, and the biofilm will suffocate. If the water level drops below 5cm, then the inflowing water will disturb the sand and biofilm. The relative water height is maintained by the height of the sand and the outflow pipe, which should be 5cm above the top of the sand.

The BSF is composed solely of concrete, sand and gravel, PVC piping, and the metal or plastic diffuser plate. Because it uses these simple materials, it can be readily assembled onsite in almost any location. Once it has been assembled, however, it is extremely heavy and difficult to move.

The BSF requires simple maintenance approximately every six months, depending on the turbidity of the feed water. When the flow-rate slows, the top 2cm of the sand should be removed, rinsed with water (it does not need to be filtered water), spread out and allowed to dry in the sun, and then replaced on top of the sand column. When the sand is cleaned, it kills the biofilm, which then needs approximately two weeks to ripen. During this period of ripening, the BSF only adsorbs particles, without the complementary bactivory, and its efficiency is greatly reduced. For a discussion of the technical details of the BSF, please see Tse Luen Lee's 2001 thesis.

2.2.2 BSF Program Background

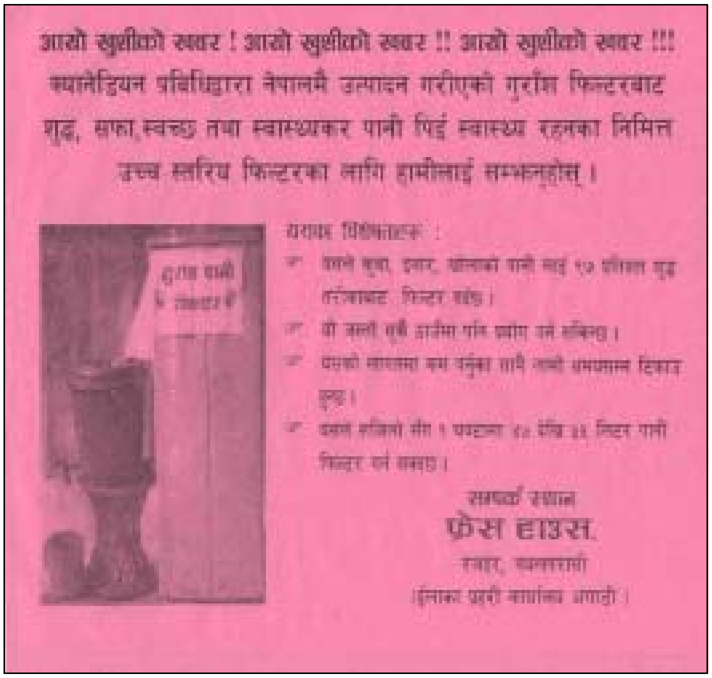
In 1998, the Canadian Non-Governmental Organization (NGO) Samaritan's Purse introduced the BSF technology to a Nepalese NGO, Hope for the Nations, Nepal (HFTN). The same year, HFTN distributed fifteen BSFs in the Palpa region near Tansen, and began selling BSFs in the Nawalparasi region of the Terai near Naranghat. A copy of their promotional flier appears in Figure 2.3. Since then, more than 100 BSFs have been constructed and distributed in the Nawalparasi District. HFTN is currently trying to expand the BSF program by raising funds from domestic and international organizations.

2.3 Background Research

Background research for this study included two components. The first, *Survey Theory and Techniques*, involved a review of the recommended methods for constructing and conducting a public health survey in developing countries. The second, *Behavioral*

Change and Sustainable Development, examines the social and psychological strategies for encouraging behavioral change.

FIGURE 2.3 BSF PROMOTIONAL FLIER



Translation[1]: (Uttam, 2001)

Good news!!! Good news!!! Good news!!!

Remember us for guras water filters built with Canadian technology. The quality, purity, cleanliness and freshness for good health are guaranteed.

Reasons to buy guras filters:

1. Guras filters water from wells, ponds, springs and streams, removing 97% of all contamination.
2. It can be used anywhere.
3. It is the well made and lasts long.
4. It filters 40 to 55 liters of water per hour.

Contact: Fresh House Rajhar, Nawalparasi (in front of local police post)

2.3.1 *SURVEY THEORY AND TECHNIQUES*

There are innumerable types of surveys, with the goal of the survey largely determining the type used, but broadly speaking, two basic types of surveys are used to acquire public health information in the developing world; a questionnaire-based traditional sample oriented survey, and a more flexible, interview-based survey.

Questionnaire Surveys

The questionnaire-based survey often starts with a fixed hypothesis, e.g. "The BSF is improving the health of the rural Nepalis," and then seeks to prove or disprove it. The surveys themselves are rigidly constructed with little or no room for interpretation or documentation of peripheral information, in an attempt to produce quantitative data. This strict format is necessary both for the traditional statistical analysis utilized and for consistency across the several hundred evaluators conducting the survey. Each question is strictly closed-ended, and the responses are always scaled, for example:

[1] In Nepal, the filter is named after "guras," the Nepali national flower.

Over the past year, are you healthier than the previous year? Circle the appropriate number:									
Sicker				*Same*					*Healthier*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*

This type of survey may be a massive, thorough, time-consuming sample-survey similar to the United States Census, for example the Demographic and Health Surveys (DHS). The DHSs, usually commissioned by a nation's Ministry of Health, is conducted by the American firm Macro International and funded by the United States Agency for International Development. This survey is enormous, involving tens of thousands of interviews and primarily focuses on population, maternal and child-health data (Aday, 1996), and has been conducted in twenty-four developing nations (DHS+, 2001). DHSs cost millions of dollars and interviewers may spend half a year in the field followed by a year of data analysis before presenting results (NIPORT, 1994).

This strict format simplifies analysis by removing any room for interpretation by the interviewer, and provides accurate information for nation-wide trends in health and population. However, it does not address the many un-quantifiable factors that may determine human health and behavior. For example, a response to the above question may be, "2, but I lost a child last year, and my health has suffered. Normally I am quite healthy." A DHS cannot handle such a situation. Clearly, a survey of this type was not appropriate for the survey I was planning to conduct. My survey was much smaller, cheaper, shorter and narrowly focused.

A similar type of survey is the Knowledge, Attitudes, Practices (KAP) survey. Also a questionnaire-based survey, its scale is considerably smaller then a DHS and focuses on one or two topics of research. As the name implies, the KAP-style survey would evaluate the knowledge, attitudes and practices of the target population towards, for example, filtration systems. It utilizes quantitative methods of analysis, but over time it has been proven to be largely inaccurate in predicting broad social behaviors and attitudes (Manderson and Aaby, 1992). The weakness of the KAP survey is its reliance on quantitative analysis of qualitative research, and so a new method of surveying needed to be devised. Although the scope of this type of survey was more appropriate to my research, its strict adherence to questionnaire-based surveying was inappropriate to the interviewing I was planning to conduct.

Rapid Assessment/Interview-Based Surveys

A more appropriate type of survey evolved from anthropology survey theory, which tends to produce a less expensive, more rapid survey with a stronger sociological perspective. These surveys go by many names, depending on the goal of the project, including Rapid Rural Assessment (RRA), Rapid Epidemiological Assessment (REA), and Rapid Assessment Procedures (RAP), Participatory Rapid Assessment (PRA) (Manderson and Aaby, 1992) - collectively grouped in this paper as RA surveys. The RA method drew from the old KAP survey, but integrated anthropological qualitative methods into the traditional quantitative-based surveys (Rhodes, *et. al.*, 1999). RA surveys "[emphasize] the socially situated nature of individual action, and [show] the value of integrating multiple qualitative methods to understand the meaning and context of behavior" (Rhodes, *et. al.*, 1999). They are constructed with a view that different people perceive and understand reality differently, but in equally valid ways, and therefore the survey needs to reflect that. The goal of RA-style surveys is also somewhat different than the traditional public health survey previously discussed - it attempts to combine assessment with action, prioritizing practical responses rather than simply scientific results (Rhodes, *et. al.*, 1999). RA surveys are well suited for small, specific goals such as needs assessment, feasibility studies, identifying priorities for development activities, implementing development activity, and monitoring or evaluating development activities.

In a RA survey, a multidisciplinary team is assembled to produce a complete perspective on the question at hand, e.g. for the BSF project it might include a biologist, civil and environmental engineers, sociologist, public health advocate, and hydrologist, among others. They typically go into the field for a short period of time, from a week to a month. In that time they conduct an intensive series of semi-structured, open-ended interviews, altering the direction or focus of the research as circumstances dictate. The collected data are then analyzed in a qualitative manner, taking into consideration the many social and cultural factors that may dictate the subject's behavior (Manderson and Aaby, 1992).

One of the strengths of the RA surveys is that they allow assessments to develop in the field, as opposed to the traditional manner of trying to prove or disprove a fixed hypothesis which requires producing an assessment after all the data analysis is completed. That flexibility is very important if one is surveying a population about which one knows little. Another strength is that RA focuses on triangulating the data, a form of cross-checking field data with existing databases, focus groups, etc., which serves to reinforce the accuracy of the findings (Rhodes, *et. el.*, 1999). Finally, a RA survey should be conducted with the help and aid of the community being studied, rather than a foreign organization coming in and asking questions. Table 2.1 compares the two types of surveys.

TABLE 2.1 COMPARISON OF RA AND QUESTIONNAIRE SURVEYS

Questionnaire Survey	*RA Survey*
Formal questionnaire	Semi-structured interviews
Long time	Short time
High Cost	Low cost
Low participation percentage	High participation percentage
Inflexible structure	Flexible structure
Analysis in office	On-the-spot analysis
Heavy statistical analysis	Little statistical analysis
Random sample	Opportunity sample
Enumerators	Multi-disciplinary team
Useful for gathering representative, quantitative data and statistical analysis	Useful for learning and understanding rural peoples opinions, behaviors, and attitudes

RA surveys do have several shortcomings and certain crucial considerations that should be kept in mind. First, RA surveys are team-based, preferably a multi-disciplinary team, and the wrong composition of the team can seriously jeopardize the quality of the research. For example, the team should be an equal mix of men and women or else risk a gender bias among the sample population. The flexibility and nature of the RA survey, which are its strengths, can also potentially be its downfall. Potential shortcomings, briefly listed, are as follows: by moving too quickly, the survey data may become superficial or partial; there is human desire for simple answers which may lead to a quantitative-based survey. Similarly, it is much easier to conduct a questionnaire-based survey, and it is often difficult to find the correct questions to ask in a RA-style survey; a lack of community involvement, understanding, and rapport will seriously undermine the survey; bringing your own values and judgements will have a larger impact on the results in an RA survey than in a traditional survey.

In Fostering Sustainable Behavior, 1999, Doug McKenzie-Mohr and William Smith discuss the proper technique for constructing, executing, and analyzing a survey. Although their focus is on sustainable development in America, many of their ideas and strategies have wider applications. They suggest doing a thorough literature search and then conducting several focus groups before constructing the survey. This background information will help define the survey and what the focus should be on.

The authors itemize seven steps to creating a survey.

1. Clear Objective The simplest way to create a clear objective is to write a short paragraph describing what you hope to accomplish. This helps to clarify the objective, as well as providing an early goal that can be shared with others, especially those with a background in the subject.

2. List Survey Items The survey items are all the questions that might constitute the survey, and are usually derived from the information gleaned during the literature search (and focus groups, when possible). After listing the items, they should be put into logical categories to provide structure to the survey. Once the items are listed and organized, check them against the objective statement derived in Step 1. All the items/categories that do not fulfill the objective should be dropped.

3. Write the Survey In writing the survey, the authors recommend making sure all the questions are closed-ended, because that keeps the interviews short and makes analysis easier, much like a KAP survey. However, I found it impossible to cover the subject with closed-ended questions – there is far too much variability and subtlety that go into questions of water and sanitation. While questions such as “Do you like

the BSF" are overly vague because "like" means many things to many people, it is not possible to specifically ask about all the possible parameters that the respondent may or may not "like". They also suggest using KAP-style scales to help orient the interviewee (e.g. see question 8 in Appendix 1). This did not work well in Nepal, where the units of time and distance are less precise than in America. However, an important point McKenzie-Mohr and Smith make is that each question should positively answer each of the following questions:

- Is this a question that can be asked exactly as written?
- Is this a question that will mean the same thing to everyone?
- Is this a question people can answer?
- Is this a question that people will be willing to answer?

4. Pilot the Survey They recommend piloting the survey with ten to fifteen respondents. While this is good advice, because it allows you to focus and tighten the survey, it is not always practicable, particularly when the target population is 10,000km away. The piloting process helps give an accurate estimate of the length of the survey, which is useful in determining the amount of time to allot to the actual interviews, as well as the necessary budget to conduct the survey.

5. Select the Sample Under ideal conditions the sample selection can be derived from a randomly generated list of addresses or phone numbers. However, in the developing world it is often impossible to have such a resource, and even if you did the survey would be biased towards the wealthy (i.e. the ones who can afford phones). In Nepal, for example, street addresses were rare and so basing the sample on addresses would be misguided. In that situation, getting a truly random sample is difficult and may simply have to be accepted as impossible, in which case an *opportunity* sample should be utilized. An opportunity sample is one where the sample population is randomly chosen by walking down the street, for instance, and asking people to be interviewed for your research.

6. Conduct the Survey If phone numbers or street addresses are available and appropriate, contact the interviewees through that list. Otherwise, travel from

household to household and ask the people if they are willing to be interviewed for this research. In the situation described in this report, the sample population was necessarily selected because they were the ones who owned the BSFs.

