Recommendations for at-risk water supplies in Capiz Province, Philippines: using water source and community assessments

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Abstract

The following thesis is part of a larger project which began in response to a request by the Provincial Health Office (PHO) in Capiz Province, Philippines for expert advice to support its drinking water quality testing program. Civil and Environmental Engineering Department Senior Lecturer, Susan Murcott, recommended specific state-of-the-art test methods for quantification of *E.coli* in drinking water as well as the involvement of a Massachusetts Institute of Technology (MIT) Master of Engineering (MEng) team in collaboration with the test program.

The results of this microbiological water quality testing program, along with water source and community assessments completed during January 2010, have been used to make recommendations for potential infrastructure upgrades and improvements to drinking water systems in the region.

In water samples collected from December 2009-March 2010, 65% were found to be contaminated with *E.coli*. While the sampling program was designed to sample a higher proportion of sources which were suspected to have contamination, the significant number of samples with *E.coli* contamination illustrates the importance for residents and for officials at the national level to focus on the provision of microbiologically safe drinking water.

Water source assessments made use of WHO Sanitary Survey templates, and they showed that many hazards are present around public water sources, and that it is highly likely that some of these- specifically septic tanks and animal waste- are contributing to poor microbiological water quality. Key-informant interviews and focus-group discussions conducted during the community assessments showed that water management systems are lacking, awareness regarding factors affecting drinking water safety are lacking, and that equal access to sources are lacking (upland areas are poorly served).

Both short and long term recommendations have been made and are the focus of this thesis. Education, monitoring and training will be key components; as well as household water treatment and safe storage for existing supplies. Longer term plans need to include strategies for aligning and developing systems within the province to existing national level regulations, the development of effective management systems both at the municipal and provincial level, and finally on securing the necessary funding to implement improved programs and services.

Thesis Supervisor: Susan Murcott
Title: Senior Lecturer in Civil and Environmental Engineering

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I was also fortunate to work with a great team on this project- big thanks to Stephanie, Patty and John for putting up with my mood swings in Philippines and for being great friends throughout the year.

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List of Abbreviations

BAWASA	Barangay waterworks system
BHW	Barangay Health Worker
CFU	Colony forming unit
COUHES	MIT Committee on the Use of Humans as Experimental Subjects
D	Doubtful Source
DWP	Deep Well with Pump (borehole) (>60ft) w or w/o piped distribution
GPS	Gravity Protected Spring w piped distribution, communal tap stands
HPC	Heterotrophic Plate Count
JMP	Jetmatic Pump w or w/o motor (Tubewell with handpump)
L1	Level 1 Source
L2	Level 2 Source
L3	Level 3 Source
LWUA	Local Water Utility Administration
MIT	Massachusetts Institute of Technology
MEng	Masters of Engineering
MPN	Most Probable Number
MSD	Minimum Safe Distance
NGO	Non-governmental organization
NTU	Nephelometric Turbidity Unit
OD	Open Dugwell
OT	Other Source (not mentioned)
PDW	Protected Dugwell
PHO	Provincial Health Office
PNSDW	Philippines National Standards for Drinking Water
PS	Protected Spring w/o distribution
RW	Rainwater Catchment (ferro cement tanks)
SI	Sanitary Inspector
SW	Surface Water (rivers, creeks, streams)
SWP	Shallow Well with Pump (<60ft)
THM	Trihalomethanes
TNTC	Too numerous to count
US	Unprotected Spring
UNDP	United Nations Development Program
US EPA	United States Environmental Protection Agency
WD	Water District
WHO	World Health Organization

1 Introduction

This thesis has been created as a requirement for the Massachusetts Institute of Technology (MIT) Masters of Engineering (MEng) project for the 2009-2010 year, within the discipline of Water Quality and Environmental Engineering.

1.1 Project Introduction

The project began in response to a request by the Provincial Health Office (PHO) in Capiz Province, Philippines for expert advice to support its drinking water quality testing, specifically the type of water quality tests that should be performed and the overall research design. Civil and Environmental Engineering Department Senior Lecturer, Susan Murcott, recommended specific state-of-the-art test methods for quantification of *E.coli* in drinking water as well as the involvement of an MEng team in collaboration with the test program. The efforts of the PHO together with the resulting MEng Philippines team have enabled a first-ever, comprehensive drinking water quality testing program in the region. The results of this microbiological water quality testing program, along with water source and community assessments completed during January 2010, have been used to make recommendations for potential infrastructure upgrades and improvements to drinking water systems in the region for at-risk supplies. The community assessments and recommendations are the focus of this thesis. The assessments were designed to capture as much information as possible in the limited time regarding the context and reality of water use and water needs in Capiz Province. Recommendations include both immediate and long-term remedial measures, and have been made based on a detailed literature review on the Philippines, site inspections, water quality results, and interviews with various community members around the province. The overarching motivation behind the project was to provide useful, realistic and sustainable recommendations for the PHO and for all the citizens in Capiz regarding how to improve and sustain their drinking water quality.

1.2 Objectives/Motivation

The general motivations of this project were to firstly identify the problems that lead to the 'symptom' of poor drinking water quality for Capiz Province, Philippines and then to propose potential solutions or steps that can be taken to reach solutions for problems relating to drinking water quality, water use and water management at a community scale.

The primary objective of the project was to:

- Make technical, managerial and strategic recommendations for improving drinking water quality and management in Capiz Province.

Secondary objectives were to:

- Design and conduct an effective technical assessment of identified 'at-risk' drinking water supplies in terms of infrastructure, treatment options and site protection relating to hazards and associated risk.

- Design and conduct interviews with key stakeholders to understand the various needs for water within the community based on water use history and water use culture, and to understand the perceived value of different sources of water for the different uses. Embedded in this assessment is identification of an appropriate management structure(s) for water use at the community level in the Philippines.

2 Country Background

In order to develop a plan for working with the PHO in Capiz Province during January it was important to learn about the background of the country and the way of life in order to determine an approach for conducting an assessment and subsequently for making recommendations. It was necessary to learn about the water availability, economy, government structures relating to water management and other issues to understand the context and reality of life for Capizians to attempt to make a reasonable contribution to their ongoing efforts to improve their own health and productivity.

The project is based in the Philippines and specifically in Capiz Province, which is located on Panay Island in the Central Visayas (Figure 2-1).

2.1 Philippines

The Philippines is an archipelago composed of over 7000 islands and is located in Southeast Asia, between the Philippine Sea, Celebes Sea and the South China Sea (Figure 2-1). It is a mountainous country with low-lying reaches along the coastline. It has a total land area of approximately 300,000km^2 and an extensive coastline of over 36,000km. It has a tropical marine climate and has two monsoon seasons- the dry, northeast monsoon from November to April, and the wet, southwest monsoon from May to October. The country is usually subject to 15 typhoons per year and 5-6 cyclones, which has major impacts on both water and land resources (CIA, 2009).

Figure 2-1. Map of the Philippines (CIA, 2009)

A census conducted in July 2009 estimated the population at almost 98million, making it the 12th most populated country in the world. Additionally, the population is relatively young, with a median age for men and women of only 22 years. The population is growing at approximately 2% per year and the fertility rate is 4 children per woman (CIA, 2009). The Philippines has an infant mortality rate of 24 per 1,000 and the life expectancy is 71 years. Despite the long life expectancy, the risk of infectious disease is high in the country. Food and waterborne diseases such as bacterial diarrhea, hepatitis A and typhoid fever abound. The high population density, increasing level of urbanization (65%, 3% growth rate) and the tropical marine climate exacerbate food and waterborne diseases.

The country is populated by a variety of ethnic groups, including Tagalog, Cebuano, Llocano, Bisaya/Binisaya, Hiligaynon Llonggo, Bikal, Waray and others; in total there are over one hundred groups (Gov.Ph, 2009). The vast majority, 91.5%, are Christian as estimated by the 2000 census (81% Roman Catholic). The Philippines is a Democratic Republic and is divided into 3 geographic areas- Luzon, Visayas, and Mindanao. There are a total of 81 provinces, 136 cities, 1,494 municipalities and 41,995 *barangay*s- which are the smallest organizational unit in the Philippine political system (a *barangay* is a geographical area within a city or municipality comprised of less than 1,000 inhabitants). The capital city is Manila, which is located in Luzon. The current President, President Gloria Macapagal-Arroyo, has been in power since 2001 and the next election is set for May 2010.

Philippines has significant natural resources of various metals, including chromate, copper, nickel, iron, cobalt, silver, gold. However, at present the economy is primarily based on service (commerce and government), industry and agriculture; with a rough breakdown of >50%, 30%, <20%, respectively (U.S. Department of State, 2009). Arable land and permanent crops account for approximately 35% of the total land use, and a total of 15,000km^2 is irrigated land (in 2003). The major agriculture products are- rice, sugarcane, coconut, corn, bananas, cassavas, pineapples, mangoes; pork, eggs, beef; and fish. Industry includes electronics assembly, garments, footwear, pharmaceuticals, chemicals, wood products, food processing, petroleum refining, and fishing. The GDP growth rate in 2008 was 3.8% and the GDP per capita as of 2008 has been reported by the CIA as $3,300 and by the US Department of State as $1,841 (CIA, 2009; U.S. Department of State, 2009). In 2006, it was estimated that 33% of the population was living below the national poverty line; the majority of these people live in rural areas (> 60% of the poor live in rural areas) (WorldBank, 2004).

2.2 Capiz Province

Capiz Province is located on the northeastern part of Panay Island, which is located in the Western Visayas (Figure 2-2). It has a land area of approximately 2,600km^2 and has roughly 80km of coastline. It is a major center for the aquamarine industry in the country, as well as a center for tourism and agriculture. The population has been estimated in 2008 to be between 550,000-700,000 (Province of Capiz, Philippines, 2009). It is composed of 16 municipalities, 1 city (Roxas City) and 473 *barangay*s (villages).

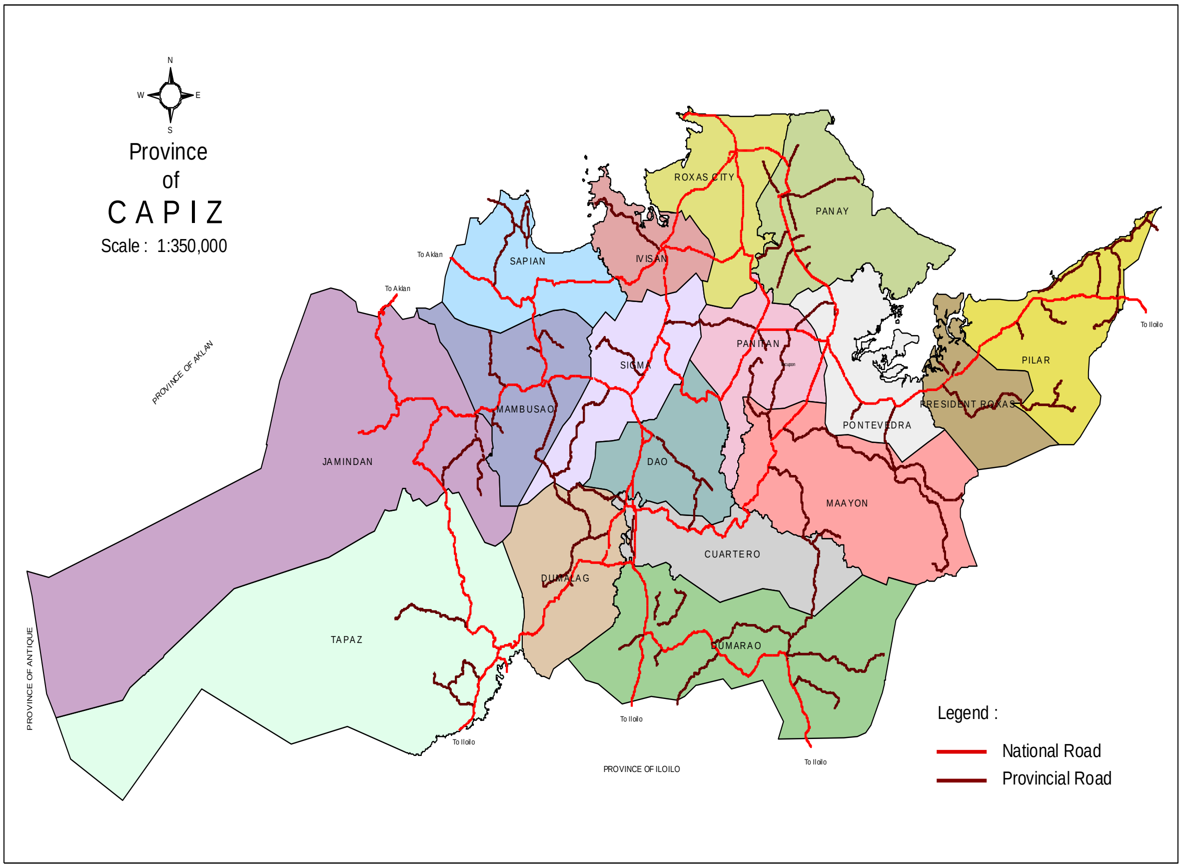

Figure 2-2. Capiz Province showing 16 municipalities + Roxas City

The capital city, Roxas City, is located along the northern edge of the province and has a population of approximately 132,000. Similar to the rest of the province, fishing and farming are the major economic activities; which together use just over 50% of the total land area. The dominant agricultural crop is rice, with over 38km^2 of land used for rice fields (Roxas City, Philippines, 2007). Other major crops include coconuts, bananas, watermelons, leafy vegetables, mungo, various citrus crops and mango. Both freshwater and brackish water aquaculture is common, as the swampy coastline lends itself well to fishpond development. In fact, over 840km^2 are used for brackish fishpond development. Marine fishing and livestock production are also major industries in the city area. As the only urban area in the province, Roxas City is the center of trade and commerce, and as a result is becoming increasingly industrialized and commercialized.

2.3 Water Use

The total renewable water resources in the Philippines in 1999 were estimated to be 479km^3 (CIA, 2009). Freshwater withdrawals in 2000 were estimated to be approximately 29km^3 per year; with a breakdown of agricultural, domestic and industrial uses, with 74%, 17%, and 9% respectively (Figure 2-3).

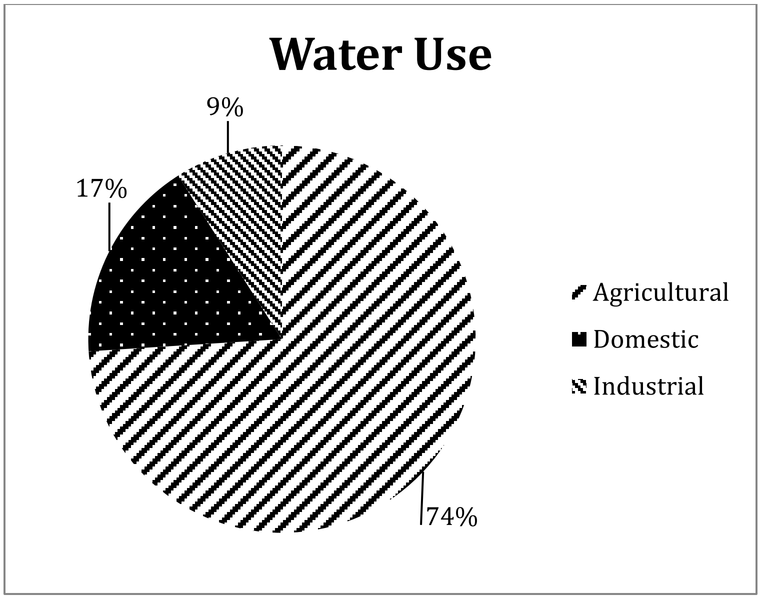

Figure 2-3. Major freshwater uses in 2000

Agriculture is a significant draw on the freshwater resources, as an estimated land area of 15,500km^2 was being irrigated in 2003. This accounts for 5% of the total land area in the country. The use of irrigation is increasing, with the threats of climate change and El Nino causing droughts and below average rainfall in certain areas in recent years. In fact, the President has recently called for early completion of a major national irrigation project in light of these facts (Gov.Ph, 2009). Thus, while the country overall remains one of water abundance, the uneven spatial and temporal distribution are key factors impacting emerging water use trends in the country.

2.3.1 Types of Sources

Currently, there are 4 main categories for the types of water sources used within the Philippines. These are termed Level I-III and Doubtful Sources. Table 2-1 below lists the types of water sources under each category:

Table 2-1. Water level categories in the Philippines

Category	Source Types
Level I	Stand-alone point sources, including shallow wells, handpumps
Level II	Piped water supply with communal water points, from boreholes
Level III	Piped water supply with private water points, such as a household connection
Doubtful Sources	Unprotected springs, open dugwells, surface water, rainwater collectors

2.3.2 Multiple Water Uses

In 2000, the basic breakdown of the major water uses in the country as shown above in Figure 2-3 reveals that 83% of the total estimated freshwater use was for productive purposes. Agricultural freshwater use alone amounted to approximately 21.5km^3 per year, and this total is expected to be significantly higher today with the increasing use of irrigation. Under this definition, agriculture includes livestock production and also aquaculture. The distribution clearly shows the importance of freshwater resources for livelihood generation. Thus, the quantity and quality required for the multiple uses of water in the Philippines is an important consideration which must be included in the water supply assessments.