7. <u>Analyze the Data</u> The authors recommend using statistical computer packages to analyze the data, particularly when examining the multivariate data. While this is probably considerably faster, a careful item-by-item analysis will give the research a more thorough understanding of the information and what it means. The final analysis should be organized with the original considerations in mind.

An important attitude to guard against both in creating the survey and conducting the interviews is the belief that the barriers to behavioral modification are already known, especially in a culture that is significantly different from one's own. Assumptions often lead you in the wrong direction, with embarrassing results. For example, during my interviews, I frequently asked if the respondents would be interested in having water piped to their residence. I was asking simply to gauge the enthusiasm for such for a project, but the respondents thought I was *selling* the project, and were reluctant to discuss it lest they inadvertently commit themselves to an expensive water project.

For this research, the survey was a combination of all the above information and theories. The subject matter, budget, and time frame all lent themselves to the RA-style of surveying. However, RA surveys require a multi-disciplinary team, as well as some experience in surveying. I had neither, and so used a questionnaire-based study to aid and structure my research. Nonetheless, the survey was designed to evolve in the field as information came to light after the model of RA surveys, with questions and sections being created and dropped along the way. See Section 3 for a discussion of the survey instrument, and Appendices 1 and 2 for copies of the surveys.

2.3.2 Behavioural Change and Sustainable Development

While there has been significant research done on behavioral change in the developed world, the research on the developing world is more difficult to come by, particularly as it applies to sustainable behavior. Therefore, I've looked at some of traditional theories of behavioral change and will seek to apply them to Nepal's particular situation, using behavioral change examples drawn from water treatment issues.

The 1972 article Attitudes and Normative Beliefs as Factors Influencing Behavioral Intentions, by Icek Ajzen and Martin Fishbein, proposed that a person's behavior is determined by the following components:

1. A personal estimate of the probability of success of a change in behavior
    a. The personal attitude towards the act
2. The estimation of friends and family of the probability of success
    a. The subject's estimation of how friends and family *expect* the subject to perform with regards to the action

What the authors found is that a person's actions are composed of the sum of components 1 and 2, each weighted by component 1.a and 2.a, respectively, with component 1 dominating the equation. What this shows is that an action is determined by the individual's estimate of the likelihood that the proposed action will be successful, multiplied by his personal feelings about the action. This is combined with the influence that the individual's friends and family exert, both in their overt estimation of the success of the action as well as the individual's belief of how his peers think he *should* act.

Applying this theory to behavioral change in regard to the adoption of development projects would take this form: the target population needs to believe that the project is both worthwhile and necessary to the improvement of their lives, as well as having a high probability of success. Less important would be the influence that the community and friends has on the individual's behavior. So, if an individual believes that a water treatment system will definitely change their life and that this change is a beneficial one, they will be more likely to adopt the program, even if the community disagrees. Naturally, if the community does agree, the probability of success is even higher.

Another influential study is In Search of How People Change, by James Prochaska, Carlo DiClemente, and John Norcross, published in 1992. The authors identify five steps of mental preparation that people experience before changing their behavior. This study was undertaken to understand why people end addictive behavior, with and without professional treatment, but the basis of behavioral progression has wider applications. The five steps that they identified are *pre-contemplation*, *contemplation*, *preparation*, *action*, and *maintenance*, with each stage having particular characteristics and definitions.

1. <u>Pre-contemplation</u> In this stage, there is no intention to change one's behavior. Individuals in this stage would not be aware that there is a water quality problem, or that it directly affects them and their family. When a behavioral change program is thrust upon individuals in this stage, it will probably fail.

2. <u>Contemplation</u> The contemplation stage may span years and indicates that an individual is aware that there is a water quality problem, but is still not prepared to take any action to alleviate it. There is a struggle between the pros and cons of the behavior change - while getting a water treatment system may improve one's health, there is also the cost involved in purchasing the system, along with the additional work-burden of maintaining it, and an added inconvenience of filtering water instead of drinking it directly from the source.

3. <u>Preparation</u> When an individual is in the preparation stage, they have both the awareness that behavioral change is necessary and the intention of doing so within the near future. In this stage, the individual realizes that the water quality has serious consequences for their health, and that these issues need to be addressed immediately. Despite this, the individual has not taken action to modify their behavior.

4. <u>Action</u> In this stage the individual has successfully altered their behavior for a period of up to six months, which requires a significant commitment of both time and energy. While *action* is often equated with *change*, this is not necessarily the case, as many individuals slip from new behavior back to old habits. An individual may decide that it's simply easier to go back to drinking water directly from the source than to carry the water back to the treatment system and treat it.

5. <u>Maintenance</u> During this stage, the individual struggles to continue their behavioral change, and to fight returning to old habits. There can be a significant number of

spirals from *maintenance* back to *preparation* and/or *action*, before returning to *maintenance* and ultimately sustaining a behavioral change. While this lapsing is readily seen in addictive behavior, such as smoking, it was also observed behavior in this survey as shown in the data discussed in Section 4, where several respondents filtered the cloudy water of the summer, but lapsed back to their old drinking habits when water clarity improved in the fall. However, with a purchased water treatment system, the individual has not only made the time and energy commitment, but a significant capital commitment as well. The compounding effects of these commitments may help the individual resist relapsing to old habits.

What these five stages illustrate is that for any treatment program to be successful, it must make sure that the population is at least in the *preparation* stage, and is also willing to move rapidly into the *action* stage. Additionally, there must be some support to enable the population to carry the *action* stage into the *maintenance* stage without suffering too many relapses.

McKenzie-Mohr and Smith also provide some insight into changing behavior in Fostering Sustainable Behavior, 1999. In it they identify three barriers to adopting sustainable behavior. First is a lack of information; naturally people will not pursue a water treatment program if they are not aware it exists. The second barrier is that while people may be aware of the technology or behavior, they may feel that it is too difficult, complicated or expensive to utilize. Finally, people who are aware of the technology may believe that it is simply easier and more convenient to continue with their present behavior, i.e. why bother filtering when it is easier to drink directly from the source?

Conversely, people will naturally gravitate towards behaviors that have high benefits and few barriers. An important consideration is that people's perception of barriers varies significantly from person-to-person, and this is particularly true when crossing cultural and socio-economic borders. Furthermore, it should be considered that behavior competes with behavior, i.e. changing one's drinking behavior (drinking filtered water) necessitates rejecting another behavior (drinking unfiltered water). It is clear, therefore, that one must understand the barriers to adoption before implementing a new program, and plans should be made to overcome the barriers. Often, however, unforeseen barriers arise. For example, as described below, the BSF requires cleaning whenever the flow rate drops. The flow rate is determined in part by turbidity, and should the turbidity be excessively high for an extended period of time, then the labor of maintenance becomes a significant barrier.

After the barriers have been identified, strategies can be developed to overcome them. An effective technique is the spread of information, i.e. information. Once people are aware that there is a problem with their water, but there is a simple, effective, and cheap device that will solve the problem, further steps to adoption become simpler. Another important step, if feasible, is to observe the target population at length to note what behaviors may be a barrier to adoption that are not readily found in either research or focus groups. Such barriers may be that the people tend to drink the nearest water source, and so when they are away from the BSF, they will consume unfiltered water. Finally, the authors recommend finding a “block leader” in the community to use the treatment technology, and agree to speak with other people in the community about it under the theory that people are more likely to change their habits if they see some one else do it first. This is in contradiction to the Ajzen and Fishbein study mentioned above, which played down the role of this form of “peer pressure.”

3.0 METHODS

Historically, engineers have focused their attention on strictly technical matters, but, as mentioned in the introduction, this narrow focus does not guarantee the success of a project. I undertook this exploratory research to try to find methods that would aid the implementation of engineering water treatment projects. However, because of the non-traditional subject, the development of my research frequently had to re-evaluated, restructured, and redeveloped. This section explains the evolution of my methodology.

A survey instrument for this project, discussed below in Section 3.1, was developed from a base survey created by MIT Department of Urban Studies Assistant Professor Jennifer Davis for a broad evaluation of people's willingness and ability to pay for water infrastructure. Her survey was restructured to focus more specifically on drinking water practices and to reflect the unique situation that we expected to find in Nepal. This instrument proved to be inadequate for this fieldwork, and it, too, was reorganized and expanded.

FIGURE 3.1 NATHANIEL PAYNTER (IN GREEN HAT) CONDUCTING AN INTERVIEW WITH ARJUN CHETTRI (IN RED CAP) TRANSLATING.

Once we arrived in Nepal, Arjun Chettri of HFTN guided Tse Luen Lee and me to the BSFs. The BSFs were typically installed in either remote households in the Tansen area of the Palpa region, or along the main East-West highway in the Naranghat area of the Nawalparasi region. While Lee collected his samples, I interviewed the BSF owners for twenty to thirty minutes via Arjun, who translated, as shown in Figure 3.1. After the interview, the longitudinal, latitudinal, and altitudinal coordinates were collected with the Garmin E-Trex Summit Global Positioning System sensor. This methodology was repeated one to two times a day in Palpa, and up to seven times per day in Nawalparasi. The higher rate of interviewing in the second region was due to the relatively accessible terrain of the flat Terai. The day's data were then re-written into a readable format each evening. Upon returning to MIT, the data were analyzed using Microsoft Excel spreadsheets in order to find maximum, minimum, and average values as well as trends and correlations.

3.1 The Survey Instrument

The survey used in the interviews went through several stages of evolution before the project ended, and there are clearly other steps remaining for it to go through for following researchers. It originated as a KAP-style survey, before evolving into a RA/KAP hybrid. This section examines the evolution of the survey, and both the original and the field surveys - Survey 1 and Survey 2, respectively - are presented in Appendices 1 and 2. The reader will better understand the following two sections after reading the Appendices.

3.1.1 Original Nepal Survey

Survey 1 was designed with specific goals and expectations in mind. It was structured to have a very precise evaluation of the health, sanitation, and filtration situation in Nepal. Each question was broken into three to sixteen possible responses in an effort to determine exact relationships and make data analysis easier upon return. Survey 1 was broken into five major sections: *background*, *current practices* (including shared and private resources), *improvements*, *filtration*, and *current sanitation services*. It suffered from both too much breadth and too much specificity. The breadth arose from an effort to create a general survey that would be useful in both Nepal and Haiti, in an effort to compare the water situations in the two countries. Simultaneously, Survey 1 used too much specificity in its detailed itemization of each section.

Background

The *Background* section was originally conceived as laying the groundwork for understanding the perspective of the respondent. This included noting their caste, ethnicity, gender, age, religion, as well as a general view of their perspective on water and noting any activities of community-based organizations. While this section did not need to be extensively reworked, it did need to be condensed as many of the ethnicities/castes overlap and have become essentially indistinguishable within Nepalese society. See Section 1.3. Additionally, it became clear that the question of age became irrelevant over the course of questioning as the respondents were all still of working age, i.e. from 15 to 60, and there were almost no complaints of aggravations due to advancing age.

The questions regarding views of water had to be reworked because it was difficult to explain to the respondents what was being asked. The point of the question was twofold: did the respondents view their water as being dirty and a source of contamination, and did they have a religious/cultural biases towards the water. However, this idea, as expressed in the open-ended question "How do you view water?" proved too difficult to convey across language and cultural barriers. Even with the prompting of "Holy/Pure", "Dirty", "Source of Disease", and "Other", satisfactory answers were not forthcoming. Eventually, this question evolved into a more open-ended "why do you skip filtration" and "why don't you use filtered water for anything other than drinking," with the ensuing conversation guided toward an understanding of any cultural or religious barriers.

Current Practices/Situation

This section intended to examine the health and water practices of the respondent. It was constructed with the intent of developing baseline data of the area illustrating broad issues and themes in a given town or region. Questions covered episodes of diarrhea (both for the respondent and respondent's family), attitudes towards using filtration systems, and water sources.

The questions regarding diarrhea were too precise, especially for a country where watches and calendars are uncommon. In asking for the number of diarrheic episodes in the past year, responses tended to be, "A few", "some", "less than before", or similarly vague. This vagueness is understandable given that diarrhea is a relatively common ailment in Nepal, and episodes probably don't warrant much notice unless unusually severe. It might be analogous to asking an American how many times they've had a cold in the past year. The question was ultimately reshaped to a comparative statement for before and after the BSF.

The filtration question was entirely out of place in this section, and should have been inserted into a section devoted to filtration. However, it was ultimately a pointless question since all the respondents visited were chosen because they already had BSFs. It had been included under the original plan of evaluating attitudes towards various possible household treatment methods.

Although the information gathered by the questions regarding water use and needs is quite useful, this section, too, needed to be reworked, though not as extensively as the previous sections. These questions examined type of water distribution system along with the respondents' knowledge of type, installation and maintenance, including questions designed to evaluate the amount of work that is devoted to collecting water. Finally, it looked at attitudes towards the taste, color, and odor of the water, both primary and secondary sources. This section, and most of the others, should not have been multiple choice. Although some of the questions warranted straightforward numerical answers, many of the others were more open ended and a multiple-choice survey cannot adequately address that. Also, Nepalis appear to be lucky in that they rarely run out of water - well and spring users almost never lack water, while people using piped water lack water only when the distribution system clogs or leaks. Therefore, many of the questions about the secondary system were either irrelevant, or the respondents couldn't remember.

Improvements

This section needed to be vastly expanded beyond the two questions of "What would you like to see in [the] way of water improvements?" and "How would that affect your family?" in order to address the range of possibilities for both water treatment and improved water convenience.

Filtration

This section, covering filtration techniques, motivations, and improved health, was good and provided much important data. However, like previous sections, the multiple-choice approach to these questions left out a lot of the finer points about filtration. The questions needed to be expanded and open-ended to allow for a wider range of responses.

Current Sanitation Services

The *Current Sanitation Services* section was included to attempt to quantify the types of sanitation that were in regular use in Nepal, along with the demand on the services, and the general condition and attitudes towards the system. This was supplemented with observational notes indicating the proximity of the latrine to both the home and water sources. This section was generally useful, and did not change much in the field, although when asked how they felt about the cleanliness, privacy, plumbing, the respondents universally replied, "It's a toilet, it's fine," so this question was abandoned.

3.1.2 Field Survey

As mentioned above, the actual field survey, Survey 2, took shape during the fieldwork in Nepal. While it helped to address the particular situation better, it did not develop all at once. Consequently some of the questions were created in the beginning of our time in Nepal, while others didn't appear until towards the end, with the result that the data are occasionally incomplete.

Background

This section was revised from the Survey 1 by adding some more pertinent information, including the name of the respondent, the town and region where they lived, along with the geographic location. The name was included so that follow up work with the respondent could be simplified. The town and regional information was added in an effort to see if there were localized differences in water use.

Water Source Information

In this section I was trying to understand how much work was involved in collecting water, whether it varied by season, and whose job it was to do this work. The section also looked at the portion of water that went towards filtering, along with finding out in what season water became cloudy. The goal of these questions was to get an idea of the total water-work burden, to see whether the BSF eased or exacerbated the water-work, and to find out the portion of work that would be dedicated to the BSF.

Health/Improved Health

This section was culled from the *Current Practices/Situation* section of the Survey 1, and focused on estimating the changes in health among the respondents since getting the BSF. The changes in this section reflect the broader perception of time that I found in Nepal. The original breakdown of diarrheic episodes was far too precise, and was ultimately pointless since the goal of this section was to evaluate the respondent's perception of the BSF's performance. Specifically, I wanted to know if they thought that they were healthier since using the BSF, and if the diarrheic episodes coincided with seasons of elevated turbidity. The placement of this section was wrong - it probably should have followed the *Filtering* section, since that forms a more natural progression.

Filtering

Very little in Survey 1 dealt specifically with filtering and other water treatment techniques. This became quite important once I learned that I would be focusing on the BSF, and so this section developed out of that necessity. There were many goals to this section, and it provided most of the data collected. It examined the attitudes towards the BSF, and what, in particular, the respondents liked about it. The section was kept deliberately open-ended and vague, because the parameters that it examined were similarly vague.

Additionally, this section looked at the performance of the BSF. Because Sagara found that the Indian and Nepali filters both had unacceptable flow rates, it was important to learn if the BSF was filtering water fast enough to be practical (Sagara, 2000). Another concern was whether or not the BSF could handle the extremely high turbidity that occurs seasonally in Nepal. I was also interested to know why the owners filtered the water, to see if they knew that the water was contaminated. Finally, once it became clear that the BSFs were not all donated, it was important to learn what the unit cost was, to understand if the technology could be applied across all economic sectors of Nepalese society.

There was some conjecture that the Indian and Nepali filters were in use around the country, and this section examined how widespread those technologies were. Once the BSF information was gathered, alternate water treatment technologies were examined. This was another way of understanding what the respondents knew about their water quality. For instance, if the respondents had always boiled their water, it would show that they had known for a long time that the water was contaminated. Alternatively, if they only strained cloudy water through a cloth, it would imply that they were concerned with water quality just when the water was visibly dirty.

Finally, this section looked at the drinking habits when the respondents were away from the house. I had a suspicion that most of the water consumption occurred when the families were at work, perhaps farming or doing construction. If that was the case, then the health improvements derived from filter could be significantly compromised.

<u>Maintenance/Cleaning</u>

This section did not exist in the Survey 1 because we were not sure of the types of filters that we were going to encounter. Once we focused on the BSF, we had to understand how much the owners knew about it. Because an important part of the efficiency of the BSF is the cleaning of the sand, this section was created to evaluate that. As I observed some of the Nepalese water practices, I became interested in how they stored water and how often those storage containers were cleaned. Much of the literature mentions that contamination often occurs during storage, particularly if the containers are not cleaned hygienically (Cave & Kolsky, 1999). So, it became important to learn how the water is stored, and how the storage containers are cleaned.

Water Use

I was curious about how the respondents used filtered water and why. This section, which probably should have been folded into the *Filtration Section*, was also created in an effort to see if there were any cultural or religious biases against using the filtered water for activities besides drinking. Unfortunately, it wasn't included until late in the fieldwork, and so did not provide complete information. However, it did show that while there were no religious/cultural biases against other water uses, the turbidity did play an important role in what uses the filtered water was put to. See Section 5.2.

Water Distribution

This is a stripped-down version of the *Current Practices/Situation* section of Survey 1, and the logic behind it is similar - I was trying to understand how much the respondents knew about their water supply. From this I was hoping to get an idea about how critical the supply situation was. For example, in America where potable water is generally supplied with regularity, my impression is that most people don't know much about their water supply. My supposition was that in a region where the supply and quality were intermittent, it would be important for the population to know who built the system, when did it break down, and what the alternative source was.

Latrine

Unfortunately, having two goals confused this section: 1) to gather information on latrines, and 2) to find out about the cost of water. Clearly, the second part should have been included in the *Water Distribution* section, as it was an examination of the respondents' ability to pay for municipal water. The first part consolidated Survey 1's section on latrines, because all but one respondent had a private toilet. Similarly, this section examined the distribution of latrine types to give an idea of how waste is disposed as well as evaluating the respondents' understanding of contaminant pathways. For example, if the latrine was installed next to the well, it indicated either a) a lack of space, or b) a lack of understanding about the connection between human waste leaching into the subsurface and contaminating the water supply.

4.0 RESULTS

4.1 BACKGROUND SECTION

The thirty-eight surveys were conducted in twelve villages within two regions. The distribution of villages within these regions is indicated in Figure 4.1. The percentage of interviews is shown per village, and the villages in the Palpa region have been shaded and

FIGURE 4.1 INTERVIEW DISTRIBUTION

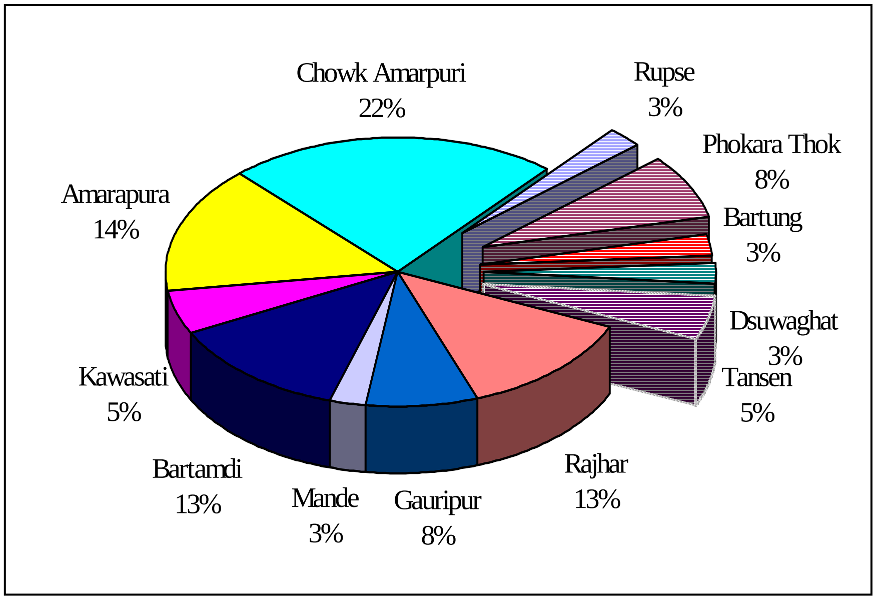
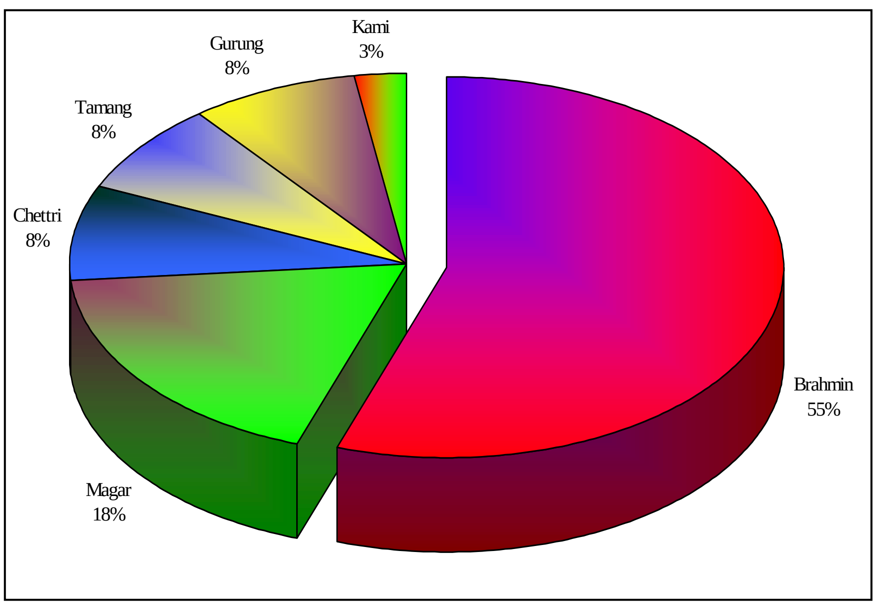


FIGURE 4.2 CASTE/ETHNICITY

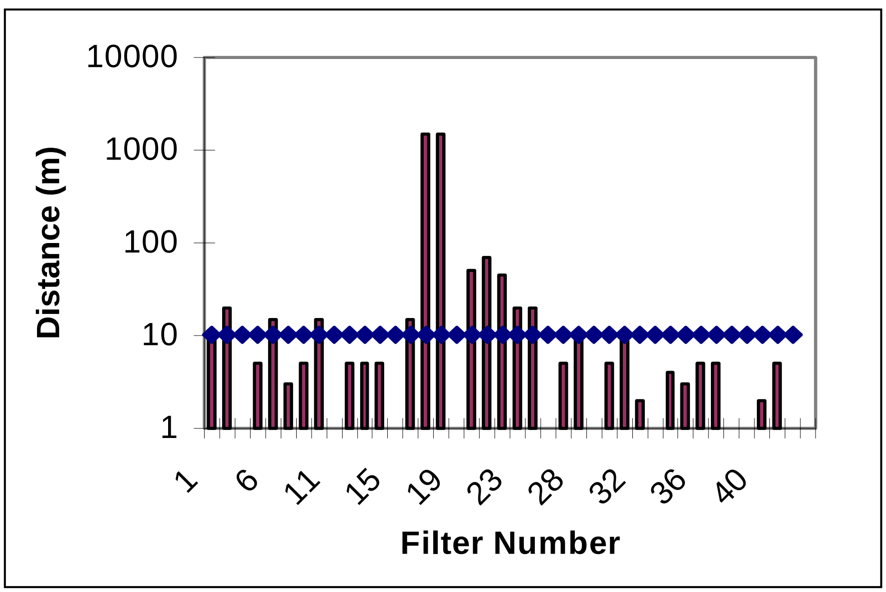


separated. Altogether, the Nawalparasi region had 79% of the interviews, while 21% of them were conducted in Palpa. The respondents were almost evenly split by gender with women comprising 51% and men the remaining 49%. Regarding caste/ethnicity, almost 50% of the respondents were the high-caste Brahmins. The overall distribution is illustrated in Figure 4.2.

4.2 Water Source Information

While seven respondents had water piped directly to their house, the majority collected water from a yard tap, standpipe, or occasionally the local river. On average, the respondents had to travel approximately 86m to collect the water, though in two instances they had to travel up to 1.5 kilometers[2]. If these outliers are disregarded, then the average distance drops to 10m. The data are shown in Figure 4.3, with the blue points indicating the 10m average distance traveled for water.

Figure 4.3 Distance to primary source

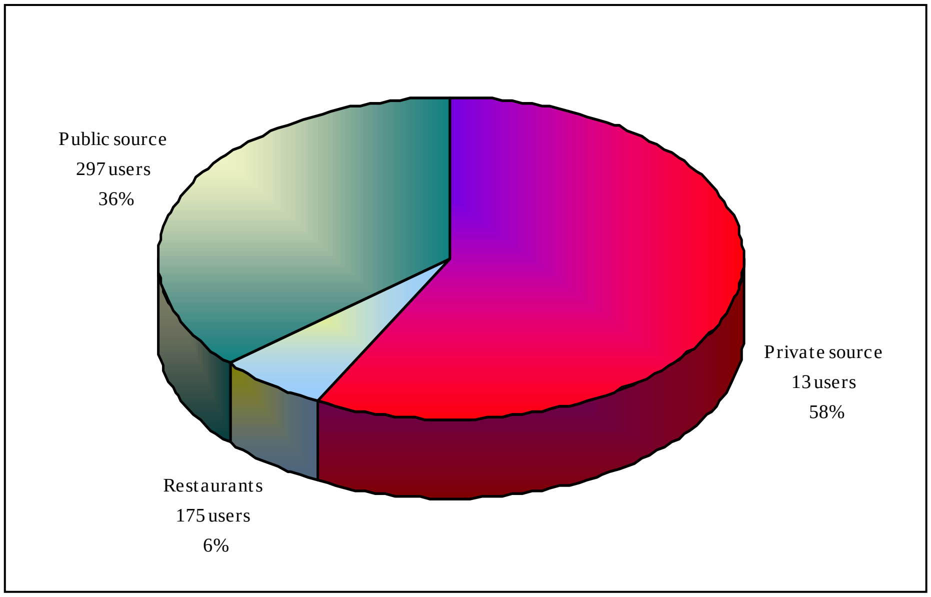


The number of users of the source depends largely on whether the water source is a private or yard tap, or if it is a public tap. If it is a private source, the average number of users of the source is the same as the number of users of the BSF - twenty-eight, when two restaurants are included in this category, or approximately thirteen when they are

[2] This survey was conducted during the dry month of January, and distances to water may vary seasonally.

omitted from the data set. In the twelve situations where the source is a public tap, the average number of users jumps to almost 300, with a range from 12 to 560.