2.4 Government involvement

With the exception of Metro Manila and four other privately managed water systems, provincial and municipal water supply systems in the Philippines are government owned. They are operated by various local organizations and technical assistance is provided by the Bureau of Public Works (BPW). Prior to 1971, urban supplies were operated by the national government (WorldBank, 2003). However, the government lacked the resources to adequately maintain and operate the systems and consequently management was passed over to local governments. In turn, the Local Government Units (LGUs) found themselves without the necessary funds, experience and capacity to improve the condition of the water supply systems; which led to the creation of the *Water District* (WD) as part of the 1973 Provincial Water Utilities Act. These Water Districts were supposed to be a partially-public management organization to operate independently of the LGUs. Support for these organizations was provided by a newly created group called the *Local Water Utilities Administration* (LWUA). Urban and community water supply were subsequently divided by the creation of the *Rural Waterworks Development Corporation* (RWDC). RWDC was responsible for towns with populations less than 20,000 and was supposed to form smaller organizations- called *Rural Water Supply Associations* (RWSA)- for dealing with the various operation and maintenance issues for the water supply systems. The Department of Public Works and Highways (DPWH) was in charge of constructing wells and springs in rural areas. Between 1978 and 1990, 11 large scale rural water supply projects were undertaken with an expenditure totaling US$120million (WorldBank, 2004). However, these projects only covered approximately 5% of the number of systems required to provide water services for the rural population. Thus, responsibility returned to the LWUAs in 1987. Currently, there are 5 main management models for water supplies in the Philippines (WorldBank, 2003):

Table 2-2. Water management models for the Philippines

Management Model	Number of Systems	Coverage
Local Water Utilities Administrations (LWUAs) and Local Government Units (LGUs)	500	Urban, large town systems
Water Districts (WDs)	430	Urban, large town systems
Rural Water Supply Associations (RWSAs)	500	Unserved urban areas, rural areas, small town systems
Water Cooperatives (COOPs)	200+	Urban systems
Private Sector (PS)	Metro Manila + 4	Urban systems

In 1991, major changes in government structure formalized the decentralization of water management, and responsibility was officially transferred back to the LGUs; however this time with 'large increases in LGU incomes' (WorldBank, 2003). A World Bank Water and Sanitation Program report from 2003 stated that these increases in funds appear to have had little impact on the water sector. LGUs and WDs are said to provide piped water to approximately 60% of towns in the country. Most of these are large towns, with the remainder covered by the other management organizations or not at all. There continue to be areas within urban regions and entire small communities not covered by any management organization. These areas rely on isolated water points such as dugwells, springs or surface water sources.

2.4.1 Management Issues

In 2003, the outcomes of a number of case studies conducted in the Philippines to address small towns' water supply and management issues were published (WorldBank, 2003). The case studies were part of a larger project called The Water Supply and Sanitation Performance Enhancement Project (WPEP); funded by AusAID (government of Australia's aid organization), the Water and Sanitation Program of the World Bank and the Philippines Government. The study made use of community assessments called The Methodology for Participatory Assessments (MPA) and specific technical and financial assessments required to understand the situation in 15 selected small towns. The results of the case studies showed various levels of success and acceptance with the different management models. COOPS and RWSAs showed the highest performance in the case studies, and the LGUs showed the lowest performance.

Local Government Units can be any organization from provincial government to a *barangay* council. While funding has increased for these organizations for water management in the 1990's, inadequate local funding, technical expertise, management capacity and the 'highly politicized environment at the local level' (WorldBank, 2003) have hindered the development and improvement of water supply systems. One of the proposed issues with this form of management is the lack of alignment with water supply budget and water revenues. The LGUs have no control over the budget that they receive and simply try to remedy whatever major issues are ongoing when the funds come in for a given year (WorldBank, 2004). The theory is that funds are recouped by water tariffs, but the tariffs are actually put into central accounts and the alignment is not made. Furthermore, because the officials are elected, it is thought that they are hesitant to raise water fees for fear of losing votes. Other major management issues include a lack of technical expertise in the units, a lack of personnel assigned specifically to the water supply and historically low salaries so incentive is low to focus on this area.

Water Districts, in contrast to LGUs, have considerable technical and financial management skills. The major management issue with this model is that water tariffs are said to be high due to required loan repayment to the LWUA; consequently, the poor are excluded from access to services managed by WDs. *Rural Water Supply Associations* are non-profit organizations which also obtained loans from the LWUA after government decentralization. However, they have not been required to repay loans, which have meant that their tariffs can be kept lower. In this organization, members do not hold any equity. In the towns studied using this management model, a high level of community involvement and transparency were thought to be factors for success; in addition to support from

Water Districts in the area, which helped with technical and financial management. Given the small number of case studies using this management model, it is uncertain whether these cases were the exception or the rule- thus, the results should be interpreted as such. *Water Cooperatives* are also small organizations assisted by WDs; however unlike the RWSAs their members are owners so have a stake in the performance of the unit. This ownership gives the community more power to decide the type of system that is being put in place and to determine if it suits their requirements and preferences within the community. In the cases studied, this unit charged the lowest tariffs and access was higher than for the other forms of management.

Lastly, *Private Sector* management has been seen in only a handful of cases in the Philippines, and these have been in distinctly urban areas where economies of scale allow the required profit to make these units viable. The higher percentage of poor in rural areas makes the likelihood of private sector involvement in small communities unlikely. The WPEP project suggested an opportunity for private sector involvement in specific areas- such as operation and maintenance, billing and financial audits.

2.5 Philippines Government Water Regulations

The Philippines currently has two primary regulatory documents relating to drinking water supply:

- The Code on Sanitation of the Philippines, Chapter II: *Water Supply* (1995)
- Philippine National Standards for Drinking Water (2007)

The Code on Sanitation of the Philippines was first published in 1976 by the National Department of Health, and was reprinted most recently in 1998 with support from UNICEF. The Code contains 22 chapters of regulations ranging from water supply to industrial hygiene to vermin control. In the foreword, the formalization and promulgation of the Code is described as a 'landmark in the history of the country's health and sanitation efforts'; and the publication is described as result of three major efforts over a span of twenty years to codify the nation's health laws and to consolidate the numerous health regulations into a single book of regulations (DOH, 1976). Contributing organizations are stated to have been Regional, Provincial and City Health Offices, the National Environmental Protection Commission, the Metropolitan Water and Sewage System, as well as the Department of Labor, National Resources, Agriculture, Education and the Philippine Public Health Association. The Code provides a consolidated, comprehensive and sanctioned document that can be used as a platform to build a solid public health management program at a provincial or municipal level in the Philippines. However, the utility of the document is contingent on the availability of resources, in terms of time, personnel and funds, to enforce the laws and regulations.

Chapter II of the Code- entitled *Water Supply*- provides the implementing rules and regulations which 'apply to all public and private water supply system projects planned by any government agency or instrumentality including government-owned or controlled corporations, private organizations, firms, individuals or other entities' (DOH, 1995). The chapter contains similar definitions, standards and requirements to those outlined in the World Health Organization (WHO) Drinking Water Quality Guidelines, and it is likely that the document was guided by these existing guidelines and instructive documents. Regulations for implementing new water sources in terms of site safety, protective measures and infrastructure standards are described. Additionally, prescribed Standards and Procedures for water treatment and drinking water examination are outlined; and it is stated that drinking water must conform to the criteria set in the Philippines National Drinking Water Standards.

The most recent version of the Philippine National Standards for Drinking Water (PNSDW) was published in 2007 by the National Department of Health (DOH, 2007). The first standards were published in 1993. It is stated explicitly that these standards are based on recommended guidelines and criteria by international organizations such as the WHO and the US Environmental Protection Agency. The 2007 document contains 82 different standards for radiological, physical, chemical and biological compounds; these include new additions of emerging chemicals such as pesticides and trihalomethanes (THMs). Microbiological parameters to be tested include total coliform, fecal coliform and heterotrophic plate count (HPC). The microbiological standards are required for water treatment works, consumer's taps, refilling stations, water haulers/vendors, and service reservoirs. The only standards described for Level 1 sources are those listed for the fecal coliform parameter (Table 2-3).

Table 2-3 Standards Methods of Detection and Values for Microbiological Quality (DOH, 2007)

Parameters	Methods of Determination	Value[1]	Units of Measurements	Point of Compliance
Total Confirms	Multiple Tube Fermentation Technique (MTFT)	< 1.1	MPN/ 100 mL	• Service reservoirs • Water treatment works • Consumer's Tap • Refilling Stations • Water Haulers Water Vending Machines
	Chromogenic substrate test (Presence-Absence)*	Absent < 1.1	MPN/ 10 mL	
	Membrane Filter (MF) Technique	< 1	Total coliform colonies/ 100mL	
	Compliance to Total coliform			
	a. For water systems analyzing at least 40 samples per month, no more than 5% of the monthly sample may be positive for total coliform; b. For water systems analyzing fewer than 40 samples per month, no more than one (1) sample per month may be positive for total coliform.			• Consumer's Taps
	At least 95% of standards samples taken in each year from each reservoir are total coliform negative			• Service reservoirs
	No standard sample taken each month should exceed maximum allowable value specified in the above.			• Water treatment works • Refilling stations • Water Haulers • Water Vending Machines
Fecal coliform	Multiple Tube Fermentation Technique (MTFT)	< 1.1	MPN/ 100 mL	• Service reservoirs • Water treatment works • Consumer's Taps • Refilling Stations • **Point Sources (Level I)** • Water Haulers • Water Vending Machines
	Membrane Filter Technique (MFT)	< 1	Fecal coliform Colonies/ 100 mL	
	Chromogenic Substrate test (Presence-Absence	< 1.1	MPN/ 100 mL	
Heterotrophic Plate Count	• Pour Plate • Spread Plate • Membrane Filter Technique	<500	CFU / mL	• Service reservoirs • Water treatment works • Consumer's Taps nearest the meter • Refilling Stations • Water Vending Machines

Along with these standards, the document contains general guidelines for developing water quality surveillance systems and also introduces the concept of water safety plans to aid in monitoring and evaluating the safety of water systems. Similar to the Code on Sanitation document, the PNSDW applies to all government and private entities; these include water refilling stations, water vending machine operations, ice manufacturers and all institutions that supply or serve drinking water, drinking water laboratories, health and sanitation authorities and the general public. The PNSDW also provide detailed and comprehensive documentation for guiding government authorities at the provincial and municipal level. However, adherence to the guidelines requires time, trained personnel and consistent financial resources. Prior research suggests that these necessities vary spatially and temporally throughout the country (WorldBank, 2003; WorldBank, 2004).

3 Methods Background

In recent years, technical assessment methodologies developed by the WHO in their Drinking Water Quality Guidelines have evolved to focus primarily on the physical condition of infrastructure and the identification of hazards surrounding the source, in terms of how they equate to a level of risk for a given supply system. The assessments are subsequently used to quantify the level of risk associated with the function and state of a water supply system and to make remedial recommendations for bringing the risk to an 'acceptable level'- i.e. to manage the risk for a specific socio-economic context (Bartram, Fewtrell, & Stenström, 2001). Philippines' own implementing rules and regulations regarding public water supplies as introduced in Section 2.4 are largely influenced by the WHO approaches.

There has also been an increasing trend by organizations such as the World Bank to incorporate an assessment of the community of which the water supply system serves. This has been based on an increasing awareness of the importance of the participation and shared responsibility of the community for the maintenance and correct use of water supply systems. More recently, the notion of 'demand responsive' water supply systems has surfaced, which makes explicit the importance of the community actually wanting and valuing, or 'demanding', a particular type of water supply system, for which they are primarily responsible (Smet & Wijk, 2003). Thus, a complete assessment must address both the physical infrastructure or the 'hardware' of a system, and the willingness and capability of the community to effectively operate the system to meet their needs- this termed the 'software' requirements.

The background for the technical methods used in the following assessment, for the microbiological water standard test methods, and for the qualitative methods where information was acquired from key stakeholders are outlined below.

3.1 Sanitary Inspections

While water supply assessment has evolved in recent years to include both technical and social components, the importance of the quantitative assessment cannot be overstressed. Infrastructure provides an essential link between water resources and a group of users. The use of the available water resources by a community is governed by the capacity of the infrastructure to supply the water required meet their needs (Moriarty, et al., 2004).

Water system assessments firstly include an assessment of the drinking water quality which is compared to WHO Drinking Water Quality Guidelines, along with national or local standards. The subsequent component of the overall system assessment includes a sanitary inspection- which primarily involves identification of system deficiencies with respect to infrastructure and the proximity of physical hazards to the water source.

Sanitary inspections are defined as 'an on-site inspection and evaluation… of all conditions, devices, and practices in the water-supply system that pose an actual or potential danger to the health and well-being of the consumer' (WHO, 1997i). They are complementary analyses to water quality analyses in that they identify the potential hazards which cause poor water quality results (i.e. livestock watering occurring near the source where water quality analysis has found the presence of *E.coli* bacteria). Sanitary inspection reports are usually structured as a checklist of components from the water source through the distribution channels where hazards may be present. The hazards are then quantified through a 'yes/no' risk checklist- with scoring based on the total number of questions to which the answer was 'yes'. For example on a 10 question report, 10=high risk and 1=low risk. These Risk Levels are defined in the same way as the Risk Levels for *E.coli* contamination in the WHO Drinking Water Quality Guidelines, providing a link between two diagnostic tools for assessing drinking water sources. Pictures of the system and surrounding areas are also used to identify hazards and to map the proximity of various activities to the water source. An example of part of a sanitary inspection report for an open dugwell is given below (Figure 3-1).

II	Specific diagnostic information for assessment	Risk
1.	Is there a latrine within 10 m of the well?	Y/N
2.	Is the nearest latrine on higher ground than the well?	Y/N
3.	Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the well?	Y/N
4.	Is the drainage poor, causing stagnant water within 2 m of the well?	Y/N
5.	Is there a faulty drainage channel? Is it broken, permitting ponding?	Y/N
6.	Is the wall (parapet) around the well inadequate, allowing surface water to enter the well?	Y/N
7.	Is the concrete floor less than 1 m wide around the well?	Y/N
8.	Are the walls of the well inadequately sealed at any point for 3 m below ground?	Y/N
9.	Are there any cracks in the concrete floor around the well which could permit water to enter the well?	Y/N
10.	Are the rope and bucket left in such a position that they may become contaminated?	Y/N
11.	Does the installation require fencing?	Y/N
	Total score of risks	/11

Contamination risk score: 9–11 = very high; 6–8 = high; 3–5 = intermediate; 0–2 = low

Figure 3-1. Sample of a sanitary inspection sheet for an open dugwell (WHO, 2003i)

3.1.1 Hazard Identification

The identification of potential hazards is primarily an exercise to assess the risk. Hazard identification is extremely important because it not only enables sources of actual contamination to be identified, it can serve to prevent contamination of a water supply system through the early identification of potential sources. The hazards or hazardous events can be assigned a level of risk, with which priorities for risk management can be set in order to increase the safety of the drinking water source. The risk associated with a certain hazard or hazardous activity is determined by both the likelihood of occurrence and the severity of consequences if the hazard impacted the source (WHO, 2003ii). The subsequent step is to rank the risks, which can be accomplished with the use of a semiquantitative matrix such as those designed by the WHO in their Water Safety Plans, among other evaluative graphical methods (WHO, 2003ii). Finally, control measures are determined, based on the results of the risk ranking. These are a set of priority actions to reduce risk.

Hazards are typically identified as part of the sanitation inspection reports, through interviews with community members and through visual inspection of the area around the source. Visual analyses can be conducted by creating pictorial representations, maps and flow diagrams to understand the movement of water from local catchment area, through the storage and distribution system, to treatment and abstraction for use. Hazards can include both natural and human factors, as well as infrastructure faults. Examples of potential hazards include:

- Septic system or sewage discharges
- Chemical use in catchment area (e.g. fertilizers and pesticides)
- Human, wildlife or livestock access to the source
- Inadequate wellhead protection, uncased bores
- Heavy rains, flooding events
- Failure of monitoring equipment

For certain hazards, a standard called the Minimum Safe Distance (MSD) has been created, which denotes the required minimum distance from the source of certain things or practices (WHO, 2003i). For example, the WHO defines an MSD for proximity of latrines or animal enclosures to be at a minimum 10m; and it is specified that they should be downhill from the source as well. Open sources of pollution should be at least 15-20m away from the source. The Philippines Code on Sanitation states that the MSD for proximity to septic tanks or animal enclosures should be at least 25m. These MSDs are only guidelines, as exact determination would include location specific analysis of the hydrogeologic conditions. In practice, it is rarely possible to conduct these in-depth analyses. Therefore the MSDs are conservative, and they can be enforced by the creation of a fence around the source, with access limited to the water managers within the community.

3.2 Drinking Water Quality Testing Standard Method

Fecal coliform bacteria are gram-negative, oxidase-negative, aerobic or anaerobic and are able to ferment lactose with acid and gas production in 48 h at 44^{o}C (Doyle & Erickson, 2006). They are found in the human and animal intestine. However, fecal coliform assays have also detected bacteria of non-fecal origin which can grow under these conditions and this has led to false-positive results for fecal contamination. *E.coli* is a member of the fecal coliform family and it is only found in the intestines of humans and animals. While there is no perfect indicator organism, recent research has indicated that *E.coli* is the most reliable indicator of fecal contamination. Furthermore, the development of rapid and dependable methods for testing for *E.coli* has further validated its use in detecting the microbiological quality of potable water. Currently there are four standard methods which are commonly used to identify coliforms in water: Multiple Tube Fermentation (SM#9221A), Presence/absence (SM9221D), Membrane Filtration (SM#9222) and Enzyme substrate (chromogenic) (SM#9223). These tests detect total coliform and *E.coli* bacteria. The Philippines National Standards for Drinking Water 2007 contain standards and procedures for both total coliforms and fecal coliform microbiological parameters, using these standard methods (with the exception of Presence/absence).

3.3 Community Assessments

There is a growing school of thought regarding the importance of the 'software' components of water supply systems, including factors such as community acceptance, user behavior, community willingness to pay for a service, preference for type of system depending on requirements, among others. Many researchers have concluded that systems are maintained and used more over time when communities have been involved in some capacity in the choice, construction and cost of the system- that is, when they have a stake in the operability of the system (Wijk-Sijbesma, 2001). The social, economic, and cultural influences largely impact how water supply systems are used, misused or disused over time. Qualitative methods are required to gather this information.