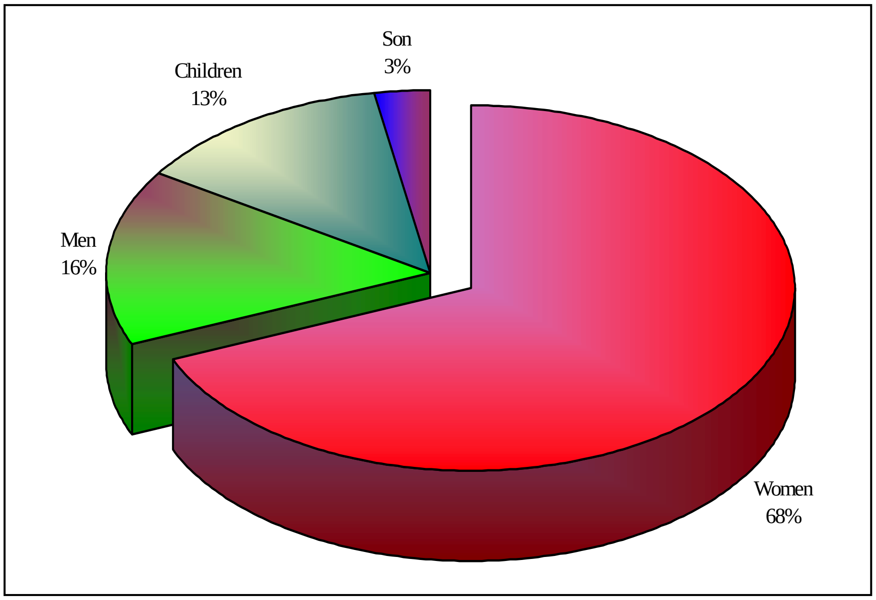
FIGURE 4.4 DISTRIBUTION OF SOURCE USERS



The number of trips required to fulfill the family's water needs varies slightly by wet and dry seasons, and the data are not consistent as to whether more or less water is needed in the different seasons. In the end the variability cancels out and there is a difference of only one trip between the two seasons. The dry season requires, on average, fifteen trips for water, while sixteen are sufficient for the rainy season.

Collecting water is a great deal of work, and in 23% of the interviews all members of the family carried it out. Nonetheless, the burden of collecting water is predominantly borne by women. 50% of them collect the water entirely themselves, and this percentage rises to nearly 70% when group water-collection is divided by gender and familial relationship, as shown in Figure 4.5.

FIGURE 4.5 WATER COLLECTION DISTRIBUTION



The respondents filtered on average four gagris (56 - 68L) per day, or approximately 6-6.8L per person per day. The residents in Palpa filter approximately two gagris per day, while in Nawalparasi they filter four. Perhaps because the predominance of interviews was conducted in Nawalparasi, the average is skewed to 4 gagris a day. Almost 90% of the respondents noted that the source water is frequently cloudy during the monsoon season. However, two of the respondents said their water is cloudier during the dry winter season, when their wells are drawn down so low.

4.3 HEALTH/IMPROVED HEALTH

The duration of time of BSF ownership ranges from sixteen days to over two years, with an average of just over one year. 56% of the respondents report feeling significantly healthier since using the BSF, with definite decreases in episodes of diarrhea, reporting the same results for their families. However, respondents often noted that they did not have a high incidence of diarrhea in general.

4.4 FILTERING

The respondents overwhelming report liking the BSF, particularly noting the high flow-rate, improved taste, and cooling effect on the water. 89% stated that they liked the BSF, while every respondent said that they got enough water out of the BSF because of the high flow-rate.

The interviewees report, and Lee's research supports, excellent turbidity removal. Thirty-seven of the respondents said that whenever cloudy water is poured into the BSF, it filters clear. One of them noted that when the filtered water is occasionally cloudy, he filters it a second time, and it filters clear.

The eight BSFs examined in Palpa were built and donated by HFTN. In the Terai, HFTN has contracted a local manufacturer to build and sell the BSFs. Though listed as costing Rps2,500 (US$32), the average value reported was Rps2,100 (US$27).

While 76% of the respondents indicated that they filtered water to improve their health, many people - 24% - in the Terai bought the BSF in an effort to remove the seasonal cloudiness that comes with the monsoon (and occasionally in the dry season).

Alternate forms of filtration are still not prevalent in Nepal. 57% of respondents do not practice any other form of water treatment, although a fifth indicated that they routinely boil water to improve its quality. Straining the water through a cloth is the next most prevalent form of treatment, although many interviewees have stopped straining since acquiring the BSF. This is shown graphically in Figure 4.6.

FIGURE 4.6 ALTERNATE WATER TREATMENT

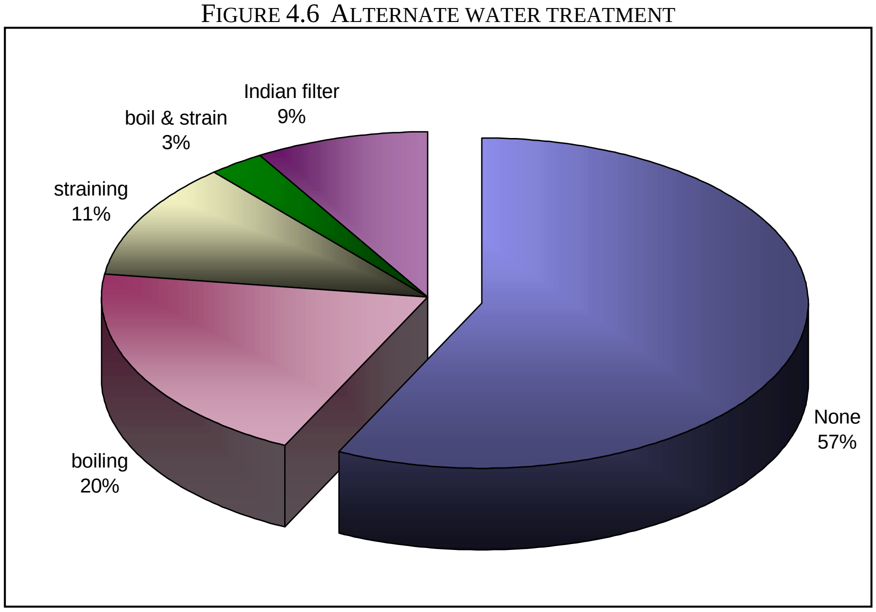


FIGURE 4.7 INDIAN FILTER

FIGURE 4.8 NEPALESE FILTER

Photos of the Indian- and Nepali-style candle filters, pictured in Figures 4.7 and 4.8, respectively, were shown to the interviewees. 76% of them had seen the Indian-type filter while only 30% had seen the Nepalese-type filter. Three people formerly used the Indian filter, but stopped because of the low flow-rate. While at home the respondents indicated that they rarely, if ever, skipped drinking filtered water, and then only if they were very thirsty. However, three people in the Terai reported stopping using the BSF altogether when the source water was no longer cloudy. 52% of the people interviewed either took filtered water with them, bought mineral water, or worked at home and therefore did not need to take the water. However, when the people who worked at home are discounted - none of them reported taking water when they leave their home/work - the percentage drops to just 26%.

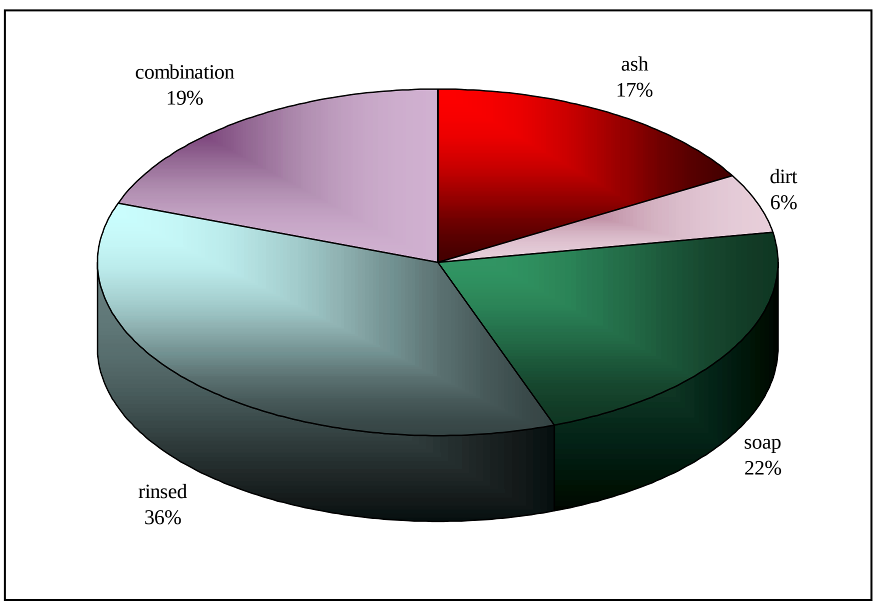
Although 89% of the respondents reported that they "like" the BSF, only 60% had no complaints regarding the filter and the remaining 40% had several criticisms of the BSF. The most common complaint was that people had been told that the BSF required constant flow, which 13% reported that they did not like. The constant flow necessitates more work for whoever collects the water, and there were also fears about overflowing the gagri which collects the filtrate. An equal number requested a tap be put on the spigot to control the flow. Other complaints were that the BSF was too heavy, that children are drawn to the constantly flowing water and play with it, and that the lid is too loose and bugs crawl in it.

4.5 MAINTENANCE/CLEANING

The respondents had great variability in their sand-cleaning schedule. 64% had cleaned the sand, on average, within four months previously, and all of them had been instructed on the proper method for cleaning. 38% had never cleaned the sand, either because they did not know how to clean it, had not owned the BSF for very long, or the flow-rate was sufficiently high that they didn't feel they needed to clean the sand yet. The regularity of cleaning varied seasonally. In the summer, during periods of high turbidity, the sand might need to be cleaned every week of two. However, during the winter when the water is clearer, the maintenance rate fell to every six months.

The general practice with cleaning the gagri is to wash it in the morning and evening, and to rinse it out with each use. Therefore the gagri-cleaning rate is directly tied to the water-needs of the family, and may vary from once a day up to twenty times a day. Additionally, in three situations the respondent had a hose attached to the tap that was used to fill the BSF, in which case the gagri that collected the filtered water was cleaned weekly. 36% of the respondents only rinsed the gagri, never thoroughly washing it. When the gagri is cleaned, in 17% of the cases it is scrubbed with ash, 6% with dirt, 22% with soap, 19% with some combination. This distribution is shown in Figure 4.9.

FIGURE 4.9 GAGRI CLEANING

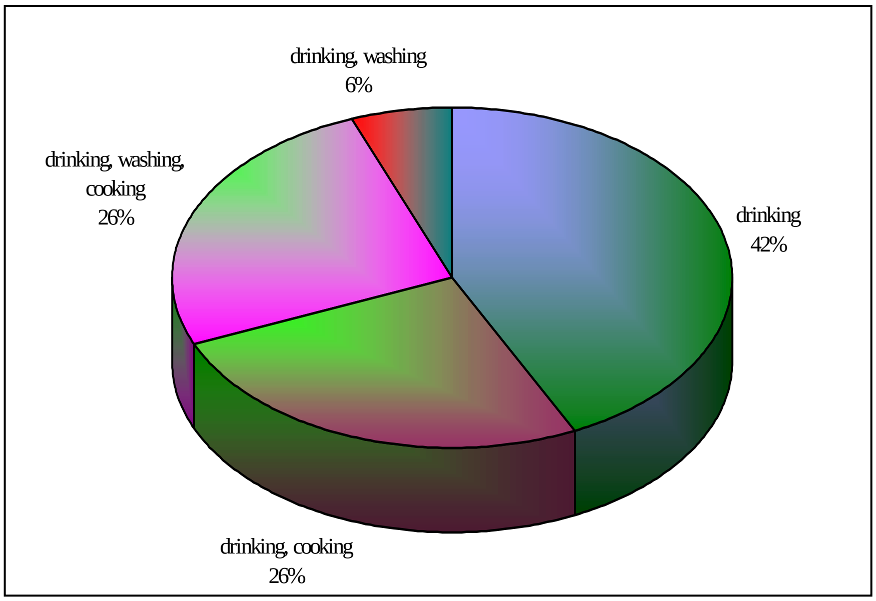


Every family stored water in gagris, but since they only hold up to 17L, additional storage is frequently needed to guard against dry periods. In addition to the gagris, water is stored in four types of containers. Buckets accounted for 46%, basins 11%, pots 4%, jug 4%, and 36% had no other form of storage. The large tanks are cleaned monthly during the rainy season, and every three months during the dry season, while the smaller containers are cleaned whenever the women have the additional energy to clean, about every three weeks. The tanks are scrubbed down with soap and brushes, while the other containers are simply rinsed out.

4.6 WATER USE

All the respondents who used the BSF drank the filtrate. However, in several situations they also used the water for washing, cooking, or some other combination with drinking. Figure 4.10 illustrates this distribution.

FIGURE 4.10 FILTERED WATER USE



4.7 WATER DISTRIBUTION SYSTEM

The interviewees reported that 43% of the water distribution systems were built by the government, and 14% of them were built by village organizations. In the Terai, where hand-dug wells are more common, several people had personal wells, and so were not part of the municipal distribution system. However, almost a quarter of the respondents did not know who installed their distribution system. See Figure 4.11.

FIGURE 4.11 WATER SUPPLY SYSTEM PROVIDER

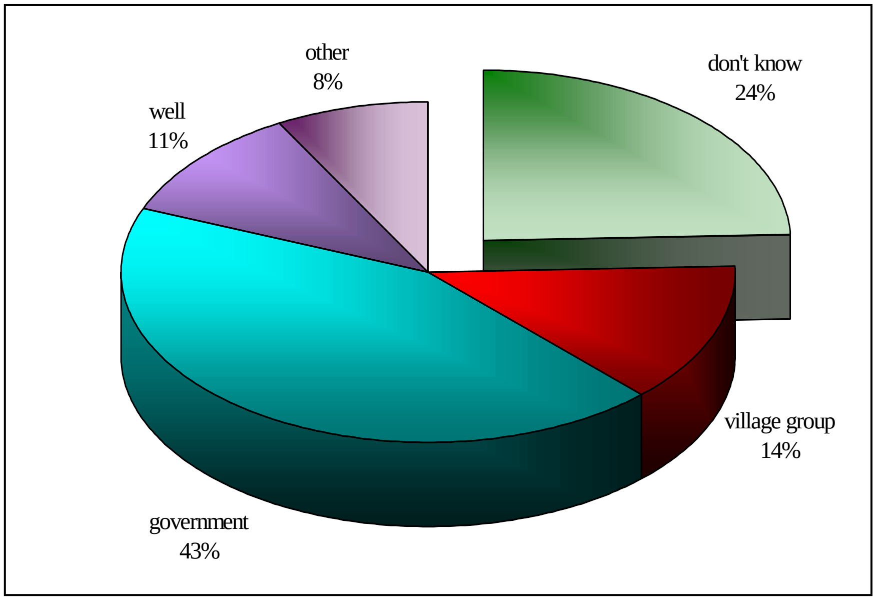


Figure 4.12 illustrates the water system failure. The respondents noted that the systems break down - or don't provide water - several times a year. While 46% of them did not differentiate the season, 17% reported that service interruption occurred during the wet season and 20% reported more occurrences during the dry season. When the service is interrupted either the government, the local village committee, or they themselves go and fix it in almost equal proportions. In some situations, the Nepal Water Supply Company (NWSC) built and maintains the system. See Figure 4.13.

FIGURE 4.12 WATER SYSTEM FAILURE

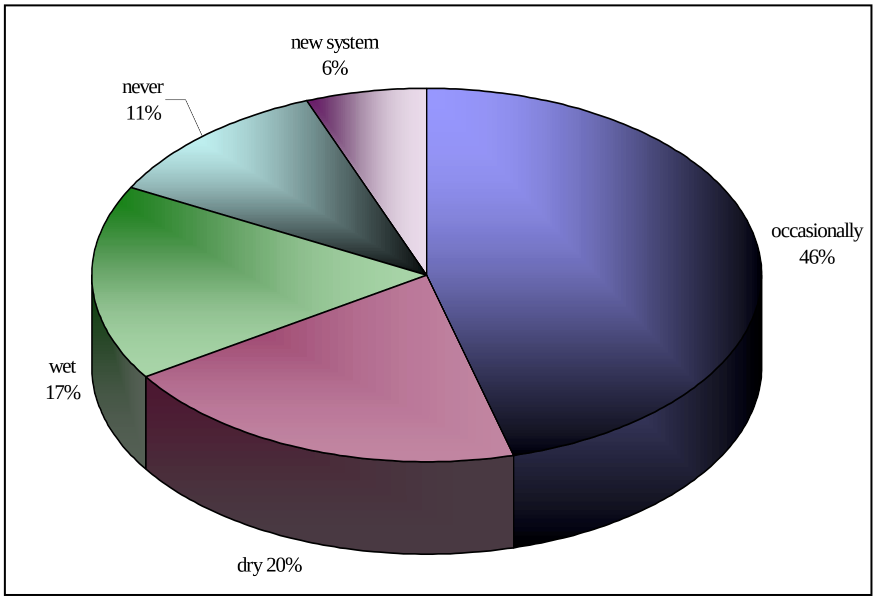
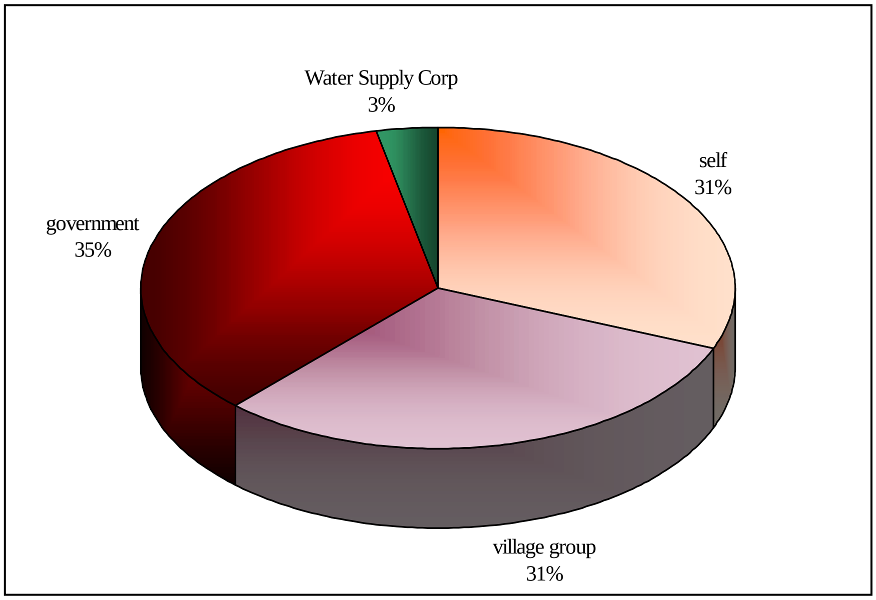
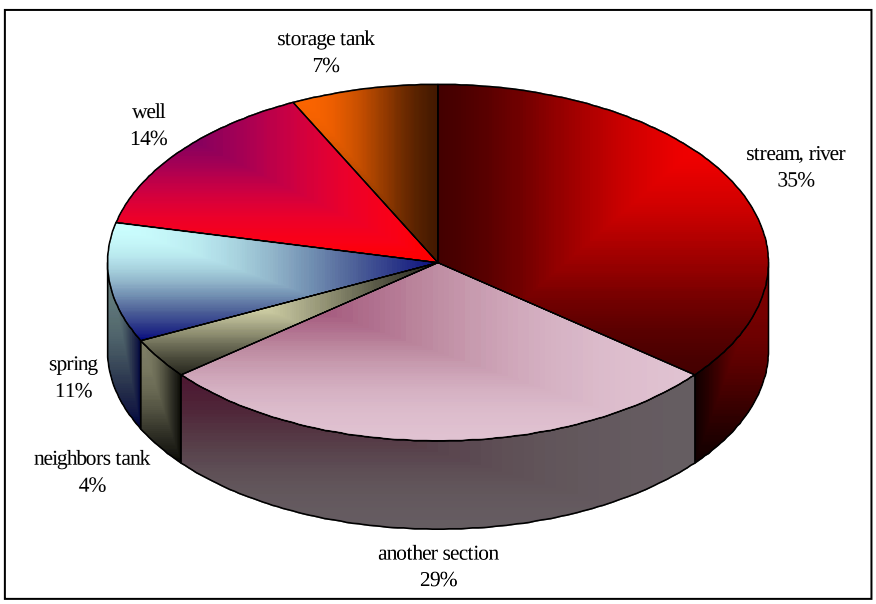


FIGURE 4.13 SYSTEM MAINTENANCE PROVIDER



During the period without their primary source, the respondents turn to several other options. 35% of them go to the nearest stream or river, 29% go to another, distant, section of the distribution system, 14% go to the nearest public well, 11% get their water from a nearby spring, 7% use water that they've stored in their tank, and 4% use water from their neighbor's tank. See Figure 4.14.

FIGURE 4.14 ALTERNATE SOURCES



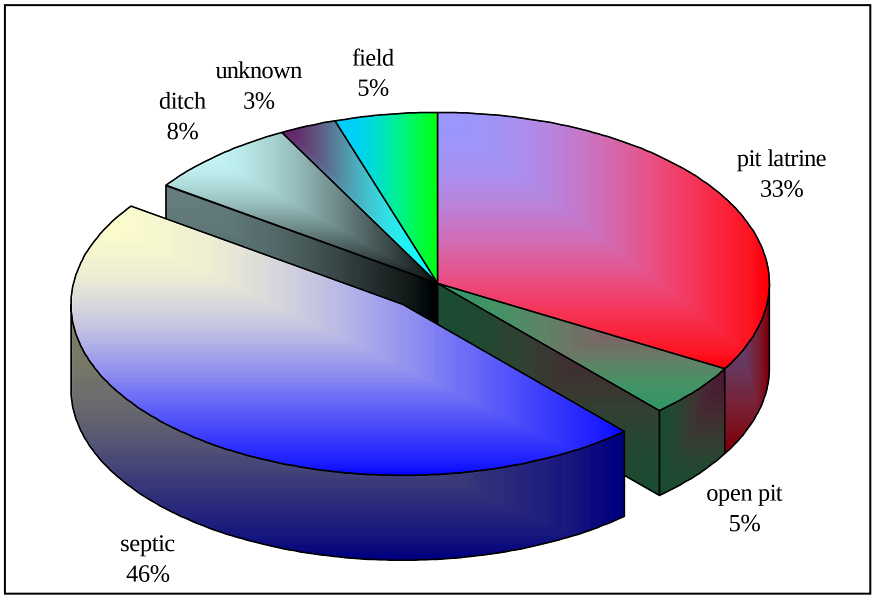
In the outlying areas of Palpa, the water is distributed free of charge. In Nawalparasi many households have private wells, on average fifteen meters deep, from which they pump the water up to their house. Other households have private lines that tap into the municipal line, usually at a one-time cost of Rps.8,500 (US$115), although they still pay a monthly water fee of approximately Rps100 (US$1.35). Still other households use the public tapstand in the center of the village. The tapstand is also attached to the municipal supply, and a monthly fee is charged for that use, as well as for the private lines attached to public mains.

In the Terai, the system of water distribution is that the municipal water supplier provides water on either metered or un-metered rates. The un-metered rate is Rps.100 (US$1.25) per month, while the metered rate depends on usage. The average metered rate is Rps.30 (US$0.40) per month.

4.8 LATRINE

50% of the respondents in the Terai own septic tanks, while 46% of the total sample population did, as illustrated in Figure 4.15 below. In Palpa they generally use pit latrines, and in two situations the latrine was of a type that could not be explained. The latrines are, on average, seven meters away from the household. The septic tanks were installed professionally and paid for by the owners, while the pit latrines were paid for and installed by the owners.

FIGURE 4.15 LATRINE TYPES



5.0 DISCUSSION

Before examining the results of the data, the limitations of the survey should be noted. First, the survey was conducted during a short period of time over a small area of Nepal, and so should not be broadly applied without wider study. Nepal's terrain encourages a tremendous ethnic and social diversity, and it is impossible for this brief examination to cover such diversity rigorously. The data bear this out - two religions represented and only a handful of castes/ethnicities.

FIGURE 5.1 CONSTRUCTING A BSF IN NEPAL, WITH A MOLD IN THE BACKGROUND

I am also wary of the respondents' replies, and the biases inherent in the interviewing process. In interviews there is often a desire to please the interviewer, to give them the answers you think they want to hear. In this situation we wanted to hear that the BSF worked well and was widely accepted, so I am not convinced that the respondents were absolutely straightforward in their responses. However, I do not have any evidence to either support or debunk this theory, but believe that it should be considered. Additionally, all the respondents owned - and many paid money for - the BSF. This generates a bias in the sample because they do not have any resistance (cultural, social or religious) to filtering in general and the BSF in particular. Finally, because most of the respondents paid a lot of money for the filter, it implies that they have an income beyond that of the "average" Nepali family, and so an economic-class bias is likely.

The act of having the questions translated - in both the asking and replying - also brings up questions of accuracy, and if possible should be avoided by having a Nepalese-speaking interviewer. The translator may give the simplest reply, without showing all the shadings and nuances of degrees of enthusiasm or distaste. Or the translator may misunderstand the question or what the interviewer means to imply. Finally, in this situation the translator was not a disinterested party - he was a co-founder of Hope for the Nations and so had a stake in the BSF program. This is not to imply that there was any manipulation of the translation - far from it. However, in such a survey, a better practice would be to have a disinterested third party act as the translator.

5.1 Background Section

The background section illustrates the exploratory nature of the research. While there are built-in biases in Survey 2 due to the realities of the BSF program, this pilot project offered a rare opportunity to study one of the first groups in Nepal to regularly use a point-of-use water treatment system. The bias evidenced in this section is born of necessity because we needed to go to the places where the BSFs were installed and interview the people who owned them. Therefore, a disproportionate number of the interviews were conducted in the Terai, where BSF construction and transport is made considerably easier - and therefore cheaper - due to the flat terrain.