3.3.1 Qualitative Tools

Tools for gathering, analyzing and interpreting qualitative information are very different than those used for quantitative information. Qualitative information is not used for statistical analysis, nor can it be used to extract information that can be applied outside the specific context in which it was gathered. It is gathered from small, purposeful sample sizes, and is temporarily and spatially distinct information. However, it is essential information for any holistic, complete water supply assessment and serves as complementary data for quantitative information through which a fuller understanding of the reality of situation can be developed. There are many tools for collecting qualitative information, many of which have been compiled by *Almedom et al* in Hygiene Evaluation Procedures (Almedom, Blumenthal, & Manderson, 1997). It has been shown that the strength of the results are increased when a variety of tools are used to obtain the same information. This approach- termed triangulation- involves using three different tools in order to cross-check the information and to verify results.

Interviews

There are two types of stakeholders that need to be considered when designing qualitative study plans. *Primary stakeholders* are those directly involved in and affected by the water supply assessment. *Secondary stakeholders* have an intermediary role- for example a municipal level manager involved at a community level assessment. Key-informants can be either type of stakeholders and are those that can provide detailed information on issues of interest for a community assessment. For example, community leaders can serve as key-informants on community water supplies, based on their knowledge of community activity and organization. Women are also commonly key-informants regarding water use due to the fact that they are often in charge of cooking, cleaning and sanitation activities around a household.

Key-informant interviewing is a qualitative tool that is especially useful at the beginning stages of a study, as the information provided by the respondents can highlight key issues in the specific community, which can help define the direction of further investigations such as specific questionnaires or where and how to observe certain activities relating to water use. Often, these interviews are informal and are conducted by simply introducing a general topic and allowing the person to take the lead to provide relevant information to the interviewer. Specific lines of questioning can also be developed based on the general information provided.

It is important to review the interview questions in advance and also to check them with other people for feedback and revision. Having someone from the area (of the same community, ethnic group) review the information and check for the appropriateness of wording, language and clarity is extremely advantageous. Especially in the situation where the first language of the people in the community is not the same as the person designing the interview, it is important that information is clear and that the messages are not lost in translation, as this would defeat the purpose of the interview.

Participatory Mapping

Participatory mapping or community mapping is a tool that is useful for determining both physical features of a community around the water source and people's perceptions about the features, in terms of relevance, importance and value (Almedom, Blumenthal, & Manderson, 1997). In this tool, community members create a map of an area; which can be either the entire village or just the area around the water source, depending on the size of the community. The map shows features that are important to the community and features that they feel are important to the researcher (ex. water and/or sanitation facilities). Maps can be drawn using a variety of mediums, depending on the preference of the people drawing them. It's important that the participants are recorded and that the maps are shown to all people in the community for approval, comments and feedback. Community mapping is useful because it can provide quantifiable information, such as potential hazards surrounding a water source. For example, sanitary facilities, livestock watering areas and other disposal facilities can be identified and their proximity to the water source determined. Additionally, people's perceptions on relevant features can be understood from the mapping exercise. The maps can also be used as a baseline and to be kept in records, along with other 'snapshot' information about the water source and condition in an area at a given point in time.

Focus Group Discussion

Focus Group Discussions are rooted in theories of social psychology and communication and are often applied in social sciences research as well as market research studies. The approach taken is similar to a particular market research application, in that groups of similar people or 'markets' are brought together to provide information to a researcher on a particular subject. 'Similar' people is a fairly subjective definition, and is inherently subject to variation depending on those creating the definitions; however, similar socio-economic statuses are often used to group people, as well as ethnic backgrounds, gender, professions, etc. The primary goal of these discussions is to investigate the range of opinions regarding issues such as water use with a group of people who are thought to have similar interests in the subject.

Tape recorders are often used to capture the discussion, as it is difficult to record information from all the different participants who are interacting and weighing in on various topics at the same time. Recording the discussions allows the opportunity to review in detail when time permits and allows the researcher time to observe non-verbal language, to keep the discussion on track and to record other details of the meeting. Additionally, if the local language is not the same as the researcher, a tape recorder can allow an interpreter more time to review and translate, as opposed to quickly trying to translate for the researcher and consequently summarizing and potentially misquoting, etc. The negative part of using a tape recorder is said to be the cost and time required to review the discussion after the fact.

A discussion group of 6-8 people has been recommended, however the exact number will be different depending on the community member's interests and circumstances. Typically the discussions last between one and two hours (Almedom, Blumenthal, & Manderson, 1997); however, this is dependent on the context and is an individual decision.

4 Field Work Methodology

The development of the methodology for the project took place in two phases:

- Preparatory work at MIT- to gather information on sanitary inspection methodologies which would be in-line with Philippines and internationally accepted standards, and to gather information on conducting qualitative research for the community assessments
- Fieldwork in Capiz- to conduct Sanitary Surveys, Key-Informant Interviews, Participatory Mapping exercises and Focus Group Discussions while water quality testing was taking place by the PHO and other members of the MIT MEng Philippines team. The author assisted with and supplemented the water quality testing program; however, the primary focus was to conduct assessments of the water sources and to gather contextual information about water management, preferences, problems, etc.

The sanitary inspection/community assessment field work commenced on January 6, 2010 and continued until January 28, 2010. Thus, there were twenty-two working days in the Philippines. Upon arrival, the first steps were for the author to introduce the study objectives to the PHO and to discuss and coordinate logistics. It was important to gather feedback from the PHO on the appropriateness of the proposed methods in Capiz.

The authors study design for conducting assessments throughout the municipalities in Capiz Province and the entire water quality testing program were designed to focus on water sources that were thought to be 'at-risk' for contamination. The sampling methodology and fieldwork methodology which utilizes the described methods in Chapter 3 are briefly described below.

4.1 Research Design

Both the water quality testing program and the technical and community assessments made use of a stratified sampling design. In other words, samples were not randomly selected from the entire water level spectrum (Doubtful to Level 3), but were rather selected within their own subpopulation (i.e. water level). This means that a set number of samples per subpopulation were first determined, and then samples within their subpopulation were randomly selected for testing. The reasoning for making use of this, as opposed to a purely random sampling program, was based on the overall study objectives of the MEng team. That is, Trottier (2010) and Chuang (2010) sought to compare alternate field-based microbiological test methods to standard methods (i.e. Quanti-Tray®), and the author's objective was to provide recommendations for 'at-risk' supplies. Therefore, these goals were accomplished by skewing the sample selection process towards Doubtful, Level 1 and known contaminated sources.

The author's fieldwork aimed to visit 1-2 villages per municipality; which allowed for a total of 51 stakeholder interviews and 52 Sanitary Surveys to be conducted. The site selection was made based on a combination of prior water quality results, specifically results that indicated intermediate, high or very high *E.coli* concentrations based on recent previous testing by the PHO and Chuang (2010), and/or where doubtful or Level 1 sources were being tested during January and where community members were available to take part in the assessments.

4.2 Sanitary Surveys

The sanitary survey forms were finalized during a face-to-face meeting with the Sanitary Engineer in the Philippines to ensure that they were in line with their existing methods and regulations. The general templates for the WHO Drinking Water Guidelines Sanitary Inspection forms for the specific water source types found in the Philippines (e.g. dug wells, springs, rainwater collection, piped supplies, tubewells) were printed and taken to Capiz for direct use or modification if it was required.

Examples of the WHO Sanitary Survey templates can be found in Appendix I.

4.3 Water Quality Test Method

The IDEXX Quanti-Tray® is the standard method which was used to test drinking water sources in Capiz. It is a lab-based, enzyme substrate coliform test that utilizes semi-automated quantification methods based on the Standard Methods Most Probable Number (MPN) model. The enzyme substrate test uses hydrolysable substrates for the detection of both total coliform and *E.coli* enzymes. When the enzyme technique is used, the total coliform group is defined as all bacteria possessing the enzyme β-D-galactosidase, which adheres to the chromogenic substrate, resulting in release of the chromogen (the sample changes color and becomes yellow). *E.coli* bacteria are defined as bacteria giving a positive total coliform response and possessing the enzyme β-glucuronidase, which adheres to a fluorogenic substrate, resulting in the release of the fluorogen (the sample fluoresces).

The tray provides bacterial counts of up to 200.5 MPN/100 mL of sample. The Quanti-Tray® is easy, rapid, and accurate and has been approved by the US EPA, and over 35 countries for drinking, source/surface, ground, and waste- waters. There is no colony counting required, no dilutions needed and no media preparation. The Quanti-Tray® detects down to 1 MPN/100 mL of sample, and has better 95% confidence limits than multiple tube fermentation and membrane filtration (Thermalindo, 2007). However, the cost of equipment and supplies for Quanti-Tray® is expensive, particularly in developing countries.

4.4 Community Assessments via mapping and key-informant interviews

Language barriers in villages were discussed and necessary translations were made to the interviews; along with allocation of PHO personnel to acts as translators. The translators were briefed about the content of the questionnaires and the intention/aims of the field work.

The aim for the community assessments was to conduct a participatory, community mapping exercise after arrival into a village. However, in practice, mapping was conducted after interviews, before heading to the water sources. In total 7 community maps were made, however these provided little information other than the roads, schools, rice fields and locations of the sources. The intention was for community members to highlight potentially hazardous activities around the source, even if they did not perceive them to be; however, the methodology was not particularly effective in this context. Therefore, it has not been reported on in Chapter 5.

Based on the literature and research into livelihood activities in Capiz Province, the following three key stakeholders were identified: Farmers, Water Managers, and Women. Participating villages were made aware of our visit prior to our arrival and various stakeholders were asked to participate. The interviews were semi-formal, with one-on-two set-up used where possible (interviewee, translator and the author). In some cases it was impossible to get a private room and other community members and sanitary inspectors were present. Two focus group discussions were carried out with a group of household users and with a *barangay* council. Additionally, permission was sought to tape record some portions of the discussions, as it was thought that this would greatly improve the accuracy and completeness of the results. These tapes were reviewed and transcribed at the end of the day. Detailed notes were also taken.

The final questionnaire can be found in Appendix II.

5 Results

The results of the sanitary surveys, water quality tests (Quanti-Tray® only) conducted from December 2009 - March 2010, and community assessments are provided below. The community assessment results are presented in general categories based on trends that were seen throughout the province. The sanitary survey and water quality results are presented by municipality and by water source type in order to highlight relative differences in water quality and guide priority lists for implementing remedial measures around the province.

As previously introduced, water sources are defined in four categories in the Philippines- Level 1, Level 2, Level 3 and Doubtful (Table 5-1). Thus, the WHO Sanitary Surveys and the Quanti-Tray® water quality results will be presented according to these categories.

Table 5-1 Review of water level categories in the Philippines

Category	Source Types
Level I	Stand-alone point sources, including shallow wells, handpumps, springs
Level II	Piped water supply with communal water points, from boreholes
Level III	Piped water supply with private water points, such as a household connection
Doubtful Sources	Unprotected springs, open dugwells, surface water, rainwater collectors

5.1 Technical Assessments (WHO Sanitary Surveys)

The types of water sources surveyed were open dugwells (OD), tubewells with handumps (JMP), unprotected springs (US), protected springs (PS), protected dugwells (PDW) and boreholes (DWP). In total, 52 sanitary surveys were completed during January. The surveys generally all revealed a number of hazardous activities taking place around water sources. The specific hazards noted for each source type are summarized in Appendix III. The hazards varied per source type; however, the lack of site protection from access by animals was noted in almost every site inspection. Additionally, the proximity of septic tanks, lack of drainage channels (enabling pooled water), and animal waste were found to be consistent hazards.

Table 5-2 shows that 54% of the surveys resulted in sources are categorized as 'high risk' according to the survey form. The proportion of intermediate risk level and very high risk level were very similar, 21% and 23% respectively. Only 2% of the sources surveyed had sufficiently few hazards to be categorized as 'low risk', which indicates that 98% of the sources surveyed were of intermediate, high or very high risk.

Table 5-2. Risk level of sources surveyed (by percent)

Risk Level	Percent of sources surveyed (%)
Low	2
Intermediate	21
High	54
Very High	23

The survey results by municipality, along with the number of sources surveyed in each area are presented in Figure 5-1.

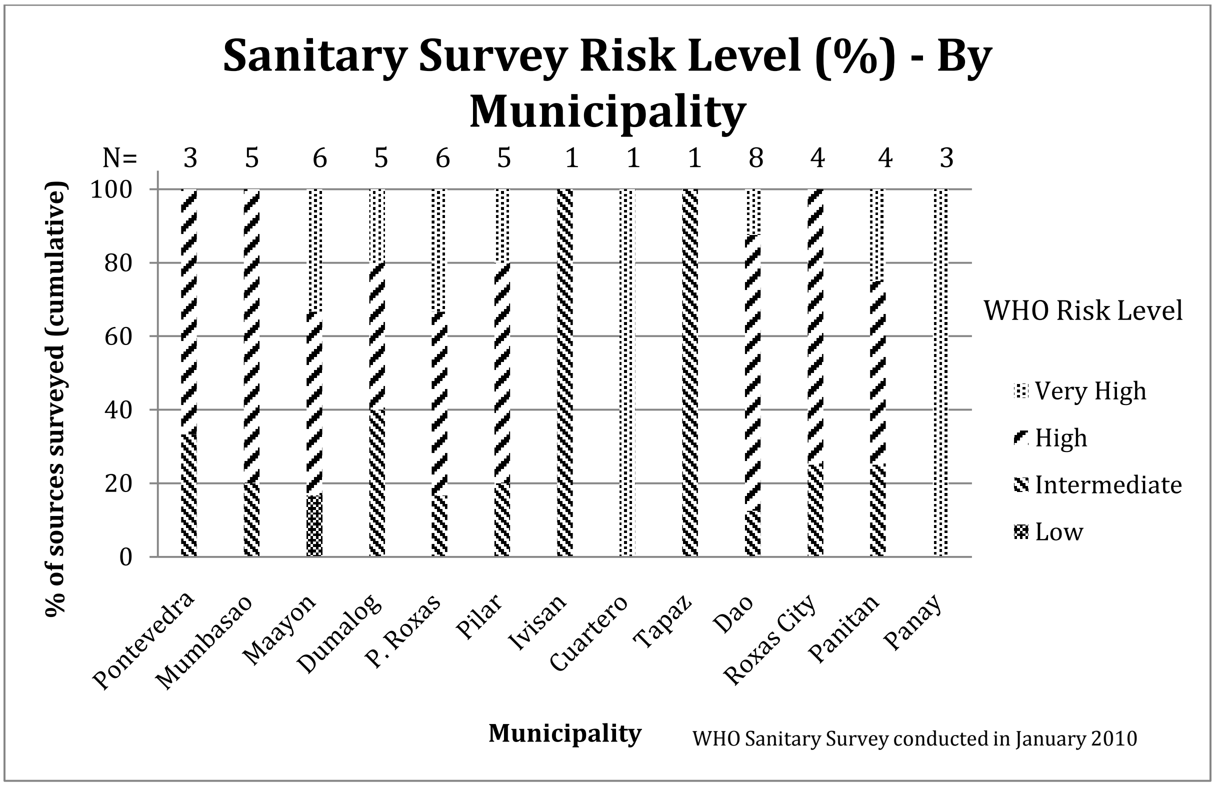

Figure 5-1. Sanitary Survey Risk Levels by municipality

The results by municipality showed that most of the sources surveyed were in the High to Very High Risk Level categories. Only one of the 52 surveys found the water source to be at 'low risk' for contamination. This was in Maayon and was a JMP source (Figure 5-1). The variable number and type of sources inspected between municipalities does not facilitate municipal comparison; therefore, Figure 5-2 presents risk levels by source type.

The sanitary survey results showed that OD had the highest risk, followed by JMP. Of the Level 1 source types, JMP were found to have the highest risk. However, it should be noted that there were considerably more JMPs visited than other Level 1 source types due to the stratified sampling design (Figure 5-2).