Another facet of this bias is demonstrated in the caste/ethnicity distribution. Over 50% of the respondents were Brahmin, the highest and traditionally wealthiest caste in the Hindu caste system. This is indicative of the fact that in the Terai, where most of the interviews occurred, the BSFs were being sold at a price beyond the means of the average Nepali. As currently priced, the BSF costs approximately 15% of the annual income (US$220) of the average family, and while this is a one-time cost and the maintenance is free, it is unlikely that most families will make this sort of investment. It is generally believed that people cannot afford to spend more than 5% of their annual income on water and sanitation, or 2.5% of there income on water alone (Pickford, 1995). In all likelihood, the Brahmins are about the only caste that can readily afford the BSF. However, there are other parameters to be examined beyond the scope of this report, such as the caste/ethnicity population distribution in the Terai vs. Palpa, the relative water quality between the regions which may drive demand and force people to buy the BSF when they cannot readily afford it. Interestingly, in Palpa where the BSFs where donated by HFTN and therefore might include a broader cross-section of society, there is also a bias towards the Brahmins.

5.2 WATER SOURCE INFORMATION

I was surprised at how convenient the water supply was for the majority of respondents. However, many respondents noted that the system had been installed within the past year, perhaps indicating a drive by the government (who installed 43% of the water sources examined) to provide more water more conveniently. Certainly, to have the source 10m (or 86m) away appears to be a considerably reduction in workload for the women who collect the water. This may not be the case, though, because several respondents noted that it is the tradition in Nepal for the women to collect water when it is a short distance away, while men collect it when it is further because the water is so heavy and the men are stronger. So, this water distribution expansion may be increasing the workload of women. Unfortunately, I don't have any hard data on this theory, and it should be examined more rigorously, and weighed against the benefits of having yard taps and stand pipes. In a 1991 study, S. A. Esry found that improving the *quality* of a water supply was less important than increasing the *quantity* under the theory that the greater quantity of water may flush away the pathogens(Esry, 1991).

It was unexpected that the water needs would be so similar in both the wet and dry seasons, because it seemed that the abundance of water during the wet season would greatly reduce the need for collecting water. However, on consideration it becomes clear why that is not the case. During the wet, monsoon season, there is indeed an abundance of water and therefore the families who have cattle, but do not drive them to water, can collect the rainfall for the cattle's consumption instead of hauling the water from the source. However, the monsoon season also corresponds with the warmest part of the year and so many respondents noted that they consumed much more water in that period. Additionally, chores that were normally done at the source, such as dish and clothing washing, now need to be done near the BSF because the extremely high turbidity that occurs in this period requires that *all* the water be filtered. All the water needs to be filtered because one cannot drink, cook, or wash dishes with cloudy water. In turn, this means that water needs to be collected and filtered for these chores.

Conversely, the dry season coincides with the cold, dry, winter months, and interviewees report drinking less water in this period while they need to bring more water for their cattle. It is surprising that the human and cattle consumption would be so similar, since almost 75% of the water collected goes to livestock. However, most Nepalis have only one buffalo or goat, and there are usually eight to ten times as many people in the family. The number of people who have a shop where the BSF is kept further modifies these data, because their water needs are not agriculturally based.

As expected from preliminary studies, women are the primary collectors of water in family. Figure 4.4 shows that women collect almost 70% of the water, and when one considers that a person collecting water needs to carry 14-17L (14-17kg) ten meters fifteen times a day, then it becomes clear that this is a tremendous amount of work. As a rough estimate, a 10m walk to the source might take five minutes, then five minutes to fill the gagri, and another ten minutes to walk home (the return trip longer because of the heavier load). This comes to five person-hours per day dedicated to water collection, and that does not take into account any lines at the water source, socializing with neighbors, or steep terrain which might lengthen the time. Almost a quarter of the families recognizes the labor this involves, and so spread it out over all the family members, or 37.5 minutes per family member per day, assuming an eight-member family. It would be interesting to note which occupations preferentially use the women for this chore, i.e. do more women on farms collect all the water, or do more women in shops?

The statistic that the respondents filter, on average, 6.4L per person per day is reassuringly close to the UNICEF estimate that a person needs 7L a day for drinking, cooking, and washing (Sprujit, 2001). This is a confirmation of the understanding that the *quantity* of water is not a problem in Nepal (i.e. there is generally plenty of water), just the *quality*, perhaps indicating that Esry's theory is not as applicable here. As shown in Figure 4.9, most of the water is only drunk, although many people sometimes cook and wash with it as well. This is probably an indication of the cloudiness of the water - which requires filtering before cooking and washing - rather than a prevalence of the belief that the filtered water is necessary for these activities. It is unlikely that filtered water is needed for cooking because most of the food cooked in Nepal is rice and lentils, which requires boiling, hence it is already receiving "treatment". Additionally, the effect of using filtered water for clothing/dish washing is thought to be negligible as the contamination concentrations are minor compared to those found on hands. Similarly, there is little evidence that recontamination within families is a serious concern because the family members would have developed resistance to the pathogens originating from other family members (VanDerslice & Briscoe, 1993). The low incidence of people washing dishes with the filtered water is also probably due to the extra labor involved. Most washing - selves, dishes, clothing - is done at the source, and so any dish washing involving filtered water requires more work as the water needs to be carried to the BSF, instead of carrying the dishes to the source.

It is unclear why respondents in Palpa filtered half as much water as the residents of the Terai. It may be because their families are smaller or that their individual water consumption is less because it is colder in Palpa and people tend to consume less water when it's cold. Or, it may be that the nine interviews in Palpa are not statistically significant in this case.

5.3 HEALTH/IMPROVED HEALTH

The 56% of the respondents who reported improved health is of concern because of the low value. Lee noted that several of BSFs in Nepal were not working properly, primarily due to poor maintenance and use of home-made, improper diffuser plates (Lee, 2001).

While it is easy to assume that the low incidence of improved health is due to the poor performance of the BSFs, an analysis of the connection between improved health and the proper removal of H_2S producing bacteria, total coliforms, and *E. Coli* by the BSF shows little correlation. Table 5.1 summarizes the correlations, and the low values indicate that there is another, unidentified, parameter (or parameters) that is more closely tied to improved health.

TABLE 5.1 CORRELATION BETWEEN IMPROVED HEALTHAND MICROBIAL REMOVAL

Parameters	*Correlation*
Health, T. Coli	0.47
Health, H_2S	0.32
Health, *E. Coli*	0.05

My conjecture is that this parameter is the drinking habits of the rural Nepalese. Everyone reported drinking filtered water at home, but very few of them took filtered water or bought mineral water while away from home. Although 52% reported either taking filtered water with them, buying mineral water, or working at home with the BSF, these numbers may be misleading and a more accurate value may be the 26% of the interviewees who always brought filtered water or bought mineral water. Here, too, there is room for debate because our research indicates that all but two of the bottled water brands in Nepal are contaminated as well. Finally, it is frequently difficult to find a sole parameter that controls health. As mentioned above, there is a theory that simply supplying more water may be more effective than supplying less, but cleaner water. Therefore, as more households get yardtaps or have water piped to the house, their health may improve. An interesting comparison might be between improved health and the BSF and a newly installed water supply system. Unfortunately data on the date of system installation were not collected.

5.4 FILTERING

While the evidence from Survey 2 doesn’t indicate that filter use is improving public health, on account of the filter performance and the other variables related to water and sanitation practices, there is a great deal of enthusiasm for the BSF. The 89% who report "liking" the BSF addressed more immediate, direct improvements in their water.

Particularly they noted that that the water tasted better, there was plenty of water, the BSF always removed the seasonal cloudiness and that the filtered water was cool (although one respondent said that it was *too* cool, and so she stopped using the BSF). It seems likely that it is these "non-essential" parameters - taste, amount, clarity, temperature - that will determine the acceptance of the BSF project. Because the health effects of the BSF may take months or years to become apparent - and that's assuming the BSF is being used properly - the non-essential parameters will greatly influence the user's decision to continue using the BSF. Of course, there are other parameters to consider in behavioral change, particularly the additional labor involved. Put another way, if a person has been using the BSF properly for half a year and doesn't feel any healthier, that person will be more likely to continue using the BSF if there are other, more tangible benefits that are not essential to the improvement of his health.

If the treated water tastes worse, because of chlorine added for microbial treatment or iron and sulfur added for arsenic treatment, or the BSF has a poor flow rate, such as with the Indian and Nepalese candle filters, or the filtrate is not clear, or the temperature is not pleasing, then the user will probably stop using the system before the health benefits become apparent. The risk of this is that if a person buys the BSF to remove the seasonal cloudiness, that person will only use the BSF during the "cloudy" season and will drink microbially contaminated water the rest of the year. Alternatively, the same person may become so enamored of the improved taste or cooler water that they decide to only drink filtered water year-round.

The Nepalis interviewed appeared to be well aware that their water supply is contaminated since 76% of them bought the BSF to remove contamination and improve their health. However, this datum does not tell the whole story. As noted above, very few Nepalese take filtered water with them or buy bottled water when they leave the house and so drink contaminated water whenever they are outside the home. Additionally, since the BSFs were supposedly sold as a microbial treatment system (Arjun, 2001), *all* the respondents should have been informed that their water is contaminated, and so 100% of them should be filtering water to remove contamination.

This, however, reflects more on the way the BSF was marketed and less on the Nepalis who bought them.

I was surprised at how few people had seen the Nepalese filter, especially in relation to the numbers who had seen the Indian one. However, much of our research was conducted within 20 miles of the Indian border, and last year's Nepal Water Project had noted the scarcity of the Nepalese-style filter (Sagara, 2000). In either case, while recognition of the Indian candle filter is high, the candle-filter technology itself has not made significant inroads into the lives of the people interviewed. As noted, only three people had ever used the Indian filter, while none had used the Nepalese one. The Indian-style users quickly abandoned the filter because of its extremely low flow rate, found to be 0.3L/hr, or 7.2L/24hrs (Sagara, 2000).

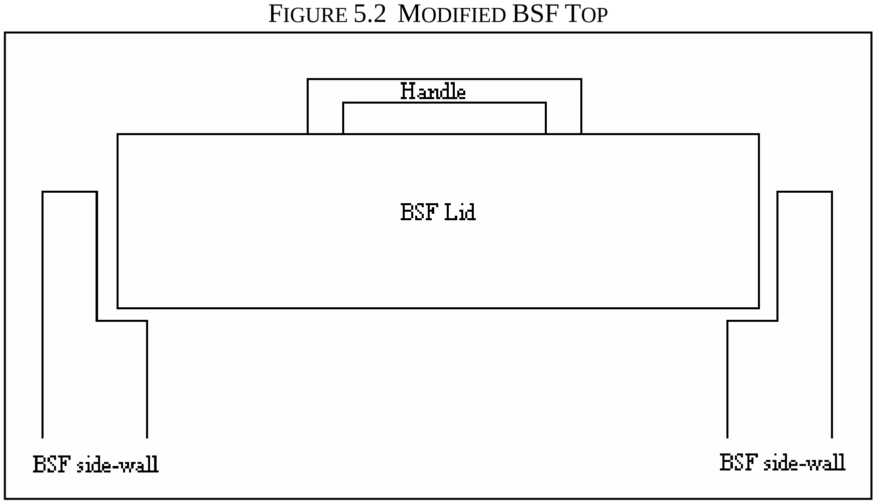
While alternate forms of filtration are still not prevalent in Nepal, the local population has several treatment methods that are in common use. Although a slim majority does not practice any other form of treatment, 20% of the respondents did report routinely boiling water to decontaminate it. This has two drawbacks in that it is expensive in terms of fuel consumption - which also contributes to deforestation - and that many respondents noted that they did not like the taste of boiled water. Nonetheless, a common home remedy in Nepal is to drink boiled water when you are feeling ill, particularly if it is a stomach ailment. This indicates that there is, on some level, an understanding that the source of disease is in the water, an idea that should probably be explored further. 11% strain the water to remove the cloudiness, and while this may make the water aesthetically pleasing and removes some of the particles on which microbes live and feed, the vast majority of contaminants is much smaller than the weave of the cloth and so slip through. The cloth would be a commonly available and inexpensive cotton fabric sold at many markets. Nonetheless, straining may be combined with the BSF in regions where the turbidity is exceptionally high and hampers the performance of the filter, although this issue requires further study.

The cost of the BSF is the biggest drawback for widespread implementation of the program. While many of the BSFs sold cost less then the list price of Rps2,500 (US$32), this was primarily due to a promotional offer in an attempt to drive up market awareness of the product. However, recent information shows that the BSF may, in fact, cost even more - Rps3,380 (US$45) - over 20% of the annual Nepali family's salary. At these prices, it is unlikely that the BSF will be appropriate for the poorest and most marginalized sectors Nepal's society or even the "average" Nepalese family.

The complaints of the users can easily be addressed either through education or minor design modifications. As noted in Section 4.4, most criticisms focused on the constant flow that is believed necessary to keep the biofilm viable. However, the BSF was specifically designed for intermittent flow, and as long as the resting water level is 5cm above the sand then the biofilm should remain viable. It appears that someone had incorrectly told the BSF owners that the filter required constant flow, but the next group of evaluators who visits these respondents can correct this misinformation. Without the constant flow, children won't be attracted to the flowing water and so will not risk contaminating the spigot with pathogens on their hands.

As for construction refinements, a tap could easily be attached to the spigot, although once there is an understanding of the intermittent flow capabilities of the BSF than it will be less likely that there will be a demand for taps. A tighter-fitting lid should be easy to make, or the BSF mold could be altered so that the lid fits onto a recessed ledge within the BSF as shown in Figure 5.2.