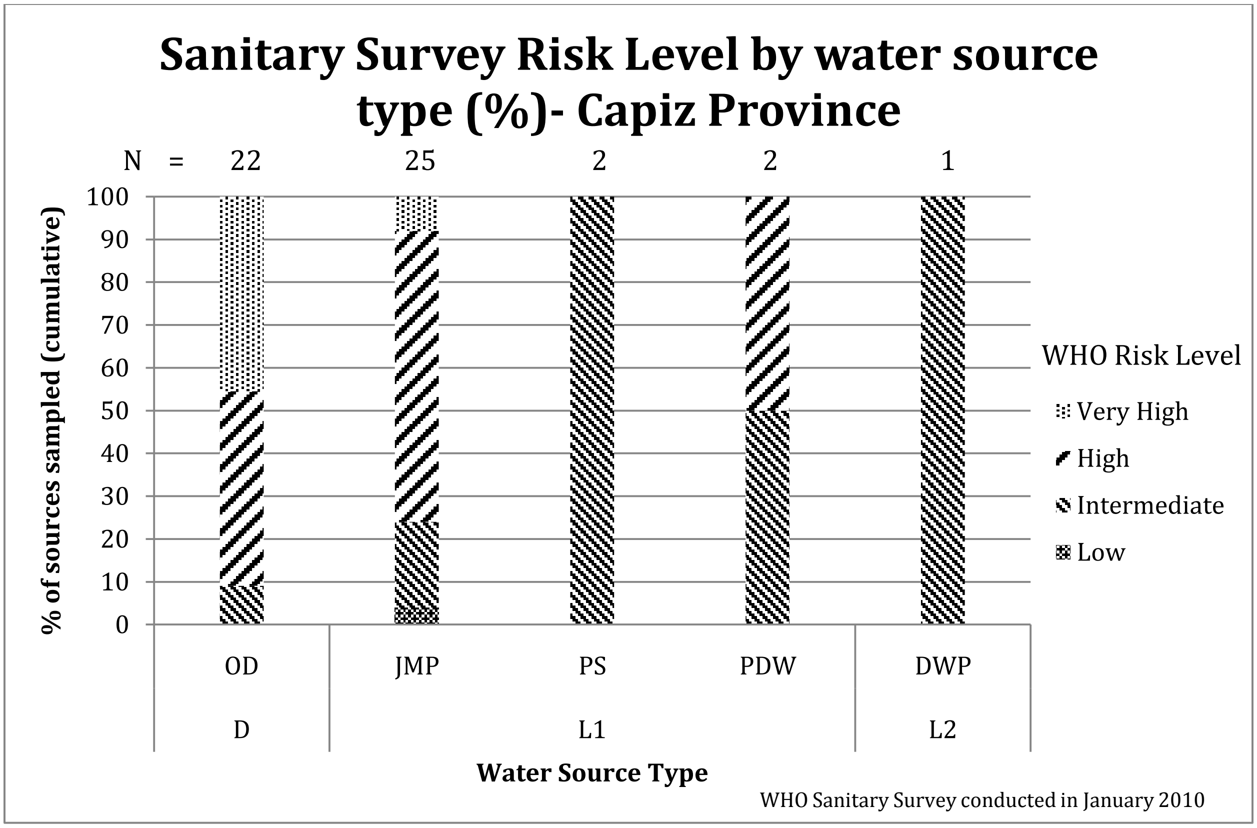

Figure 5-2. Sanitary Survey Risk Level by water source type based on % of sources surveyed

As Figure 5-2 shows, ODs showed the highest percentage of high and very high risk level based on the hazards identified during sanitary surveys. Ninety percent of ODs surveyed showed high or very high risk levels, followed by 76% of the JMP sources surveyed. PS and PDW generally showed lower risk levels; however there were only two of each of these source types visited, and more surveys would have to be conducted to say conclusively if these sources are lower risk (according to the WHO Survey templates) than ODs and JMPs. The only Level 2 source sampled (DWP) was found to have an intermediate risk level for contamination. This score was due to lack of a drainage channel, lack of fencing around the borehole, less than 1m diameter concrete platform around well-head and a loose well-seal.

5.2 Water Quality Results

The following graphs represent the water quality sampling and test period from December 2009 – March 2010. In total there were 569 samples collected over this period, and the majority of these were from Doubtful and Level 1 sources due to the intentional stratified sampling design. The graphs show the results from the Quanti-Tray® analysis and the corresponding risk levels for *E.coli* based on guidance established by the WHO in its Drinking Water Quality Guidelines (WHO, 1997i).

Table 5-3. WHO Risk Level corresponding to *E.coli* level in sample (Adapted from WHO, 1997) (Metcalf, 2006)

Risk Level	***E. coli* in sample (coliform forming unit (CFU)[1] per 100 mL)**
Conformity	<1
Low	1-10
Intermediate	10-100
High	100-1000
Very High	>1000

The type of Quanti-Tray ® system used in Capiz Province, only allows detection up to 200.5MPN/100 mL; thus, the risk levels for the water quality test program are defined as Conformity, Low, Intermediate or High.

To frame the results within the Philippines context, the National Standards for Drinking Water state that, using standard methods of analysis:

- *E.coli* test must give a result of <1.1MPN/100 mL
- Total coliforms should be at a conformity risk level for 95% of samples taken in a given time period (defined based on sample location)

The Code on Sanitation states that water should not be supplied for public use unless a level of treatment has been provided based on the following water quality results for coliform organisms:

- <50MPN/100 mL → this is stated as a 'low degree of contamination' and water which falls in this group requires only **disinfection { Conformity, Low and Intermediate Risk Levels as defined by WHO (Table 5-3)}**
- 50MPN/100 mL < sample < 5,000MPN/100 mL → this group requires **complete treatment {Intermediate, High and Very High Risk Levels as defined by WHO (Table 5-3)}**

Thus, the Code states that results which show intermediate (>50MPN/100 mL) or higher levels of risk at least require disinfection, and anything which is intermediate (>50MPN/100mL) , high or very high risk level category, requires 'complete treatment'.

First, the *E.coli* Risk Levels are shown by municipality in Figure 5-3. This method of presentation of the data in terms of risk level categories is useful for officials at the municipal level to develop priority action plans. Additionally, graphical results by water source level for each municipality are contained in Appendix IV. These municipality-by-municipality graphs will be a further aid to guiding action at the municipal level.

[1] CFU is equivalent to MPN

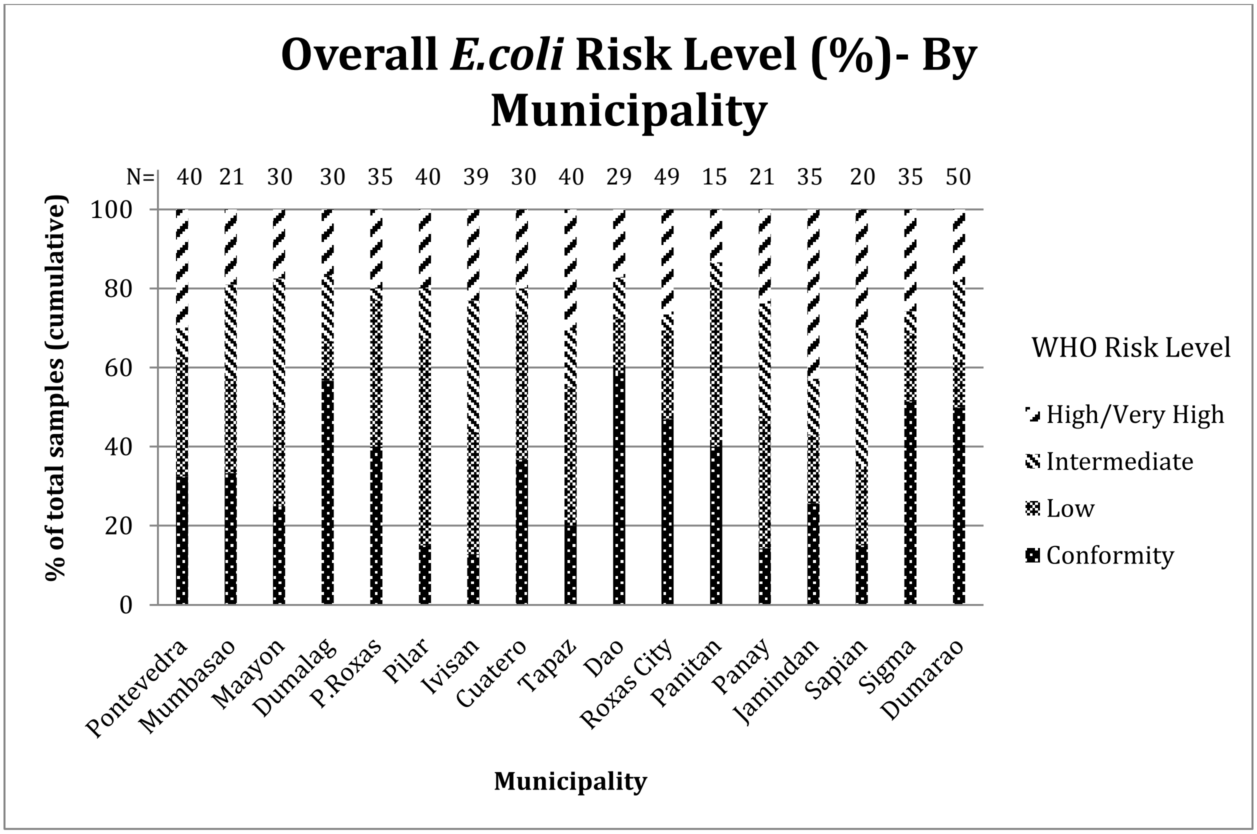

Figure 5-3 *E.coli* Risk Level (%) by municipality determined from samples collected January-March 2010

Table 5-4 Water source type sampled (%) by Municipality

Municipality	% D	% L1	% L2	% L3
Pontevedra	10	53	13	25
Mumbasao	24	76	0	0
Maayon	13	63	25	0
Dumalag	13	53	0	33
P.Roxas	14	43	14	29
Pilar	13	50	0	37
Ivisan	18	64	18	0
Cuatero	3	63	33	0
Tapaz	0	63	38	0
Dao	14	86	0	0
Roxas City	2	98	0	0
Panitan	0	100	0	0
Panay	24	76	0	0
Jamindan	14	71	14	0
Sapian	0	100	0	0
Sigma	14	43	14	29
Dumarao	10	50	10	30

Figure 5-3 provides the overall *E.coli* risk level of the total samples collected in each municipality during January-March 2010. Because of the unequal number of samples collected per municipality, Table 5-4 complements Figure 5-3 and provides a percentage of each source category tested in order to provide potential causal links. Comparatively, Jamindan had one of the highest percentages of high risk water quality results. A potential reason for this is that of the 15 water samples collected from this municipality, 85% were from Doubtful or Level 1 sources. Similarly, samples collected from Sapian were all from Doubtful and Level 1 sources; Figure 5-3 shows that this municipality also has a comparatively high percentage of high risk sources. However, Table 5-4 shows that Sigma had the highest percent of Level 2 and Level 3 sources sampled from January-March (43%), and this municipality showed one of the lowest percentages of water samples of conformity.

Given the difficulty in extracting trends with results presented by municipality, water quality results were next grouped according to general water level category and by specific water source type.

Figure 5-4 and Figure 5-5 show the number of samples within each source level, as well as by risk level, both in terms of the actual number of samples and in terms of the percentage.

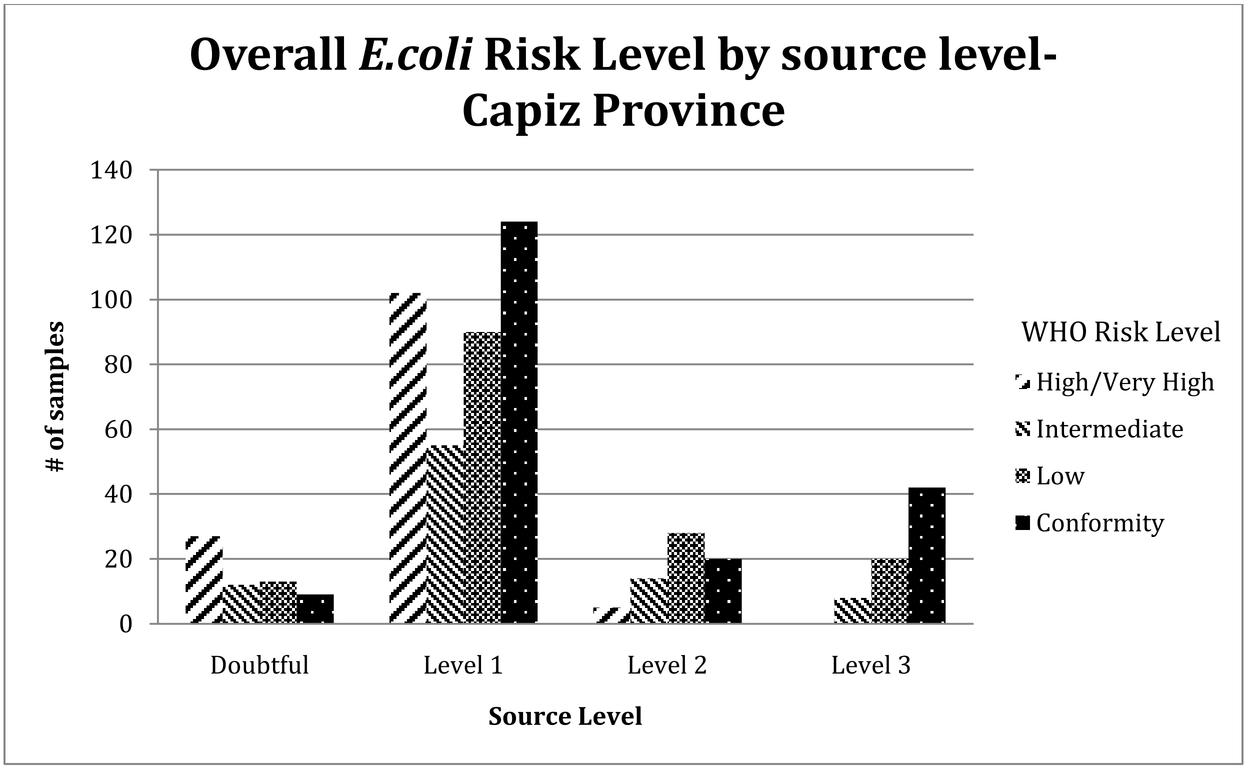

Figure 5-4. Overall *E.coli* risk level and number of samples by source level category

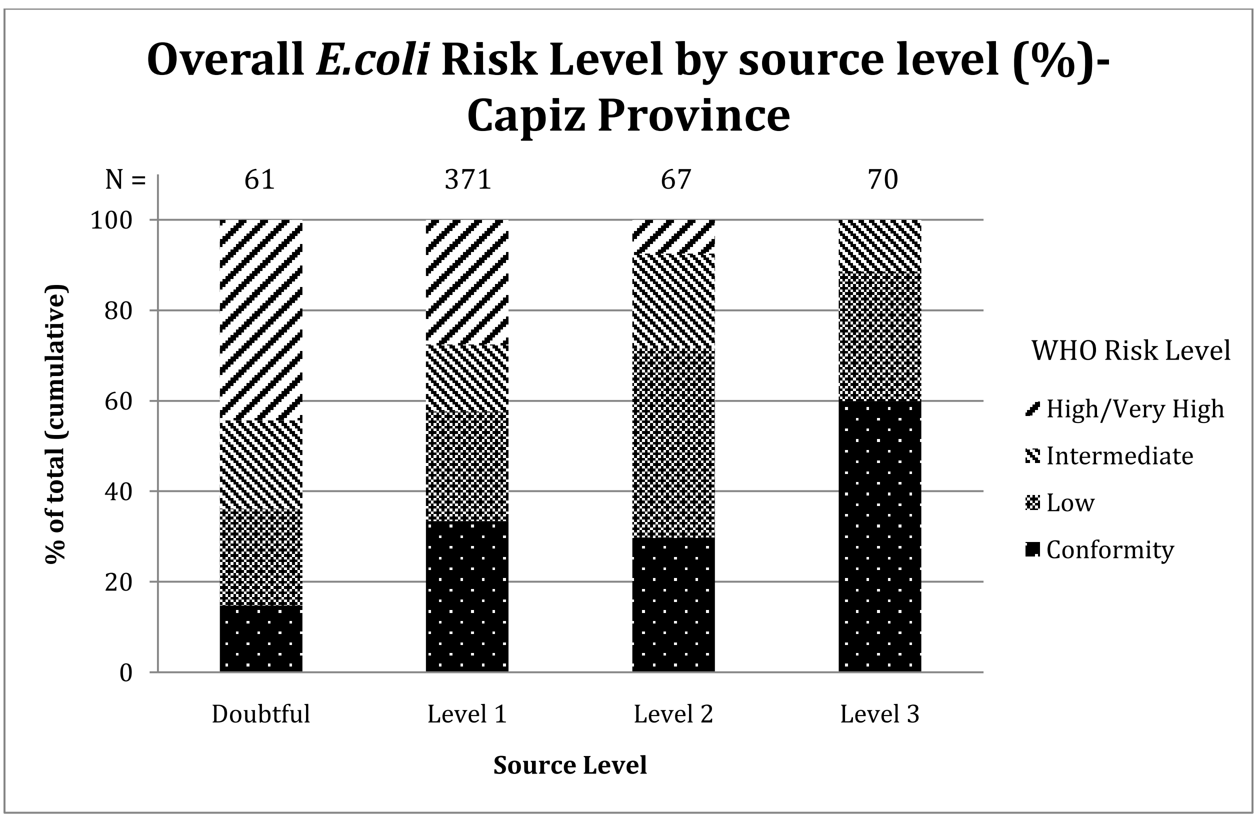

Figure 5-5. Overall *E.coli* risk level by water level category (%)

Figure 5-5 shows a decreasing trend in high risk levels from Doubtful through to Level 3 sources. Of the 61 Doubtful water sources sampled, 64% were categorized by intermediate and high risk levels; comparatively, only 11% of Level 3 sources were of intermediate risk and none of the 70 samples collected were of high risk. Similarly, an increasing trend in conformity levels was seen from Doubtful to Level 3 sources. These Level 3 sources were generally small village systems which employed sand filtration and/or chlorination treatment prior to distribution. **It is of note that Roxas City, Panay, Ivisan and Panitan Level 3 treatment distribution systems were tested with a different test method; the results of which are outside the scope of this work, but are included in the Philippines Group Team Report which will be provided directly to the PHO**. Chlorine residual testing was conducted on these samples, instead of microbiological tests.

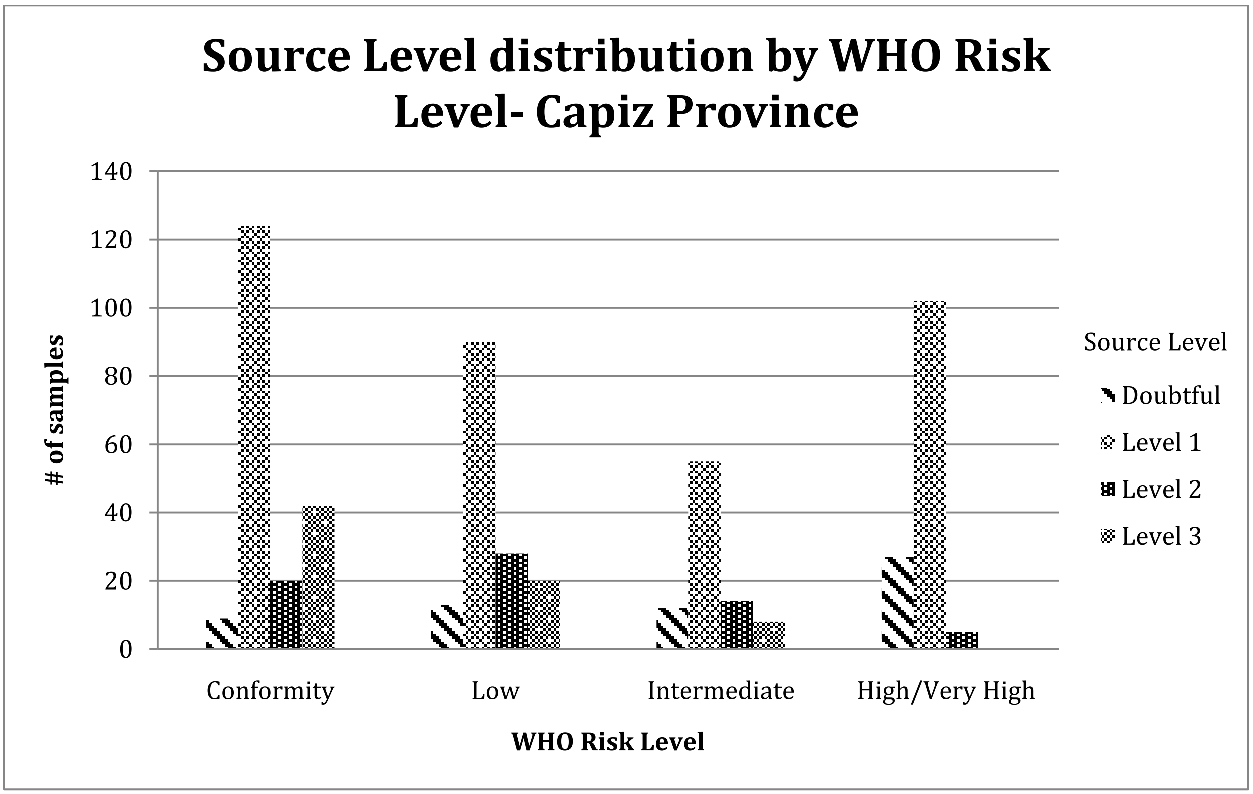

Figure 5-6. Source Level distribution by WHO Risk Level

Figure 5-6 shows a different interpretation of the aforementioned water quality results. When grouped according to WHO Risk Level, Level 2 and Level 3 are seen in greater proportions in the conformity to low risk level end. Level 1 samples, however, are seen in large number throughout the risk level categories, illustrating potentially the range of water quality within the different Level 1 source types and/or within a particular source type of different age, condition, and maintenance. A similar variability in the quality of water from Doubtful sources is seen; again, this could be illustrative of the large variability in condition and type of sources within this water level.

Finally, water quality test results were grouped according to specific water source types within each water level category. Table 5-5 below contains the legend for the water source codes for the entire test program.

Table 5-5 Water Source Codes for each Water Level in Capiz Province

LEVEL	Water Source Code	Water Source
D	OD	Open dug well
	US	Unprotected spring
	SW	Surface water (Rivers, streams, creeks)
	OT	Others not mentioned above
L1	SWP	Shallow well with pump (<60 ft)
	JMP	Jetmatic Pump w/ or w/o motor
	DWP	Deep well with pump (>60 ft)
	PDW	Protected dug well
	PS	Protected spring w/o distribution
	RW	Rain water catchments (ferro cement tanks)
L2	GPS	Gravity protected spring w/ pipe distribution, Communal tap stands
	DWP	Deep well w/ pump w/ pipe distribution, Communal tap stands
L3	WD	Water Districts
	LWUA	Local water utilities administration
	BAWASA	*Barangay* waterworks system

There is a considerable variation in the sample size for each of the different water source types shown in Figure 5-7 due to the stratified sampling methodology. Seventy-six percent of the 569 samples collected during January-March were of Doubtful and Level 1 source types. However, within each source type, a sample size of greater than 30 generally facilitates some statistical trends.

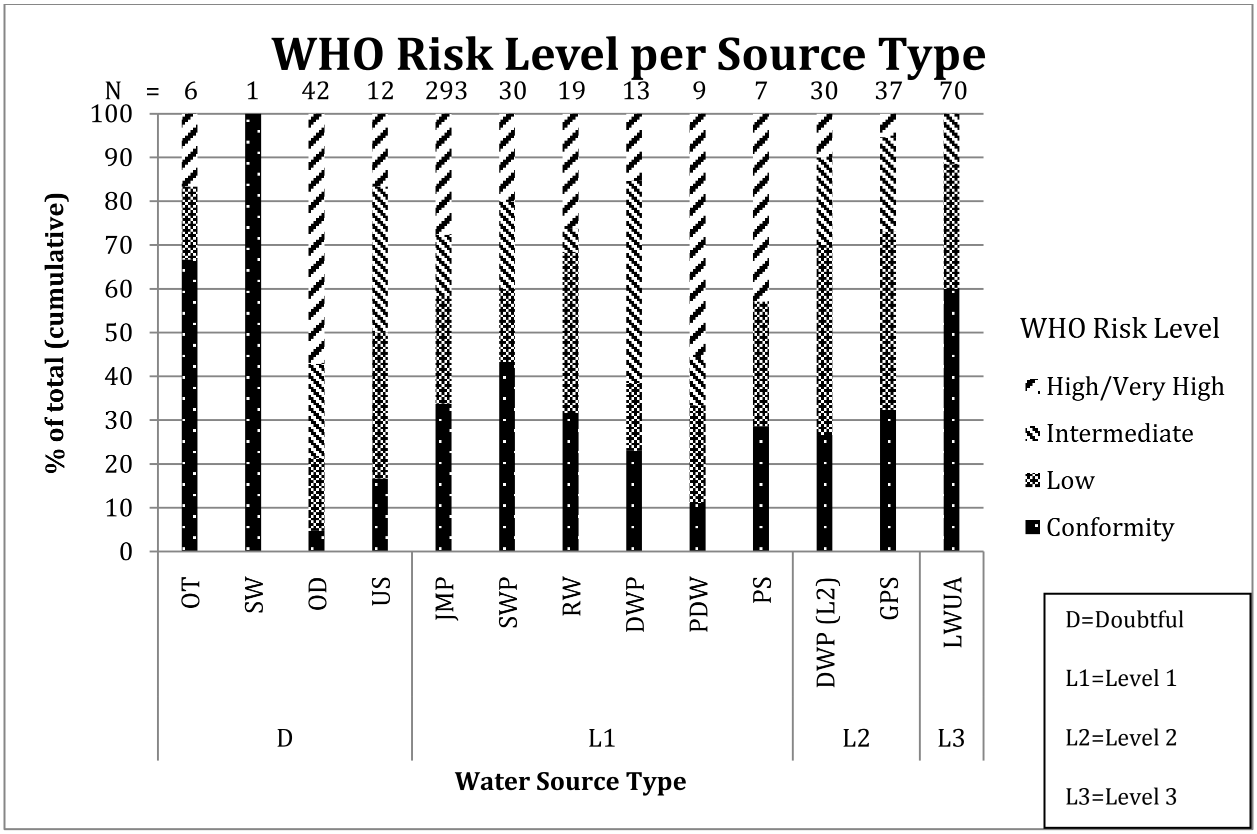

Figure 5-7. Overall *E.coli* risk level by specific water source type (%)

Of the Doubtful sources, 78% of the open dugwells tested had intermediate or high levels of risk for *E.coli* contamination. This is followed by 50% for unprotected spring sources. For Level 1 sources, which were 65% of the total water quality test program sample size, the percent of sources with high or intermediate risk levels decreased from protected dugwells, deep well pumps, protected springs to jetmatic pumps; with 67%, 61%, 43% and 42% respectively. It is of note that of the Level 1 sources tested, rainwater catchment samples showed the highest percentage of low risk and conformity water quality levels (69%). This potentially has implications for recommendations which should be made by the PHO for those without access to Level 2 or Level 3 systems. However, of the Level 1 sources, only JMPs and SWPs had a significant sample size. The risk level distribution for each source type by total sample number is shown in Appendix V. The disparity in the sample sizes becomes clear in this representation.

Within the Level 2 sources, gravity protected springs appears to have marginally higher water quality than deepwell pumps (boreholes); 73% of samples were in conformity and low risk levels, and 5% in the high risk level, compared to 70% and 10% respectively. Level 2 and Level 3 source types all showed 70% or more of samples in the low risk to conformity levels. This indicates a decreased likelihood of contamination in water source types that have piped distribution or in systems that receive treatment prior to distribution; this is demonstrative of the potential health benefits of increasing the proportion of the Capizian population with access to these services. Recommendations based on this water quality data, along with other assessment results are continued in Chapter 6.

5.3 Community Assessments

Key informant interviews were conducted in one or two communities in each of the 16 municipalities and Roxas City. Key informants included household users (women), local government members (*barangay* officials) and farmers. In total 51 interviews were conducted. Two focus group discussions were also carried out as part of community assessments; one with a group of household users and one in another location with the *barangay* council. During the 1st two days a 'pilot survey' was conducted, which was modified based on learning from the field. The second and final version of the questionnaire was created, which omitted some non-applicable questions, added a few new ones and also changed the wording in some questions. The final questionnaire is in Appendix II. Because this questionnaire only sought to learn from community members what the water use needs, awareness, preferences and current management situation was, and did not entail any intended intervention by the author or MIT research team, this questionnaire was not submitted to the MIT Committee on the Use of Humans as Experimental Subjects (COUHES). Based on the responses, the results are discussed below under 4 main headings:

- Water use needs
- Awareness regarding water use and safety
- Preferences regarding water use
- Current management in water use

These allow the major findings to be highlighted in a way that frames the recommendations made in Chapter 6.

5.3.1 Water use needs

The key informants interviewed represent different stakeholder groups in this largely rural, agricultural society. Their responses provide a picture of basic household and livelihood water needs around Capiz, and also provide a glimpse of both individual and collective priorities among the different groups. For example, farmers often mentioned crops as one of the uses for water in the community and, unsurprisingly, household users generally noted household uses before uses such as animal watering and farming uses. A long list of uses were compiled based on responses to the question of what exactly water is needed for in the communities visited in each of the 16 municipalities and Roxas City. According to these stakeholders, water in Capiz is needed for:

- Drinking
- Cooking
- Laundry (clothes washing)
- Dish washing
- Household washing (cleaning)
- Food washing
- Food preparation
- Car washing
- Animal washing (bathing)
- Stall washing
- Watering animals

- Washing/flushing toilets
- Bathing
- Gardening
- Farming(crops)

The answers cover a range of domestic needs as well as livelihood needs and illustrate the importance of considering the multiple uses of water in planning water system expansions and improvements. A holistic approach for improving water systems should include emphasis on not only the health improvement, but on the well-being and socio-economic improvement which water use in the productive sector enables (Koppen, Smits, Moriarty, Vries, Mikhail, & Boelee, 2009). Equally important in water system improvements is the acknowledgement of the multiple sources of water that are used to provide for the multiple uses.

Drinking was most often listed as the most important use of water. This is not a surprising answer, given that it is fact, but also not surprising given the respondents' prior knowledge of the purpose of my interview and the water quality testing program. However, the use of water for cooking was also listed frequently as the most important use for water. Bathing, washing and water for crops and animals were also listed by some as the most important use for water. In terms of water quality characteristics that are required for drinking, interviewees had numerous responses, including that water should be clean, clear, tasteless or natural tasting, odorless, and safe. The numbers for each response were as follows (Table 5-6):

Table 5-6. Desired characteristics of drinking water

Characteristic	Number of responses	% of total
Clean	21	41
Clear	23	45
Tasteless or Natural taste	8	16
Odorless	1	2
Safe	7	14

The amount of water that people reported that they needed for daily use varied widely, but the most common response was approximately 200L for a family of five. One respondent answered that she required 600L for her family which was usually between 5-9 people (depending on who was home). Other people stated that they needed much less; some people said 200L would suffice for a family of 10 people. The variability is thought to be caused by people misinterpreting the question; for example, thinking the question meant just for drinking and omitting uses such as laundry. Another potential cause is simply the differences between people's daily activities, the distance to the water source and also their socioeconomic status. One respondent actually stated that the amount of water that is needed on a daily basis depends on the wealth of the family; he stated that wealthy families cook and bath more. Other respondents might have a piggery on their property, or small gardening plots, and others may not. Generally, the results show that people in Capiz require between 20 to 100L/capita/day at the present time. This need or expectation has implications on planning for improvements to water services in the province. For example, it can be assumed that people would not commit to using water from a source that prevents them from collecting at least this amount on a daily basis- even if it were potentially of a higher quality.

For planning purposes, the following excerpt from *Howard and Bartram* (2003) puts the daily water consumption into context (Table 5-7). From the interviews by the author and her team, the access to water described generally falls between basic and intermediate access as defined by *Howard and Bartram*. For those living with basic access among those interviewed by the author and her team, the quantity of water available would generally meet consumption requirements (drinking and cooking). However, certain basic needs, such as hygiene, are not assured. This implies a high level of health concern based on Table 5-7, and therefore efforts should be made to increase this access level to at least intermediate (50l/c/d) to allow health gains to be realized. This goal is independent of increasing the quality of the water. The optimal aim should be to increase access to water to 100L/c/d, as this allows the quantity for all consumption and hygiene needs to be met. However, incremental increases from 20l/c/d need to be planned for in water system improvements for Capiz.

Table 5-7. Excerpt from Table S1. From Domestic Water Quantity, Service Level and Health (Howard & Bartram, 2003)

Service Level	Access Measure	Needs met	Level of health concern
Basic access (average quantity unlikely to exceed 20l/c/d	Between 100 and 1000m or 5 to 30 minutes total collection time	Consumption – should be assured; Hygiene – handwashing and basic food and hygiene possible; laundry/bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50l/c/d	Water delivered through one tap onplot (or within 100m or 5 minutes total collection time)	Consumption- assured Hygiene- all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access	Water is piped into the home through multiple taps	Varies significantly but likely above 100l/c/d and may be up to 300l/c/d	Very low. All uses can be met, quality readily assured

Additionally, the implications of service level vs. access to water needs to be considered in each location. While a water source might have the capacity to provide more than 20l/c/d in a community in Capiz, the access (lack of) to the water could actually prevent people from obtaining this basic service level. Table 5-7 shows that in order to enable intermediate access, the location of water points must allow access within 5 minutes and within a distance of 100m. This should also be taken into account when planning for improvements to water sources.

5.3.2 Awareness regarding water use and safety

The awareness of respondents on issues regarding water use and water safety varied considerably. In some aspects, such as water treatment options and safe storage, there was considerable awareness. Similarly, awareness regarding the importance of sterilizing water (boiling) for use for baby milk and feed was very high. However, other issues such as the effect of land use activities and features around water sources on the water quality were not widely understood. Additionally, there was mixed awareness and perceptions regarding the water quality from different types of sources. Finally, clarity was lacking on who was responsible for the maintenance of the water sources and on the need for training to maintain water supplies.

Firstly, there was a high awareness among respondents on water treatment methods. While the practice of these treatment methods was not commonplace except in specific conditions (such as when there were iron deposits in the water), most people were able to describe various treatment options that could be employed. For example, when asked how the water sources could be improved, people often answered that they could be treated either with chlorine, boiling or filtration. Filtration was provided as an example primarily in locations where high iron concentrations were noted or described by interviewees. Therefore, it is uncertain whether people were aware of the use of filtration for reducing microbiological contamination. However, chlorine and boiling were commonly described as sterilization methods for water supplies.

People were also generally aware of the importance of storing drinking water separately and storing it in a sealed container and withdrawing from a spigot/tap. All household respondents stated that they stored water in the home; with plastic being the most common material, followed by ceramic and rubber. For some people, water used for different purposes was stored separately. For example, water used for dishwashing and cooking was stored separately from water used for toilet flushing or washing. Drinking water stored in a dedicated and sealed container was also common practice and perhaps less intuitive than using different vessels for different uses. Respondents reported using plastic, sealed water jugs, and many respondents also described containers with a spigot (these were also observed in practice).

There also appears to be a widespread awareness regarding the importance of high water quality for babies and young children. The Province of Capiz evidently has had a major pre- and post-natal education campaign, along with developing a high level of care at Local Health Units. The effect of these efforts was seen in the high level of awareness regarding water safety for babies. This has positive implications for the potential for similar messages being communicated to households via health workers regarding water safety issues where awareness is currently lacking.

Awareness regarding the effect of activities around water sources on the water quality of the source was variable, and the responses are tabulated as follows (Table 5-8):

Table 5-8. Response to Q: Do you think activities around the water source can affect the water, and if so, which ones?

Activities/Substances	Total responses	% of total
Can't affect the water	15	29
Pesticides from rice fields	10	20
Laundry/clothes washing	8	16
Animals	8	16
Bathing	7	14
Septic tanks	7	14
Garbage	5	10

Approximately 30% of respondents stated that it isn't possible for activities around the source to affect the water. Impacts such as septic tanks, bathing and animals were not as commonly thought to affect the water as things such as pesticides. In reality, these activities are likely to have a much greater effect than pesticides on water supplies. These results illustrate that there is a major need for education regarding water safety and source protection in Capiz Province.