FIGURE 5.2 MODIFIED BSF TOP



Additional alterations to the mold may be necessary to make the assembly simpler where the sand layers are concerned. Because the layering of the sand is so important, the sand depths should not be left up to simple judgement. The mold could be modified so that a small ridge runs around the interior of the BSF at 5cm, 10cm, and 56cm above the bottom of the filter. These ridges would indicate that each grade of sand - gravel, coarse sand, fine sand - should be filled to the respective height.

There is nothing that can be done to alleviate the complaint about the weight of the BSF. Indeed, it is quite heavy and once it is assembled it will not be readily moved. However, the immobility is an integral design feature because each time a fully-assembled BSF is moved, the sand settles which will greatly compromise the flow rate of the BSF. The weight of the BSF could be used as a benefit, though, by making it an important part of the kitchen; for example, if brackets were attached, it could serve as one side of a shelving unit.

5.5 MAINTENANCE/CLEANING

The sand requires periodic cleaning because the top layer gets clogged with particulate matter which impedes the water flow. Therefore, the higher the turbidity or the greater the volume of water filtered the more frequent the required cleanings. With each cleaning, the microbial layer is killed and it takes about two weeks of growth before it can effectively be used to filter again.

It is difficult to prescribe a sand-cleaning schedule for the BSF because so much depends on the size of the family and the source conditions. The larger the family, the more water is filtered and the more often the sand needs to be cleaned. Similarly, the higher the turbidity, the more frequent the cleaning. A rough estimation of when to clean the sand might be whenever the flow rate drops below a certain level. The difficulty is in trying to find the appropriate flow measurement as it is unlikely that the Nepalis have the capability to accurately measure milliliters per minute. However, there may be a standard cup in Nepal that could be used to measure the flow while the owner counts sixty seconds. Unfortunately, in regions where the monsoon turbidity is so high that the sand requires cleaning every two weeks, the biofilm never has time to re-grow, and the BSF only uses the adsorption mechanism of filtering. Another question is how to properly measure the amount of sand removed. My recommendation is to use the length of the second knuckle of the index finger, which is approximately 2cm long.

The cleaning of the gagris illustrates the potential of contaminating the vessel and then pouring filtered water into it, resulting in contaminated water in the gagri. Although 22% of the respondents use soap to clean the gagri, the respondents who use sand, dirt or other detritus effectively re-elevate the turbidity of the filtered water, providing surfaces for the pathogens to grow and hide. In several situations, Lee found that the gagri had a higher turbidity than the filtrate, although there were few instances of re-contamination by *coliform*s or H_2S-producing bacteria in the gagri (Lee, 2001). Because water collection is such a burden and because sources run out during the dry season, water is frequently stored in an array of containers in case of water scarcity. Although these containers are regularly cleaned out in a manner similar to the process described earlier for cleaning the gagris, the water is then filtered and captured in the gagri, essentially rendering the question of cleaning these vessels moot.

5.6 Water Distribution System

Respondents knew a great deal about their water distribution system, illustrated in Figures 4.11 - 4.15, as might be expected in an area where regional distribution occurred in recent memory and service is intermittent. However, the men tended to be better informed about the water distribution system and maintenance, a possible indication of the limited information given to women in this society.

I was surprised that there were two seasons when service failed - the dry and the wet. It was explained to me that in the dry season the sources frequently dry out. One village appeared to be in a rather serious situation where they had to collect from the heavily polluted Narayani River, almost 6km distant. Alternatively, in the wet season, the distribution system often becomes clogged with dirt, leaves and branches, necessitating repairs. Often there is an organized village committee that maintains the system, but I did not get a clear idea of the structure of these committees, or how they are funded. Fortunately, all of the families had alternative sources of water when the primary sources failed, and often these sources are simply the old sources that the new distribution system has replaced. A point of consideration is that these secondary sources where probably replaced because they were 1) inconveniently located, and/or 2) severely contaminated. So, their use during these periods constitutes greater work, as well as the possibility of greater exposure to pathogens.

5.7 LATRINE

The prevalence of septic tanks was unexpected as they appear to be out of the price range of most Nepalis. Septic tanks cost, on average, Rps13,900 (US$188), or 85% of the average annual income of a Nepali family. In my surveys, though, the respondents appeared to be better off then the average Nepali and so could afford a septic tank. Additionally, the sandy soils of the Terai require a septic tank as the hydraulic conductivity is so high that any waste will be readily carried to the water sources in the region (NEWAH, 1996). Nonetheless, the expense involved in installing a septic system probably prevents much of the Terai's population from doing so. In Palpa, where the BSFs were donated and so do not indicate a wealthy clientele, the most common latrine was the simple pit latrine. Although there was a high incidence of septic tanks in the Terai, they were often installed next to the well, as shown in Figure 5.3. Of course, this merely exacerbates the water contamination. In one situation, we interviewed a man who was installing a well between his latrine and his chicken coop. Unfortunately, lack of space is often the deciding factor in the determination of where to install a well, and even if it isn't near their own latrine, it is often next to their neighbor's.

FIGURE 5.3 WELL IN CLOSE PROXIMITY TO SEPTIC SYSTEM

6.0 CONCLUSIONS AND RECOMMENDATIONS

The research discussed in this paper indicates that there is both a general acceptance of the BSF as well as a broad, general understanding of water and sanitation issues. The respondents showed both a willingness to change their behavior to incorporate the BSF in their daily lives and evidence of actually doing it. However, the study was limited in many ways, both in temporal and spatial scope, and more work needs to be done, particularly during the rainy season when the BSF's filtration capacity is taxed.

6.1 CONCLUSIONS

Survey 2 generated interesting data that showed the widespread acceptance of the BSF program, but highlighted its limitations as well. The BSF program fulfills many of the criteria laid out in Section 1.2.2:

- The BSF effectively removes microbial contamination when it is functioning properly (Lee, 2001).
- The BSF does not conflict with any religious or cultural mores.
- The BSF does not place a significant additional burden on the families.
- The system is easily understood and maintained by the Nepali users, although many of them have not been taught about the BSF.
- It fulfills three of the four criteria for appropriate technology.
    - However, at US$43/unit it is too expensive for the general Nepali population.

The BSF has two significant limitations, which are discussed at greater length below: it is relatively expensive, and it has limited capacity to handle the seasonal elevated turbidity of Nepal. Should these two limitations be accommodated in some manner, then the BSF would be entirely appropriate for Nepal.

The BSF program also has some important limitations that should be considered before it is expanded. First, whoever sells or distributes the filters should make sure that the recipients understand how the BSF works, how it is maintained, and that it is primarily for decontaminating water, a facet of which is removing cloudiness. This also means that the new owners need to understand water contamination and how it affects their health. The data show that most respondents did know about the water contamination, but were not aware of other possible contaminant pathways. I did not specifically research these, but for the BSF program to effectively improve people's health, the other fecal-oral pathways should be identified and eliminated as much as possible. These include washing hands, covering food to protect it from flies, overcoming a possible belief that infant's feces is harmless (because it is just mother's milk - Pickford, 1995), and education about the sanitation/water contamination connection. Further research needs to be done on all those topics.

To allow time to properly educate the target population, the BSF program will need to expand slowly. In Palpa there were only fifteen BSFs, and there was a better understanding of water contamination and issues of hygiene in the region as well, perhaps indicating that the program was managing the region well. However, in the Terai, there were over 100 BSFs, and a much higher incidence of misunderstanding about the water use and consumption. Occasionally we would find an entire village of people who had bought their BSF at the same time who did not know that the BSF was designed to remove microbial contamination. It seemed that the program expanded too swiftly in the Terai, and that it would benefit from scaling back its operations there.

The interviews also showed a broad understanding about the water supply in Nepal. Three-quarters of the interviewees knew who put in their water distribution system, and three-quarters also filtered the water to improve their health, indicating that they know their water supply is contaminated. While these data can certainly be improved, it is a very good start. It also shows that people are interested and involved in their water supply, and are willing to take steps to alleviate the contamination. As mentioned above, the people of Nepal appear to be getting sufficient quantities of water, though it is often of poor quality. It would be interesting to explore Esry's theory of laying more emphasis on the quantity of water instead of the quality in Nepal, particularly during the monsoon season.

Finally, the surveys have provided a great deal of information on the water and sanitation situation among the rural Nepalis. This is a good basis for future researchers to expand on and develop this exploratory research.

6.2 RECOMMENDATIONS

6.2.1 FUTURE SURVEY RECOMMENDATIONS

Because of the exploratory nature of this research, Survey 2 was quite broad. While this research does give a general idea of the BSF project and the water needs in Nepal, further studies would benefit from a narrower focus. A limited, narrow focus would allow for deeper exploration into either the BSF or the water supply, providing more specific answers with a wider application may result. Additionally, before constructing the survey, research should be done regarding the proper methods of survey construction, execution, and analysis. Both Aday's Designing and Constructing Health Surveys and McKenzie-Mohr and Smith's Fostering Sustainable Behavior are good resources.

As much as possible, the survey questions should mean the same thing to all people, and so one should be careful about using synonyms too freely. For example, I ran into a great deal of trouble by using the "*monsoon season*," "*wet season*," and "*summer*" interchangeably. Also, the researcher must try to avoid leading questions, ones that guide the respondents towards an expected or desired reply. Most importantly, future first-time interviewers should not become too attached to their original survey, as it will almost inevitably be inadequate in some way.

In order to account both for the "need-to-please" phenomenon, and for the inaccuracies of estimation (e.g. it is difficult for the respondents to estimate time because they rarely own watches), future researchers should spend more time in one place observing the actual water practices of a specific village. Also, if the interviewer cannot speak Nepalese, the choice of translator is very important. While I had complete faith in the abilities and motivation of my translator, Arjun Chettri, future surveyors should use someone who does not have a stake in the outcome of the project. This will remove any question of bias in the translations.

6.2.2 BSF PROJECT RECOMMENDATIONS

A major drawback to the widespread implementation of the BSF, as mentioned in Section 5.5, is its limitations in handling turbidity. If the BSF clogs every two weeks in the monsoon season, then users will soon stop filtering their water. I don't think the BSF design can be altered to accommodate this, so some form of pre-treatment is necessary in these regions. Two of the simplest solutions are settling and/or straining.

It was common practice among the respondents before getting a BSF to let cloudy water sit for a few hours after collection so that the particles could settle to the bottom of the gagri. They would then carefully decant the clarified water from the top, and discard the cloudy water from the bottom of the gagri. The decanted water could then be run through the BSF, and this may lengthen the time between cleanings. One of the drawbacks to this system is that it involves more work because a portion of the collected water is discarded and therefore more trips are necessary to gather the needed water. Another drawback is that it takes some time for the particles to settle and the respondents may not be willing or able to wait.

The other option is straining the cloudy water through a folded cloth. This could be an old, clean piece of clothing, perhaps a sari, folded several times to reduce the pore size within the weave. The cloth could be held in place over the BSF as the cloudy water is poured into the filter, catching the larger particles before they enter the BSF. An advantage to this is that as the cloth is used for straining and collects particles, the pore size in its weave gets smaller because of the accumulation of particles. This will then allow the cloth to capture smaller and smaller particles. An important drawback to this system is that it would be very difficult for one person to manage alone - holding the cloth over the opening and pouring the water at the same time is probably impossible for one person to do. However, if the cloth is folded several times and placed on top of the diffuser plate, within the BSF, thoroughly covering the surface area, then a single person may be able to manage. Additionally, Huq, *et al* found that by folding a sari four times they achieved a ~97% reduction in particles greater than 20:m in Bangladesh's drinking water (Huq, *et. al.*,1996). The pathogens they used had a diameter larger than 20:m, while the colloidal turbidity particles are typically between 0.5 and 100:m, so this system should be effective in removing large particulates in the water (Osmonics, 1993). However, *coliforms* are much smaller and will slip through the cloth, but will be captured by the BSF.

Another drawback to the BSF is its cost. While the price may drop with mass production, it would need to cost Rps407 (US$5.50) for the average Nepali family to be able to afford it, assuming an annual income of Rps16,280 (US$220), and a willingness to pay 2.5% of the annual income on water. This figure rises to Rps814 (US$11.00), one-third of the current price, on the assumption of a willingness to pay a one-time cost of 5% of a year's income. It is unlikely that the BSF could be made available for that price without large, long-term subsidies. The World Bank's Water and Sanitation Program has noted that long-term subsidies are both detrimental to the sustainability of a development project and frequently do not benefit the poor that they are designed to help (World Bank WSP, 1999). If the target population pays for the BSF at fair market price, then they are making a significant financial commitment towards filtering and it is probable that they will continue filtering. The program, too, needs to be self sufficient, for a similar reason: it is a large temporal and financial commitment to run a business, and once that commitment has been made there is a greater impetus to continue the enterprise. Therefore, without subsidies, the BSF will remain beyond the reach of many parts of Nepali society, and may only be appropriate for the middle class niche market, while another system needs to be devised for the majority of the population of Nepal.

From this preliminary study there are some conclusions about implementing the BSF as a sustainable water treatment system. Michael Edesess and Paul Polak recommend the following seven steps in implementing a development project:

1. Identify a market niche
2. Find a product/service to fill that niche
3. Conduct market research, product cost estimation, and rate of return projection
4. Test the prototype
5. Market test and refine the prototype
6. Pilot project
7. Production planning
8. Promotion, advertising and marketing

9. Production
10. Sales and distribution
(Edesess and Polak, 1993)

The BSF program has taken many of these steps (particularly 2, 4, 6, 10, and to a lesser extent 8), but has missed many of the other important ones. The authors point out the need to find a *market* niche, not just a need, and to see if the market will bear a product of a given expense and technology. This does run counter to traditional development theory of finding a need and then filling it, but experience shows that if "needs" are decided by outsiders, they are often grossly inaccurate (Edesess and Polak, 1993). If the BSF program is going to attain sustainability, it should probably be run as a market-driven project. By *sustainability* I mean that the program becomes self-sufficient, owned, financed and run entirely by Nepalis, with a stable and secure business plan with a long-term commitment.