There was also a lack of consensus and different perceptions on water quality from different sources- such as that from rainwater, dugwell water and tubewell (jetmatic) sources. In many cases, these perceptions were based on physical evidence, such as the presence of cloudy color after rain events, color due to iron deposits or a bad taste. Water quality in these instances was based on this evidence; instead of on the type of water source. For example, in some locations where iron deposits were present in the tubewells, respondents said that open wells were of higher quality because the water was generally clear. Conversely, stakeholders often replied that tubewell water was of higher quality than dugwells because they are closed to the surface. People said that because the wells are enclosed, it is not possible for contamination to enter. For open wells, there was a general understanding regarding the potential for surface activities or substances (dirt, leaves, animals) to enter the well.

There were also some interesting responses relating high water quality to the source of water coming from 'between stones or rocks'. This response was noted in two different locations for two different types of water source (one explaining the high quality in a dugwell and the other in a tubewell). A consensus on the high quality of spring water was recorded; in fact, this was the source that was most highly rated across the province. People thought that this source was higher quality than water from another source that had been treated with chlorine. There was also a commonly held belief that rainwater was unsafe and unsuitable for drinking. Two respondents remarked that rainwater is contaminated, though it was not clear whether this was thought to be because it was coming off the roof. Superstitions, such as rainwater causing illness due to the temperature and foreign composition, were also expressed. However, some respondents did report drinking rainwater and stated that it was fine after it was boiled. Others described using rainwater only for washing, cooking and bathing. The examples given show that overall, peoples' perceptions of quality are generally based on the physical appearance of the water (historic and present), in addition to community norms and common practices and beliefs. The collection of real water quality results from the test program will help counter some of these unfounded beliefs (i.e.

regarding the safety of rainwater for drinking); however, peoples' preference will still play a pivotal role in which water source types become widely used.

Finally, when asked who was responsible for maintaining the communal sources, there were a variety of responses including the households or individuals who use the sources, the whole community and the *barangay*. *Barangay* officials usually responded that they were responsible for maintaining the sources; however other respondents stated that it was individuals and users of the wells that usually did maintenance and upkeep. There was almost consensus that the *barangay* officials funded repairs, however sometimes this was only if the users could not produce the funds themselves. It can be concluded that generally, there is a lack of clarity on who is responsible for looking after the sources. Some respondents said plainly that no one is in charge; and this may well be the case in many situations. However, there was no response that indicated that no one was capable or willing to do the repairs, which indicates that, with training, clear responsibilities and systems in place, communities should be able to maintain their sources well.

One final point of importance is that there were mixed views on whether training was required to be able to maintain the supplies. Many respondents stated that they didn't have training, but they were already able to look after the sources. Some people stated that they thought training was needed or that they didn't know how to maintain the sources, but the majority did not realize the importance or need for training to upkeep the sources. Evidence from site surveys indicates that in most cases maintenance and upkeep are currently lacking; thus, training is an issue that needs to be addressed when planning improvements.

5.3.3 Preferences regarding water use

Respondents were asked about their preference on having a community well supply that was centrally located, shared by the community, and that had easy access or private wells that were owned and operated by individual households. Not surprisingly, the majority of respondents stated that they would prefer household wells because then they would not have to travel any distance to fetch water, and it would be readily accessible for them at all times. People also stated that in having their own well, they could make sure it was well maintained and cleaned. Others responded that it would be difficult to find someone in the community who was willing to take on the role of maintaining a community supply. In total 29 respondents stated they would prefer household wells; approximately 64% of those asked[2]. However, 16 respondents (36%) did state that a community well would be better. Reasons for this choice were that everyone could share, easier to manage, safer because they can be in protected locations and potentially cheaper to maintain.

The majority of the 36% who would prefer community wells were *barangay* officials or captains who were already in charge of maintaining communal sources. Some who preferred this are thought to currently have strained water sources or to not have their own well; while others actually perceived of the risks of other activities occurring in close proximity to household wells. Obviously access is a primary concern for people, as this allows basic consumption, hygiene and

[2] Question was added to interview after the second day (i.e. of 51 respondents, only 45 were asked this question)

livelihood needs to be met. Therefore, improvements to water access must be prioritized as highly as improvements to water quality.

In terms of management preferences, the stakeholders generally were divided between *barangay* management and users' management. For private wells, it was consistently stated that the owners were responsible. For shared sources, it was not always clear whether these feelings of roles/duties were due to financial contributions, community norms or standards, or potentially even preference. Some people did state that the community voted for the *barangay* officials to look after the source. In other locations, a particular person or family agreed to look after a source. There were cases when a group of households (*sitio*) asked for a water source to be installed, and therefore they assumed responsibility from the *barangay* council. Similarly, it was stated that communities were asked where sources should be located, and were involved in the installation; and in these cases ownership feelings may impact management of the sources.

However, the possibility exists in some locations that the management is less of a choice than it is simply a reality of the situation and the capacity (or lack thereof) of the community government. The responses from *barangay* officials consistently reported *barangay* management of communal water sources; however, other respondents stated that this wasn't the case. Their feelings on whether the user management was appropriate or preferred were not asked.

Some respondents stated a preference for Sanitary Inspectors and *Barangay* Health Workers to be involved in management of sources. Additionally, many respondents expressed a feeling of shared responsibility between *barangay* officials, health workers and community members for management of water sources. One respondent stated that if 'one person does it, they have to be paid…however if everyone contributes and shares this role there is no need to pay'. The variety of preferences indicates that the management roles will potentially have to be dealt with on a case-by-case basis. However, this will have to be balanced with longer term objectives for capacity-building and regulatory planning.

5.3.4 Current management in water use

Generally, current management of water sources is mixed across Capiz Province. Funding for installation and maintenance of community sources comes from the annual budget allocated to the local (*barangay*) government from the Municipality and ultimately the Provincial and National Governments. There are exceptions to this, however, where communities have contributed to installation and maintenance and also where local politicians and NGO's have contributed. The majority of *barangay* council members interviewed stated that the management of the sources is their responsibility; partially as a consequence of this funding scheme. However, there are also situations where the officials felt that the users who benefit from the water sources should look after them. Similarly, there were some community members who expressed that it should be the users responsibility to look after the sources. More often, however, community members pointed to the *barangay* council as the appropriate management organization. In reality, the current management practices are thought to be dependent on the individuals involved in the *barangay* council as well as the perceptions and experiences of the community on the capacity of the council to manage a particular source effectively. The implications of this are that there is little to no formal roles in place for management of community water sources or at the very least no enforcement of these roles, if they do exist in some form.

In terms of financing repairs and maintenance for community sources, there was a consensus among stakeholders that the money should come from the local government. The people interviewed in Capiz Province do not feel that they should have to pay for untreated and un-piped community water sources. While there was a preference expressed for household access to water, in one location an individual stated that a proposal for the development of a spring source with piped access was actually rejected by the community because they did not want to have to pay a monthly fee. Another stakeholder who had access to a piped source said that they would prefer to have their own well so that they wouldn't have to pay for it. Yet another stated that they did not mind paying for piped access, but were concerned about having to pay for unreliable service. Willingness to pay is an important consideration in planning financing mechanisms for improvements.

6 Recommendations

The recommendations for improving Doubtful, Level 1 and Level 2 water sources in Capiz Province are based on the results from the Sanitary Surveys, Water Quality results and Community Assessments. The following chapter presents four primary focus areas and the order of presentation is consistent with the recommended order for the province in moving ahead with improvements:

1. Site protection measures relating to the state of current infrastructure and hazardous activities surrounding the water sources are recommended. The focus in this section is on the required education and enforcement/monitoring for hazard minimization.

2. Water Quality Monitoring Program consistent with Philippines National Standards for Drinking Water 2007.

3. Household treatment and storage recommendations are made based on preferences of respondents and also on options thought to be readily accessible and feasible in the area.

4. Longer term recommendations for incremental upgrade of water services in the province. These include the required regulatory framework, management roles and funding.

6.1 Site Protection Measures

The results from the Sanitary Surveys detailed in Section 5.1 reveal infrastructure faults and the lack of site protection around both private and public water sources. Cumulatively, these hazards translate to intermediate/high/very high risk levels for 98% of the sources surveyed and provide causal links to the microbial contamination found in many of the water sources. The completed WHO Sanitary Survey forms from the field work in January 2010 should be passed along to the Sanitary Inspectors at the time of the education and training session(s) so that these hazards get highlighted. Graphical results in Appendix III show the breakdown of infrastructure faults for each source type surveyed, which allow infrastructure repairs to be prioritized based on the availability of time and resources. One of the immediate issues is that infrastructure faults such as damaged concrete platforms, lack of drainage channels, loose entry points and faulty pumps require materials and labor to remedy. Interviews with local government members suggest that these are locally available. Consistent access to the capital and operating funds are needed to ensure that infrastructure is safely maintained at the sources. This will be discussed further in Section 6.4.

Hazards from lack of site protection can be reduced with education and/or regular monitoring. Both of these activities can be conducted at the present time, with the present capacity of the Capiz Provincial Health Office, and without financial obstacles to overcome. Nevertheless, the time and commitment that is required to introduce new attitudes and behaviors relating to water safety present significant challenges and thus need to be addressed immediately.

6.1.1 Education Activities

Education has been described as one of the most effective actions for changing attitudes and behaviors relating to water use and safety (Cairncross & Shordt, 2004). It provides the knowledge required for individuals to make rational and informed decisions, and can empower people to improve their lives. The premise on which the importance of education is based is that people want to lead healthy, productive lives and do not knowingly engage in activities in which they put themselves and their families at risk. Thus, if people are educated about contamination sources and transport routes, it is assumed that they will have an interest in minimizing the activities that cause contamination to water supplies.

The community assessments show that there is generally a lack of awareness about the effect of activities and land uses on the water safety from the various sources. Specifically, there is a lack of awareness that contamination could enter wells that are closed to the surface. People understand the potential for chemical and biological contaminants to affect water supplies- they mentioned pesticides and animal and other organic wastes entering open wells. However, the fact that contaminated surface water can travel in subsurface conduits to enter closed well sources was unknown. Thus, the education primarily needs focus on providing basic information about groundwater flow and also on increasing the awareness regarding the imperfect seals around tubewells and the fact that these can change and deteriorate over time.

The required information that should be disseminated can be broken down into 3 components:

1. Basic water cycle and groundwater flow diagrams.
2. Above and subsurface structural components of the different water source types.
3. Descriptions of all hazardous activities around water sources and the distances within which these must be avoided in order to protect supplies (Appendix VI- Control Measures).

There are a number of web-based resources which can be readily accessed to supplement this effort, based on the preferences of those in charge of implementing the education program. Table 6.1 below provides a list of recommended resources.

Table 6-1. Recommended web resources for developing education program

Author	Description	Source (weblink)
World Health Organization	Water Safety Plans	http://www.who.int/water_sanitation_health/dwq/gdwq3_4.pdf
World Health Organization	Sanitary Survey Templates	http://www.who.int/water_sanitation_health/dwq/2edvol3h.pdf
US Environmental Protection Agency	Information about source protection (activities around wells)	http://cfpub.epa.gov/safewater/sourcewater/sourcewater.cfm?action=Assessments&view=general
The National Groundwater Association	Schematics of groundwater flow and the hydrologic cycle	http://www.ngwa.org/public/gwbasics/index.aspx

6.1.2 Coordination

The next important consideration for developing the education strategy in Capiz Province is the decision of how the education should proceed between groups, and subsequently how the coordination of the information can be maintained. Firstly, it is recommended that the information needs to proceed from the Provincial Sanitary Engineer directly to both Municipal Sanitation Inspectors (SIs) and *Barangay* Officials. The Provincial Sanitary Engineer has experience conducting province-wide training courses and in fact has already provided training to Sanitation Inspectors on conducting water quality testing as part of the test program reported on in this thesis as well as in the work of Chuang (2010) and Trottier (2010).

The more challenging aspect is the gap that exists between SIs at the Municipal level and the local government and population at the *Barangay* level. Currently, the ratio is one SI per approximately 20,000 persons (Table 6.2).

Table 6-2. Population per municipality, # of SI's per municipality and estimated ratio of individual : SI (provided by the Provincial Sanitary Engineer in Capiz)

Municipality	Estimated Population	# of SIs	Estimated Ratio
1. CUARTERO	28733	2	14367
2. DAO	36233	1	36233
3. DUMALAG	30669	1	30669
4. DUMARAO	47686	2	23843
5. IVISAN	28702	1	28702
6. JAMINDAN	40186	1	40186
7. MAAYON	38687	2	19344
8. MAMBUSAO	43533	2	21767
9. PANAY	48036	1	48036
10. PANITAN	44320	1	44320
11. PILAR	46031	2	23016
12.PONTEVEDRA	47449	2	23725
13. P. ROXAS	32573	2	16287
14. SAPIAN	27109	1	27109
15. SIGMA	32380	1	32380
16. TAPAZ	52164	2	26082
17. ROXAS CITY	148809	12	12401
TOTAL	**773300**	**36**	**21481**

There are only 1-2 SIs per municipality, with the exception of Roxas City. Because of this reality, it is necessary to extend education regarding water source safety to the local level. Capiz Province has a total of 473 *barangay*s (Province of Capiz, Philippines, 2009), which means that there are roughly 20-30 *barangay*s per municipality. It is recommended that there be an annual or semi-annual education session for both SIs and a representative from each *barangay* council (*barangay* appointed) in every municipality. This will ensure that consistent information is presented and will also allow open dialogue between *barangay*s. The sessions should include the creation of community (*barangay*) maps of communal/public water sources, as well as an annual inspection schedule for Sanitation Inspectors to visit each *barangay*. These events could also be linked with a community celebration and be part of a 'water health festival'. Potential opportunities for the PHO to create annual awards for municipalities based on these themes should be explored.

Following these educational sessions, it will be the *barangay* officials' responsibility to report back to their respective communities with the information they have been provided. This will include:

- copies of schematics
- forms for control measures
- sanitary surveys
- water quality results

Community assemblies should be scheduled where the information can be disseminated to the general public and appropriate action taken to protect the public water sites. *Barangay* Health Workers (BHWs) should be present at these information sessions, and should be given the information required to be able to identify hazards around water sources. These officials operate at the household level, and therefore can serve as important advocates of water safety around private water supplies.

In creating a municipality-wide education session, there is the potential for alliances to be created to make water safety a collective priority. By organizing the event to bring together individuals nominated by the individual *barangay*s, there is an opportunity to formally create an organization of people interested in water issues and invested in their communities. The municipal sessions will allow experiences and knowledge held at the *barangay* level to be shared, so that the communities can learn from each other. Thus, the formal creation of a **municipal consortium** to coordinate activities and to manage technical and financial resources could be highly beneficial for the municipalities of Capiz Province. Strong municipal level organization within the Municipal and Rural Health Units was consistently seen through fieldwork, and the organization at the provincial level has already been displayed through numerous national awards and through the existence of this PHO/MIT collaboration, which was initiated by the PHO originally. The success of these consortiums has been proven elsewhere, for example a specific case in Ecuador has been shown to help (Lockwood, 2004):

- Maximize limited resources for the design and execution of community-managed water and sanitation projects
- Create a unifying technical design criteria for different source types
- Strengthen local governments in the execution of their strategic development plans as well as in technical back-stopping

Along with a municipal consortium for overall management, there is also potential to explore opportunities for the coordination of technical work for both new construction and maintenance of existing supplies. This will be explored further in Section 6.4.2 using examples from both South Asia and Latin America.

6.1.3 Enforcement/Monitoring

The WHO recommends that sanitary surveys be conducted 6 times per year for open dug wells and 4 times per year for protected dugwells, springs and tubewells (WHO, 1997i). These should be conducted by *barangay* council members with support from SIs. The selected representative from each *barangay* council should be responsible for carrying out these regular inspections. The municipal consortium could enforce this at the local level, and they would report to the Provincial Sanitary Engineer with the results from the surveys and control measures taken. Records need to be kept in order to monitor progress and track changes over time with respect to source protection measures and water quality; these should be maintained as a database in Excel, along with hardcopies. For microbiological testing, The Philippines National Standards for Drinking Water (2007) states that the minimum frequencies for sampling public drinking water supply systems are as follows (DOH, 2007):

Table 6-3. From Philippines National Standards for Drinking Water (2007)

Source and mode of Supply	Population Served	Minimum Frequency of Sampling
a. Level 1	90-150	Once in three (3) months
b. Level 2	600	Once in two (2) months
c. Level 3	Less than 5,000	1 sample monthly
	5,000-100,000	1 sample per 5,000 population monthly
	More than 100,000	20 samples and additional one (1) sample per 10,000 population monthly
d. Emergency Supplies of Drinking Water		Before delivery to users
e. Water Refilling Stations (product water)		1 sample monthly
f. Water Vending Machines (product water)		1 sample monthly

Chapter II: *Water Supply* in the Code on Sanitation of the Philippines (1995) states that periodic bacteriological examination of drinking water sources must take place every six months, at a minimum. The use of the information contained in Chapter II: *Water Supply* will be extremely important for the development of effective water management models in Capiz. It provides the regulatory framework required to clearly define roles and responsibilities and also to solicit support from the national level in moving forward with improved management. This topic will be covered in more detail in Section 6.4. The document contains a monitoring scheme which calls for the establishment of a Water Surveillance Program through development of a monitoring committee. The proposed committee describes representatives from both provincial and municipal levels. The 'Local Drinking Water Quality Monitoring Committee' is stated to be composed of, but not limited to individuals from:

- Municipal/city health authority
- Rural health units/city health departments
- Water districts/private water suppliers
- *Sangguniang Panlalawigan/Panlungsod/Bayan*
- Municipal/city engineer's office
- Department of Environment and Natural Resources (CENRO)
- NGO's and Professional groups related to health and sanitation
- DOH representatives to the Local Health Board
- Provincial Health Office (Provincial Sanitary Engineer)

The inclusion of health representatives in the proposed committee is important for tracking incidence of waterborne disease and coordinating this data with water quality data. In Capiz Province, the committee could include the Provincial Sanitary Engineer, Municipal SIs, a representative from each Municipal Health Unit and any NGO's that are actively involved in water & sanitation projects in the province. Alternatively, the monitoring committee could primarily function at the municipal level and include members of the consortium as well as a representative from each of the rural health units.