The BSF program also needs some trained, well-paid, personnel to travel around the countryside, testing the filtered water and maintaining the BSFs. Ideally, these personnel will be drawn from the community because they will know where the filters are and will be locally known and trusted. The BSF owners could either pay a small monthly fee to the personnel as compensation for their work, or the filters could be rented or leased for a somewhat larger fee. A rental system means a smaller initial capital expense, which may be more attractive to a larger number of people, but of course it is a for a longer period. However, I'm not sure that the custom of renting or leasing exists in Nepal - possibly a significant obstacle. Another question is how the renters would pay, and if there would be any sort of accountability. The threat of taking away the BSF for non-payment is an empty one, since it would probably cost more to move it than to let the renters skip payments.

The design of the BSF may be copied, and filters might be sold by a competitive concern - I don't know where Nepal stands in terms of intellectual property rights. If this happens and the competing model is of inferior quality, it might degrade consumer confidence in the BSF program as a whole. I'm not sure how to guard against this, but if HFTN continues to promote the filters, they should be prepared for this possibility.

The BioSand Filter and Hope for the Nations implementation project have tremendous potential for alleviating water contamination in rural Nepal. The BSF technology is sound, and HFTN has laid the groundwork for a successful program. Now they need to make sure that the target population learns about the filters and realize the positive impact it can make on their lives. With the additional information gathered each year, this project can become a model for water-treatment implementation throughout Nepal.

APPENDIX 1: ORIGINAL SURVEY - SURVEY 1

Haiti/Nepal Survey

Background

1. Caste
   - ___ Bahun/Brahmin
   - ___ Chhetri
   - ___ Thakuri
   - ___ Kami
   - ___ Sarki
   - ___ Damai
   - ___ None
   - ___ Other______________________________

2. Ethnicity
   - ___ Bhotia
   - ___ Gurung
   - ___ Indian
   - ___ Lepcha
   - ___ Limbu
   - ___ Magar
   - ___ Mithili
   - ___ Newar
   - ___ Rajbansi
   - ___ Rai
   - ___ Sherpa
   - ___ Sunwar
   - ___ Tamang
   - ___ Tharu
   - ___ Thakali
   - ___ Other______________________________

3. Gender
   M_____ F_____

4. Age
   - ___ < 10
   - ___ 11 - 20
   - ___ 21 - 30
   - ___ 31 - 40
   - ___ 41 - 50
   - ___ 51 - 60
   - ___ 60 +

5. Are you aware any community activities by:
   - ___ Community Board Organization (CBO)?
   - ___ Dept. of Water, Sewage & Sanitation?
   - ___ Other NGOs? (UNICEF, Nepal/Haiti Red Cross, etc.)

6. How do you view water?
   - ___ Holy/Pure
   - ___ Dirty
   - ___ Source of disease
   - ___ Don't think about it
   - ___ Other____

Current Practices / Situation

7. How many days have you been sick/had diarrhea in the past year?
   - ___ <5
   - ___ 6-10
   - ___ 11-15
   - ___ 16-20
   - ___ 21-25
   - ___ 26-30
   - ___ 31-35
   - ___ 36-40
   - ___ 41-45
   - ___ 46+

8. How many days has a member of your family been sick/had diarrhea in the past year?
   Relation____________________

   ___ <5 ___ 6-10
   ___ 11-15 ___ 16-20
   ___ 21-25 ___ 26-30
   ___ 31-35 ___ 36-40
   ___ 41-45 ___ 46+

9. Would you perform filtration if it would improve your family's health?
   ___ Yes ____ No ___ Depends

10. If "Depends", on what does it depend?
    ___ Flow ___ Type of filtration
    ___ Other ____

11. Which sources of water does your household use now on a regular basis?
    ___ Private connection (inside home) ___ Private connection (outside home)
    ___ Shared connection ___ Illegal connection
    ___ Private well with pump ___ Private well (hand drawn)
    ___ Public standpost (tap) ___ Public tubewell (with handpump)
    ___ Vendor / Purchase from private person ___ Public garden
    ___ Surface water (river, spring, *etc*.) ___ **Captage**
    ___ Other ____

12. What is your primary source of water?
    ___ Private connection (inside home) ___ Private connection (outside home)
    ___ Shared connection ___ Illegal connection
    ___ Private well with pump ___ Private well (hand drawn)
    ___ Public standpost (tap) ___ Public tubewell (with handpump)
    ___ Vendor / Purchase from private person ___ Public garden
    ___ Surface water (river, spring, *etc*.) ___ **Captage**
    ___ Other ____

For **shared** primary water source:

13. How far from your home is ________ (this water source)?
    _______________ meters, and/or _____________ minutes' walking time (one way)

14. How many people (or households) rely on ________ (this water source) on a daily basis?
    ______ people / households

15. How many times per day do you obtain water from ________ (this source), on average?
    Monsoon season: _________ times per day
    Dry season: _________ times per day
    Wet$_1$ season: _________ times per day
    Wet$_2$ season: _________ times per day

16. About how long do you wait in a queue to get water on an average trip?

Monsoon season: _________ minutes
Dry season: _________ minutes
Wet$_1$ season: _________ minutes
Wet$_2$ season: _________ minutes

17. About how much water do you obtain from ________ (this source) each day, on average?

Monsoon season: _________ liters / [containers/gagro: __________________]
Dry season: _________ liters / [containers/gagro: __________________]
Wet$_1$ season: _________ liters / [containers/gagro: __________________]
Wet$_2$ season: _________ liters / [containers/gagro: __________________]

[*If other container is used, indicate approximate volume of container:* ____________ *liters*]

18. How would you rate the quality of the water you obtain from ________ (this source) in terms of

…taste?	Good/normal	Salty	Chlorine/chemicals	Other:_____________________
Monsoon				
Dry				
Wet$_1$				
Wet$_2$				
…color?	Good/clear	Cloudy	Brown/rusty	Other:_____________________
Monsoon				
Dry				
Wet$_1$				
Wet$_2$				
…odor?	Good/none	Sewage	Chemicals	Other:_____________________
Monsoon				
Dry				
Wet$_1$				
Wet$_2$				

19. In the past month, how many leaks or pipe breakages have affected your household's water supply? ____________ leaks ____________ pipe breakages

20. (If answer is greater than zero,) What do you typically do when a leak or breakage occurs?

___ Call Dept. of Water to request repair
___ Visit Dept. of Water to request repair in person
___ Lodge a written complaint to the Dept. of Water and receive complaint number
___ Visit the neighborhood organization (does it exist?)to request repair
___ Hire someone else to repair it ___ Repair it ourselves
___ Other: ____

21. During the breakage, where do you get water?

___ Stream
___ Pond
___ Another well
___ Snow/Ice
___ Rain
___ Do without
___ Other: ____

22. Overall, how satisfied are you with your current water supply situation? Would you say you are [*Enumerator: Read choices aloud and record response.*]

___ very satisfied? ___ somewhat satisfied? ___ not very satisfied?

For **private** primary water supply source

23. About how much water do you obtain from ________ (this source) each day, on average?

Monsoon season: __________ liters / [containers/gagro ____________________]
Dry season: __________ liters / [containers/gagro: ____________________]
Wet$_1$ season: __________ liters / [containers/gagro: ____________________]
Wet$_2$season: __________ liters / [containers/gagro: ____________________]

[*If other container is used, indicate approximate volume of container:* _____________ *liters*]

24. [*If respondent's water source is a piped source, ask the following questions]*

During what hours is water available from piped source?

Monsoon season: ____
Dry season: ____
Wet$_1$ season: ____
Wet$_2$ season: ____

Does the water generally come at the same time every day, or does it vary from day to day?

___ Comes at same time each day ___ Varies from day to day

25. How would you rate the quality of the water you obtain from the piped source in terms of:

…taste?	Good/normal	Salty	Chlorine/chemicals	Other:_______________
Monsoon				
Dry				
Wet$_1$				
Wet$_2$				
…color?	Good/clear	Cloudy	Brown/rusty	Other:_______________
Monsoon				
Dry				
Wet$_1$				
Wet$_2$				
…odor?	Good/none	Sewage	Chemicals	Other:_______________
Monsoon				
Dry				
Wet$_1$				
Wet$_2$				

26. Overall, how satisfied are you with your current water supply situation? Would you say you are
___ very satisfied? ___ somewhat satisfied? ___ not very satisfied?

27. In the past month, how many leaks or pipe breakages have affected your household's water supply? ____________ leaks ____________ pipe breakages

28. (If answer is greater than zero) What do you typically do when a leak or breakage occurs?
___ Call Dept. of Water to request repair
___ Visit Dept. of Water to request repair in person
___ Lodge a written complaint to the Dept. of Water and receive complaint number
___ Visit the neighborhood organization (CBO) to request repair
___ Hire someone else to repair it ___ Repair it ourselves
___ Other: ____

29. During the breakage, where do you get water?
___ Stream ___ Pond
___ Another well ___ Snow/Ice
___ Rain ___ Do without
___ Other: ____

Improvements

30. What would you like to see in way of water improvements?
    ___ Better flow? ___ Better quality?
    ___ Better taste ___ None
    ___ Other______________________________

31. How would that affect your family?

Write answer:

Filtration

32. Do you practice any of these water treatments?
    ___ Filtration ___ Boiling
    ___ Chemical disinfection ___ SODIS
    ___ Other______________________________

33. If any of the previous are checked, Why do you treat the water?
    ___ Mother also treated water ___ To clean it
    ___ Social custom ___ Don't know
    ___ Other______________________________

34. How often do you skip filtration?
    ___ Often (Daily) ___ Occasionally (Weekly)
    ___ Rarely (Monthly) ___ Yearly
    ___ Other ______________________________

35. Why do you skip filtration?
    ___ Filtration's too slow ___ Has bad taste
    ___ Too much work ___ Too complicated
    ___ Don't have access to it ___ Don't believe it works
    ___ Don't need it
    ___ Other ______________________________

36. If you filter regularly and properly, has there been improvement in you/your family's health?
    ___ A lot ___ Some
    ___ Not much ___ None
    ___ Other ______________________________

Current sanitation services

37. What is the main type of sanitation service your household uses currently?
    ___ Private toilet with sewer connection
    ___ Private toilet (pour flush) with septic tank
    ___ Private pit latrine
    ___ Shared toilet or latrine (a few private households sharing)
    ___ Public toilet or latrine
    ___ Other ____

38. How far away is this facility?
    _______ meters   _________ minutes

39. How many people (or households) use this facility on a daily basis?
    _______ people / households

40. How would you rate your [toilet / latrine / other] in terms of:

Cleanliness?	___ Good	___ Fair	___ Poor
Privacy?	___ Good	___ Fair	___ Poor
Plumbing/piping?	___ Good	___ Fair	___ Poor

41. In the past year, about how many times has your [toilet / latrine] been clogged or backed up?
    _______________ times

42. At what season does this usually occur?
    ___ Monsoon   ___ Dry   ___ **Wet_1**   ___ **Wet_2**

43. *If answer is greater than zero* - What do you typically do when a clog occurs?
    ___ Call Dept. of Water staff to repair it
    ___ Hire someone else to remove it
    ___ Remove it ourselves

44. What facility do you use when the latrine is clogged?
    ___ Field   ___ River
    ___ Pond   ___ Use latrine anyway
    ___ Other____

APPENDIX 2: FIELD SURVEY - SURVEY 2

Background

Name:	Caste:
Gender:	Religion:
Town:	Region:
N:	E:
Elev.:	

Water Source Information

1. Where do you get your water from?

2. How many people use that source?

3. How many times a day do you go?

4. Same for wet and dry?

5. Who goes?

6. How much of that water is filtered?

7. What is the true source?

8. Is the water always clear

9. Even in monsoon?

Health/Improved Health

10. How long have you had the filter?

11. How many episodes of diarrhea have you had since filtering?

12. Other family members?

13. In which season did the illness occur?

14. Have you had more or less episodes since filtering?

Filtering

15. Do you like the filter?

16. Satisfied with taste of the filtered water?

17. Satisfied with smell of the filtered water?

18. Satisfied with flow of the filtered water?

19. Do you get enough water?

20. When you pour in cloudy water, does it come out cloudy?

21. Who built and paid for the filter?

22. Why do you filter water?

23. Do you practice other water treatment?

24. Do you recognize these filters?

25. Do you skip filtration?

26. Why?

27. Do you ever take filtered water with you when you leave the house?

28. Have you felt healthier since filtering?

29. How often do you refill the filter?

30. What don't you like about the filter?

Maintenance/Cleaning

31. When did you last clean the sand?

32. How do you clean the sand?

33. How often do you clean the sand?

34. How often do you clean the gagri?

35. How do you clean the gagri?

36. Do you store water in other containers?

37. What kind?

38. How often do you clean other containers?

39. How do you clean other containers?

Water Use

40. Do you use the water only for drinking? Washing?

41. If it's only used for drinking, why don't you use it for other uses?

Water Distribution System

42. Who built and paid for the water supply system?

43. Does the system ever break?

44. What season?

45. Who fixes it?

46. Where do you get water during the broken period?

Latrine

47. Where do you go to the bathroom?

48. What kind of toilet is it?

49. How far away is it?

50. Does it ever clog/backup?

51. Who built and paid for it?

52. Do you pay for water?

53. If yes, how much?

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