6.2 Household Treatment and Safe Storage Options

While Capiz is building technical and financial capacity to improve existing sources and to increase access to safe drinking water supplies, an interim solution is household water treatment and safe storage. However, it should be stated that these options are always useful for providing an additional barrier to microbial contamination. Household water treatment and safe storage technologies have been shown to improve and maintain the microbial quality of water for drinking and other potable purposes, such as food preparation and childcare (Sobsey, 2002). They can also be more cost effective than treating water at the source (Clasen, 2005). There are a variety of treatment options, and the ones recommended here have been selected based on environmental and socio-economic factors observed during the fieldwork in January 2010. However, community participation, education and responsibility for the water treatment systems must be included when making the final decision about which technology(s) to move forward with; as this is the only way to ensure long-term sustainability of the intervention. Disinfection, flocculation/disinfection and filtration are suggested. For safe storage, the use of by-definition 'safe' storage vessels were sporadically seen in Capiz, however the widespread dissemination of these vessels is recommended to supplement household water treatment efforts.

6.2.1 Disinfection + Flocculation/Disinfection

Disinfection has been proven to effectively inactivate or destroy disease-causing pathogens in water. Boiling is a form of thermal disinfection and has been used since ancient times to disinfect water, particularly in Asia; however, the high fuel requirement makes this option expensive and restrictive in some areas. Chemical disinfection relies on the use of strong oxidants; namely compounds which derive free chlorine (Skinner, 2003; Clasen, 2005). Liquid sodium hypochlorite, solid calcium hypochlorite and tablet formed chlorinated isocyanurates (NaDCC) are the most common forms available for household chlorination. As opposed to thermal disinfection, chemical disinfection is effective only when the water has low turbidity (<30NTUs) or after it has undergone filtration or coagulation/flocculation to remove impurities such as suspended particles or dissolved metals such as iron. However, chemical disinfection has been recognized as the most direct treatment and as an 'effective, practical and affordable disinfectant of drinking water' (Sobsey, 2002). Coagulation using alum or iron-based salts is used primarily to remove colloidal particles in water by destabilizing them, precipitating them and accumulating them into larger 'flocs' that can be moved by gravity settling or filtering. The flocculation can attract microbes and in fact can achieve removal of >90% (Sobsey, 2002). However, it should be followed by a disinfection step to achieve a safe drinking water.

6.2.1.1 Aquatabs

Technology Description (based on manufacturer's claims)

- Aquatabs are a product used to chemically disinfect water
- Aquatabs are effervescent (self-dissolving) tablets which, when added to unsafe drinking water, make the water safe to drink
- Aquatabs rapidly release a measured quantity of chlorine in a safe and effective manner
- They are used to self-disinfect water at the point-of-use at the household level
- Aquatabs utilize the active ingredient sodium dichloroisocyanurate (NaDCC), also known as sodium troclosene and sodium dichloro-s-triazine trione
- The NaDCC used in Aquatabs is approved by the US EPA and NSF International for routine treatment of drinking water for human consumption
- The Joint FAO/WHO Expert Committee on Food Additives (JECFA) have approved NaDCC for routine use for drinking water
- The European Union has produced a specification for the use of NaDCC in treating drinking water.
- Aquatabs only use pharmaceutical or food grade ingredients for the effervescent base. Sources of NaDCC are available that do not conform to the above standards and specifications and may not be safe for the treatment of drinking water

- Aquatabs do not use these unsuitable sources
- Aquatabs are exclusively manufactured by Medentech Ltd to pharmaceutical standards. Medentech holds a Certificate of Good Manufacturing Practice for the manufacture of Medicines and is an ISO9001:2000 Quality Assured Company

What contaminants does it remove (based on manufacturer's claims)?

They are used to kill microorganisms in water, to avoid diseases such as cholera, typhoid, dysentery and other waterborne diseases. They are not used for chemical pollution

How does it remove contaminants?

Chlorine disinfection

Capacity (flow rate and/or batch volume)

- Aquatabs are available in a range of sizes to suit the different circumstances found at the household level
- Where water is collected from outside the home, the typical vessel size is approximately 20 liters
- A free available chlorine (FAC) level of 0.5 mg/L is recommended 30 minutes after adding the 67 mg Aquatabs tablet to the water. At 24 hours after the addition, a minimum FAC level of 0.2 mg/L is recommended
- From a series of field evaluations in a wide range of polluted water sources and from household storage vessels, the following Aquatabs dose is recommended:
  - For clear water, for example from municipality supplies and groundwater, add one 67 mg Aquatab in 20 liters of clear water
  - For dirty-looking water (turbid water), for example surface waters, the water should be filtered through a cloth before adding the Aquatabs. Add two 67 mg Aquatabs in 20 liters of turbid water
- Each 67mg Aquatab contains 40 mg free available chlorine (FAC)

Cost of technology (per single unit)

The 67 mg strength Aquatabs is available in boxes of 100's at P600.00 ($13.33USD) per box (retail price to the household) or P6.00 ($0.13USD) per tablet (email on 04/10 from Aileen Puzon) (contact info at the end of description)

Effective Household Water Management with this Product

Operation

From manufacturers label instructions:

1. Use one 67 mg Aquatab to treat 20 liters of clear water in a jerry can.

2. If water is dirty, filter it first with cloth, then treat with two Aquatabs.

3. Close the jerry can and wait 30 minutes before use.

4. No stirring or shaking is necessary.

5. Do not swallow the tablet.

- Aquatabs are non-hazardous for transportation. They can be shipped by land, sea or air without any special conditions
- Being in tablet form, they are easier and safer to handle than liquids or powders
- The tablets are individually strip-packed (in strips of 10 individual tablets) protecting access by children

Maintenance/Cleaning

It is recommended that Aquatabs are stored in cool, dry conditions, away from direct heat and sunlight.

Replacement period

Aquatabs are a recurrent use product, which means that each time the 20 liter treated volume is used up, another 20 liter volume needs to be treated with a new tablet.

Aquatabs have a shelf-life of 5 years, including tropical conditions.

Table 6-4. Advantages/disadvantage of Aquatabs

Aquatabs**Advantages**	**Disadvantages**
Convenient	Users may not accept the taste or odor of chlorine
Reduction in most bacteria and viruses	Low protection against protozoa, such as cryptosporidium or giardia
Provides a chlorine residual that is easily monitored to indicate successful use	Low efficacy in waters with high turbidity or high organic content
	Potential for carcinogenic effects of disinfection by-products over long-time periods of use

Name of Implementing Organization

Manufacturer: Medentech
Distributor in the Philippines: Chiral Pharma Corporation

Location and Extent of Implementation / Sales

All over the Philippines

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6.2.1.2 PuR

Technology Description (based on manufacturer's claims)
PuR® is a flocculation/disinfection product. Proctor and Gamble (P&G), as part of a collaborative effort with the U.S. Centers for Disease Control (CDC), has developed a sachet registered under the brand name PuR®, comprised principally of ferrous sulfate and calcium hypochlorite.

What contaminants does it remove?
Colloidal and suspended particles, microbes, some metal (arsenic, lead, other), pesticides such as DDT and other organic chemicals

How does it remove contaminants?
PuR® cleans turbid water by coagulation/flocculation, precipitation of metals and chlorine disinfection.

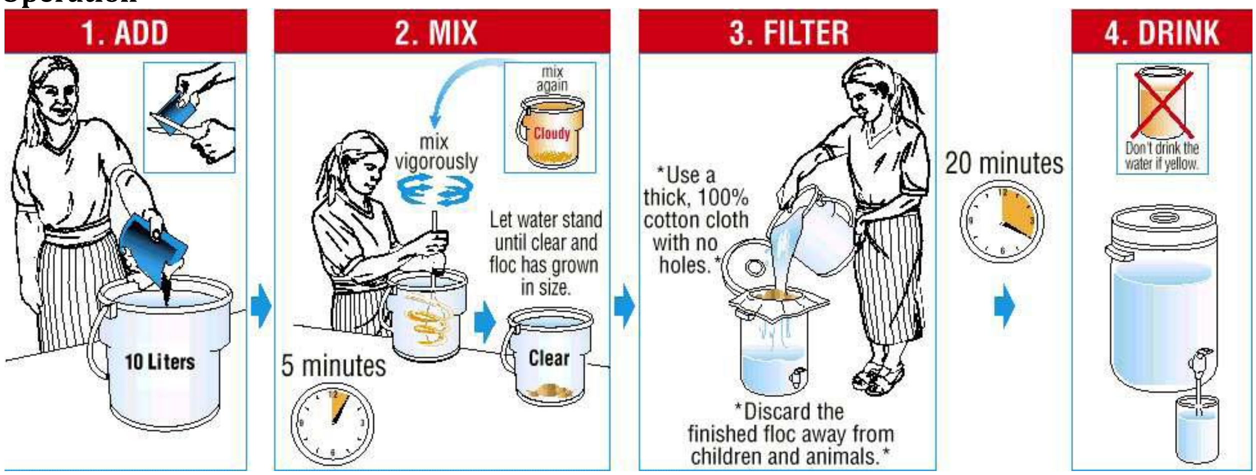
Capacity (flow rate and/or batch volume)
A single sachet of PuR® purifies 10 liters of drinking water.

Cost of technology per unit
Capital: Cost of the two 10-liter buckets, one bucket for mixing and one for treated water storage.

O&M: The consumer cost is about $0.07-0.10USD per packet depending on the local duties & import taxes when PUR is brought into the country (based on 03/10 email with Allison Tummon and Greg Allgood (contact info at end of description).

Effective Household Water Management with this Product

Operation



The sachet is cut open and the contents are poured into a bucket filled with 10 liters of water. Jerry cans are not appropriate mixing vessels for use with PuR®, as water cannot be stirred properly. The contents are manually mixed rapidly with a large, clean spoon, and then allowed to precipitate and settle for 5 minutes. Next, the 10 liters of water is decanted by pouring into a second safe storage container covered by a piece of clean cotton material. After 20 minutes, the water is safe to drink. The sludge that has collected in the bottom of the first bucket can be discarded into a latrine.

Maintenance/Cleaning
The mixing and the storage buckets should be cleaned with soap and clean water on a daily basis.

Replacement period
PuR® is a recurrent use product, which means that after the 10 liters of treated water is consumed, a new 10 liter volume must be treated. The replacement period therefore likely occurs on a regular, daily basis.

Water Quality –Independent Testing Results
See "Health Impact Studies" below.

Health Impact Studies
Luby et al, 2006
Methods: The study was conducted in squatter settlements of Karachi, Pakistan, where diarrhea is a leading cause of childhood death. Interventions were randomly assigned to 47 neighborhoods. Households in 10 neighborhoods received diluted bleach and a water vessel; nine neighborhoods received soap and were encouraged to wash hands; nine neighborhoods received flocculent-disinfectant water treatment and a water vessel; 10 neighborhoods received disinfectant-disinfectant water treatment and soap and were encouraged to wash hands; and nine neighborhoods were followed as controls. Field workers visited households at least once a week from April to December 2003 to promote use of the interventions and to collect data on diarrhea.

Results: Study participants in control neighborhoods had diarrhea on 5.2% of days.
Compared to controls, participants living in intervention neighborhoods had a lower prevalence of diarrhoea:55% (95% CI 17%, 80%) lower in bleach and water vessel neighborhoods, 51% (95% CI 12%, 76%) lower in hand washing promotion with soap neighborhoods, 64% lower (95% CI 29%, 90%) in disinfectant-disinfectant neighborhoods, and 55% (95% CI 18%, 80%) lower in disinfectant plus hand washing with soap neighborhoods. Conclusions: With an intense community-based intervention and supplies provided free of cost, each of the home-based interventions significantly reduced diarrhea (Luby, et al., 2006).

Crump et al, 2005
Results: In children < 2 years old, compared with those in the control compounds, the absolute difference in prevalence of diarrhoea was − 25% in the flocculant-disinfectant arm (95% confidence interval − 40 to − 5) and − 17% in the sodium hypochlorite arm (− 34 to 4). In all age groups compared with control, the absolute difference in prevalence was − 19% in the flocculant-disinfectant arm (− 34 to − 2) and − 26% in the sodium hypochlorite arm (− 39 to − 9). There were significantly fewer deaths in the intervention compounds than in the control compounds (relative risk of death 0.58, P = 0.036).
Fourteen per cent of water samples from control compounds had *E coli* concentrations <
1 CFU/100 ml compared with 82% in flocculant-disinfectant and 78% in sodium hypochlorite compounds. The mean turbidity of drinking water was 8 nephelometric turbidity units (NTU) in flocculant-disinfectant households, compared with 55 NTU in the two other compounds (P < 0.001).
Conclusions: In areas of turbid water, flocculant-disinfectant was associated with a significant reduction in diarrhoea among children < 2 years. This health benefit, combined with a significant reduction in turbidity, suggests that the flocculant-disinfectant is well suited to areas with highly contaminated and turbid water. (Crump, et al., 2005)

Table 6-5. Advantages/disadvantages of PuR

Advantages	**Disadvantages**
Clinically proven. About equal health protection as chlorine disinfection alone	Comparatively expensive
Locally available through the distribution network	Requires behavior change in usual water handling practices
Combines turbidity removal with microbial disinfection	Requires well-established distribution channels
Can precipitate metals and remove some organic chemicals	Some users find the process of stirring, pouring and waiting tedious
Visually impressive improvement in water clarity. This can be convincing to users of the efficacy of the product	Taste is also a potential issues- there will be a chlorine taste in water treated
Measurable chlorine residual allows an easy way to monitor use	Customers use it sporadically as ‘medicine’ and/or only for young children
Simple to use	Issues with user acceptance
Residual protection to prevent recontamination	Available in limited number of countries

Name of Implementing Organization

Proctor and Gamble (P&G)
Type of Implementing Organization
For profit multi-national corporation
Location and Extent of Implementation / Sales
P&G is selling PuR® to large relief organizations, such as UNICEF, Americare, and
CARE – where it is being distributed in disaster areas. PUR is currently being marketed in Kenya, Uganda, Haiti, Pakistan, Philippines, Guatemala, Morocco, and Ethiopia. P&G has introduced the product at a loss in Uganda and also Haiti as well.

There is experience with PUR in the Philippines already as PUR has been used in previous typhoons (including Ondoy & Parma in October 2009) by P&G global emergency relief partners including AmeriCares & their local NGO partner Asia America Initiative. These organizations worked with the local Department of Social Welfare & Development and also Global Medic (a Toronto based relief organization) & their partner UMCOR (United Methodist Committee on Relief) (03/10 email with Allison Tummon).

Contact

Organization Name: Proctor and Gamble (P&G)
Contact Person: Greg Algood
Telephone(s): 1-800-PUR-LINE
Email: Greg Allgood <allgood.gs@pg.com>

6.2.1.3 Boiling

Technology Description
Boiling is a form of thermal disinfection. It is among the oldest forms of household water treatment and is effective in destroying all classes of waterborne pathogens (including viruses, fungi, protozoans, helminthes, bacteria and bacterial spores) (Sobsey, 2002). Additionally, it can be used on all waters, including those that have high turbidity.

What contaminants does it remove (based on manufacturer's claims)?
All classes of waterborne pathogens (including viruses, fungi, protozoans, helminthes, bacteria and bacterial spores).

How does it remove contaminants?
Thermal destruction and inactivation of pathogens.

Cost of technology

Depends on local fuel prices and practices.

Effective Household Water Management

It used to be recommended that water be brought to a rolling boil and held for 1-5 minutes; however the lower end of this range is usually sufficient for destroying all pathogens according to the latest WHO recommendations. The water should ideally be stored in the same container in which it was boiled, however transfer to a safe storage container with a lid and a tap is also beneficial as this prevents the possibility of recontamination. Water should be consumed within the same day, once it has cooled.

Maintenance/Cleaning
Vessels used to collect and boil the water should be cleaned with soap and clean water on a daily basis.

Table 6-6. Advantages/disadvantages of boiling

Advantages	Disadvantages
Convenient- most households can practice this method without capital investment	Affects the taste of water
Little or no training required	Wood fuel consumption causes deforestation
Widely known and practiced	Dirty cooking fuels affect indoor air quality and can cause respiratory illnesses
Effective against all microbial pathogens	Post-boiling storage issues can lead to recontamination; no residual protection
Scientifically proven	Handling large boiled water volumes can be hazardous

6.2.2 Filtration
Filtration is one of the oldest forms of water treatment and has been used since ancient times. It is primarily a physical process that removes particles and microbial contaminants to varying extents, depending on the media. Table 6-7 below from *Sobsey* (2002) shows the characteristics and relative advantages and disadvantages for different filtration media that can be employed.

Table 6-7. Types and characteristics of filter media (Sobsey, 2002)

Type of filtration	Media	Availability	Ease of Use	Effectiveness	Cost
Granular media, rapid rate depth filter	Sand, gravel, diatomaceous earth, coal, other minerals	High	Easy to Moderate	Moderate (depends on microbe size and pre-treatment	Low to Moderate
Slow sand filter	Sand	High	Easy to moderate (community use)	High (in principal but often low in practice)	Low to moderate
Vegetable and animal derived depth filters	Coal, sponge, charcoal, cotton, etc	Medium to high	Moderate to Difficult	Moderate	Low to moderate
Fabric, paper, membrane, canvas filter	Cloth, other woven fabric, synthetic polymers, wick siphons	Varies, some low, others high	Easy to moderate	Varies from high to low (with pore size and composition)	Varies; low for natural, high for synthetics
Ceramic and other porous cast filters	Clay, other minerals	Varies; high-low, with materials availability and fabrication skill	Moderate. Must be physically cleaned on a regular basis to prevent clogging and biofilm growth	Varies from high to low (with pore size and ceramic filter quality)	Moderate to high

Filtration uses one of two general mechanisms (Nath, Bloomfield, & Jones, 2006):

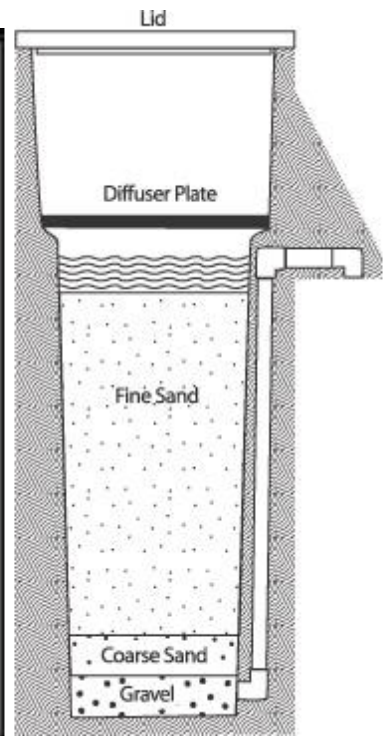
- **Straining-** the size of the pores in the filter medium are smaller than the particle being removed. This can occur on the filter surface or within the filter wherever the water flow channels are narrower than the particles.
- **Depth filtration-** occurs when particles passing through the channels become trapped on the surface of the channel wall by physical mechanisms e.g. hydrophobic or charge attraction. These absorptive processes may be reversible and/or the number of sites become eventually occupied such that breakthrough of the particles/pathogens occurs.

Another mechanism involves cake formation at the surface of the filter where either the initial straining of larger particles reduces the effective pore size so that small particles are excluded or particle aggregation causes bridging of the pores. In some sand filters the surface layer is also biologically active and the growth of slime-forming micro-organisms provide an effective straining layer which removes most pathogens (bacteria, viruses and cysts).

Generally, filtration has advantages over other methods as it does not require the addition of chemicals, nor narrow conditions of temperature, pH or turbidity. For Capiz, three options for household filtration will be described:

- A slow sand filter called the Biosand Filter, which has been developed primarily by a Canadian NGO called CAWST
- A commercially available filter, called the Megafresh Filter
- A form of ceramic filter designed by Potters for Peace in Central America

6.2.2.1 Biosand Filter



Technology Description

The Biosand filter (BSF) is an intermittent, household-scale, slow sand filter. This water filtration system is comprised of precisely measured and arranged layers of gravel, coarse sand, fine sand and a standing layer of water housed in a concrete (or plastic) container. Water is poured into an upper diffuser basin which contains small holes enabling the water to gently rain down on the sand filter. The BSF operates according to the same principles as traditional slow sand water filters, which were invented in Great Britain and France several centuries ago. The difference is that the BSF is designed for the household, as opposed to a larger, community scale, and water can be added intermittently – it does not need to flow through the filter continuously. The filter can be constructed almost anywhere in the world, because it is built using materials that are universally available. The concrete BSF is made using a steel mold. There are several sizes and shapes of concrete BSFs. Production is always done locally, due the weight of the product.

What contaminants does it remove (based on manufacturer's claims)?

Bacteria, worms, including guinea worm, protozoa cysts, some viruses. Biosand filters have been shown to remove:

- More than 90% of *E.coli* bacteria
- 100% of protozoa and helminthes (worms)
- 50-90% of organic and inorganic toxicants
- up to 67% of iron and manganese
- most suspended sediments

How does it remove contaminants?

As with all slow sand filters, the removal of microorganisms happens in the filter through a combination of mechanical, biological and electro-chemical processes. When water is poured into the top of the filter, the dirt, organic material and microscopic organisms contained in the water are trapped at the surface of the sand, forming a biological layer called a *schmutzdecke* (in German) or "dirty layer". Over a period of several days to weeks, depending on a variety of factors such as temperature, quality of the source water and volume fed to the filter, microbes colonize the biological layer, where they find organic material (food) and oxygen supplied by the water, which in turn, supports their growth and reproduction. Four processes remove pathogens and other contaminants in this filter:

- **Mechanical straining-** Sediments, cysts and worms are removed from the water by becoming trapped in the spaces between the sand grains. The filter can also remove some inorganic compounds and metals from the water when they are precipitated in solid form and get trapped by the sand.
- **Predation-** The *schmutzdecke* microorganisms ingest bacteria and other pathogens found in the water.
- **Natural death-** Pathogens naturally die because there is not enough food and oxygen.
- **Adsorption-** Viruses are adsorbed (become attached) to the sand grains. Once attached, they are metabolized by the cells or are inactivated by antiviral chemicals produced by the organisms in the filter. Certain organic compounds are also adsorbed to the sand and therefore removed from the water.

Capacity (flow rate and/or batch volume)

45 – 60 liters/hour

Cost of Technology per Unit

Capital: $29-$33/ concrete system (full cost) (P1,300-P1,500) (Maycumber, 2009)

O&M: After multiple years use, sand may need replacement if regular cleaning does not succeed in removing accumulated debris. Estimated investment in equipment: $333 (P15,000) per single steel mold for concrete filters (Maycumber, 2009).

Effective Household Water Management with this Product

Operation

1. Use the filter daily - this will maintain the water level 5 cm above the sand (measured during the pause period) and keep the bio- layer alive.

2. Ensure water quality is from the best possible source. Always use the same source if possible. If water is very dirty, allow the water to settle for 24 hours, and then pour the clear water through a fine woven-cloth (folded many times).

3. Use two separate containers; one container should be used as a receiving container to properly store and disinfect water from the filter, a second container should be used as a source container to collect the water from the water source. *Ensure both containers are kept clean.*

4. Typically, add between 1 to 5 drops of bleach for each liter (or up to 1 teaspoon per gallon) to the empty receiving container - for example, if the container is 20 liters then add at least 20 drops of bleach.

5. Remove the filter lid and slowly pour contents of the source container into the filter, without letting the sediments enter the filter, and then replace the lid. As the water fills the receiving container, it mixes and reacts with the chlorine to treat any remaining bacteria.

6. When filtration is complete, cover receiving container.

7. Feed the filter with source water by repeating this process at least once a day.

8. Clean the filter spout daily.

9. Do not store food on the diffuser plate.

10. Keeps animals away from the spout and filtered water (CAWST, 2007)

Maintenance/Cleaning

- **Location-** Protected from the weather (dust & wind), birds, animal, mosquitoes and insects. Placing the filter indoors is preferred.
- **Level-** Filter placed on a level spot- even floor, not slanted, no bumps.
- **Leaks or Cracks-** Drips of water or wet spots under the filter will indicate a leak in the concrete box.
- **Lid-** Clean on the outside and inside; no rotting wood parts; tight fitting but not sealed.
- **Diffuser-** Clean regularly; sand under diffuser should be level and smooth; rotten wood should be replaced; diffuser should rest securely on the lip. This should be approximately 5 cm (2”) above water level.
- **Sand Level-** The surface of the sand should be 5 cm (2”) below the water level. Contact your technician to add (or remove) sand if this dimension is not correct; the sand should be smooth and level.

- **Spout**- Clean daily; eliminate any direct human and animal contact with spout and filtered water.
- **Receiving Container**- 5-10 cm (2" - 4") – a small opening will prevent contaminants from entering the container that now hold treated water. Sanitize the container frequently (every second day) by washing it with soap and water or with a chlorine cleaning solution. Ensure the container has a lid. Do not scoop water out of receiving container. It is best to pour the water out.
- **Flow Rate**- Measure the outlet flow rate from the spout when filter reservoir has just been filled with water; 0.6 liter/minute (100 seconds per liter) is the design rate for the standard concrete filter; if the flow rate is less than about 0.3 liter/minute (1/3 quart/min), clean the sand in the filter by using the "swirl and dump" technique (CAWST, 2007).

Replacement period

Concrete Biosand filters are durable and robust and are expected to last 5-20 + years.

Water Quality – Independent Testing

Membrane filtration tests carried out in the MIT laboratory indicated that the Biosand technology effectively removes an average of 99.5% of total coli form from river water (Lee, 2000).

Table 6-8. Advantages/disadvantages of Biosand Filter

Advantages	Disadvantages
Used properly, the biosand filter removes bacteria (about 90-99), parasites (100%), and certain contaminants and toxins such as turbidity, iron, and manganese	Biological layer takes 1-2 weeks to develop to maturity
Water tastes and looks good	High turbidity (>10-25NTU) causes filters to clog and should not be applied to biosand filter without pretreatment
Simple to operate and maintain	Filter must be used regularly to maintain its efficacy
High flow rate: concrete biosand filter provide flow rates ranging from 30-60L/h depending on unit size	There is a lag time after start-up and after disturbance or removal of the sand during cleaning, before the filter attains its best level of bacterial removal
Visually, one can see the water become cleaner after treatment. This can be convincing to users by showing the visual effect of the process	Biosand filters removes viruses only partially and do not remove color or dissolved compounds
Needs few replaceable parts	There is no residual protection with the biosand filter and safe storage is necessary after filtration to prevent recontamination
Concrete biosand version is high durable and robust- may last 5-20+ years	Biosand filters cannot be easily moved once they are put in place, because each unit is extremely heavy. Moreover, moving the filter may disrupt the carefully leveled sand and gravel beds and may crack the container
May be constructed from locally available materials, including sand, gravel	
No chemicals need to be added to the filter to make it work effectively	
Opportunity exists for local businesses to produce and market this product	

Name of Implementing Organization

- Center for Affordable Water and Sanitation Technology (CAWST) – Calgary, Canada
- A Single Drop for Safe Water (ASDSW)- Philippines

Most training by this NGO has been focused in Mindanao as well; however there are Peace Corps Volunteers that have worked as close as Iloilo to introduce the technology. Kevin Lee heads the BSF program for ASDSW and has been trained by CAWST directly.

Type of Organization

Concrete Biosand filters have typically been implemented by NGOs

Implementation Approach

Partial cost recovery and charitable donation are typical approaches used by NGOs implementing the concrete Biosand filter. In the Philippines, 80% of the filters disseminated through ASDSW (approximately 1000 filters) have been sold through aid or development organizations such as Rotary, LGSPA, LGU and others (email with Kevin Lee, 05/10).

Location and Extent of Implementation / Sales

Worldwide, 270,000 filters have been installed reaching more than 2.5 million people. As of 2008 in the Philippines, approximately 1,300 filters have been installed. ASD currently has active BSF projects in Mindanao, Palawan and Camarines Sur (email wth Gemma Bulos 04/10).

Contact

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6.2.2.2 Megafresh Filter (commercially available)

Various models and sizes of Megafresh Water Purifiers or X-Green Filters, manufactured in Korea, are currently commercially available in the Philippines. While the price point may be high for many people in Capiz, they are still a viable option for some households.

Technology Description

The filter uses a variety of media to purify water; there are 6-stages of media through which water flows when poured into the top of the filter unit. The main component is a 0.9micron ceramic filter, which is followed by an activated carbon filter, a bio-ceramic mineral ball, a zeolite component, a mineral sand component and finally a mineral stone component.

What contaminants does it remove (based on manufacturer's claims)?

Sediments, solid impurities, bacteria (typhoid, cholera, amoeba), chlorine, THM, pesticides, organic chemicals and odor/color causing impurities, heavy metals (such as lead, mercury, arsenic, chromium).

How does it remove contaminants?

The 0.9micron diatomaceous ceramic component filters out bacteria and particles greater than 0.9microns. The activated carbon stage is said to remove chlorine, trihalomethanes (THM), organic chemicals and odor/coloring-causing materials. This is followed by the 'bio-ceramic mineral ball' which is said to enrich the water with minerals. The zeolite component helps eliminate heavy metals, and finally the mineral sand component re-mineralizes the water and restores the pH to mildly alkaline levels. The final 'mineral stone' stage is comprised of stones which contain germanium- which is said to absorb heavy metals, toxins, odors and other impurities, while releasing minerals and aiding in oxygenation of the water before it enters the storage component.

Cost of Technology per Unit

Capital: In Roxas City, filter units available at prices ranging from P750-P5,000 ($16.67-$110.00USD).

O&M: Regular replacement of both ceramic and activated carbon components means recurring costs every 3-6 months. A replacement component for a larger filter unit was observed to be P380 ($8.45USD).

Effective Household Water Management with this Product

Maintenance/Cleaning

It is recommended that when discoloration occurs, the ceramic cartridge should be taken out of the unit and the surface scrubbed with a nylon pad.

Cleaning: Scrub cartridge until cartridge becomes clean again. It is suggested that the cartridge is cleaned after 15 to 30 days.

Any detergent, chemicals or an oily pad should NOT be used for cleaning the cartridge.

Replacement period

The manufacturer states that the ceramic water filter should perform for 6 to 12 months. ('Depending on your water's level of total dissolved solids (TDS)'). The activated carbon component is said to require replacement every 3 to 6 months.

Water Quality – Independent Testing

One test was conducted in January 2010 using a Megafresh filter to treat a sample from an open dugwell. Two test methods were used to analyze the results, given as follows:

Sample	Test Method	Total coliform result (colonies/1mL)	*E.coli* result (colonies/1mL)
Raw water	Petri-film	2	TNTC[3]
Treated water	Petri-film	0	0
Sample	**Test Method**	**Total coliform result (colonies/5mL)**	***E.coli* result (colonies/5mL)**
Raw water	EasyGel	TNTC	TNTC
Treated water	Easy Gel	0	0

Table 6-9. Advantages/disadvantages of Megafresh household filters

Advantages	Disadvantages
Proven to remove bacteria, particles, organic chemicals	Requires regular cleaning
Includes safe storage	Requires replacement parts (3-6months)
Presently available in Capiz Province	No residual disinfection
	Expensive

Contact

Website: http://www.x-green.com/english/products_1.html

6.2.2.3 Ceramic Pot Filters

Ceramic filters have been used for water treatment since ancient times and are commonly used throughout the world today. One of the most common designs seen for a household filter was developed by a US-based NGO called Potters for Peace. The Filtron filter or the Potters for Peace (PFP) Filter is a colloidal silver-impregnated ceramic filter that was first developed in Guatemala in 1981 by Marzieagos. Ron Rivera, a sociologist and potter, was instrumental in improving and disseminating the technology at the international level. PFP disseminates the filter, along with a cooperative of potters in Central America and other NGOs located in many countries around the world. Currently, there are 25 ceramic pot filter workshops in 18 countries around the world. A similar filter called the Kosim Ceramic Filter has been introduced and developed in Ghana by the MIT Department of Civil and Environmental Engineering, and currently a non-profit called Pure Home Water develops and disseminates the technology.

Technology Description

The system consists of a ceramic pot filter, which is approximately 30cm in diameter, 24cm high and has a capacity of approximately 7L. The filter has a large lip and is suspended over a 20L storage receptacle (typically plastic but sometimes ceramic as well). A spigot is inserted at the bottom of the bucket, to create 'safe storage'. A plastic or ceramic lid covers the top of the filter + bucket. Figure 6-1 below shows the general design of the ceramic pot filter.

[3] TNTC = too numerous to count

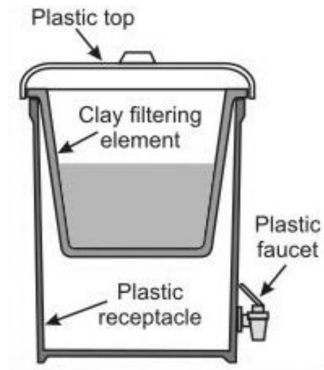

Figure 6-1. Ceramic pot filter schematic (Duke, Nordin, & Mazumber)

The ceramic pot is made in a mold and is composed of a defined mixture of clay and sawdust (or other combustibles such as rice husk) (PFP, 2006). The clay is pulverized and comprises a little more than half of the weight, with screened sawdust making up the remainder. The components are mixed and press-molded using a 10-ton hydraulic jack. Firing takes place at temperatures between 860 and 887ºC. After cooling, the filters are tested to ensure a filtration rate between 1 and 2 liters per hour. Filters that meet the standards are then coated with colloidal silver, which acts as a bacteriostatic agent. Specifically, two milliliters of 3.2-percent strength Microdyn colloidal silver is mixed with 250mL of filtered water and applied with a paintbrush (Lantagne, 2001).

What contaminants does it remove (based on manufacturer's claims)?

The effectiveness of ceramic filters at removing bacteria, viruses, and protozoa depends on the production quality of the ceramic filter. Most ceramic filters are effective at removing the majority of the larger protozoal and bacterial organisms, but not at removing the smaller viral organisms. Studies have shown significant removal of bacterial pathogens in water filtered through high quality locally-produced and imported ceramic filters in developing countries. Potters for Peace claims that field experience and clinical test results have shown the filter to effectively eliminate approximately 99.88% of most waterborne disease agents. Turbidity, color are also removed, along with partial removal of MS2 coliphages.

How does it remove contaminants?

The firing process causes the sawdust to burn, which creates a system of tiny pores in the ceramic. Particles, bacteria, protozoa and guinea worm cyclops are removed by physical straining, and also by other mechanisms including sedimentation, diffusion, turbulence and adsorption. The filter element is treated with colloidal silver which may act as a bactericide and viricide.

Capacity (flow rate and/or batch volume)

1-2.5 liters per hour

Capital and O&M: unknown for Philippines at present

Effective Household Water Management with this Product

Operation

1. Settle turbid water in a storage vessel before filling the ceramic pot.

2. Keep the ceramic pot filled to the top. This will improve filtration rate.

Maintenance/Cleaning

1. Clean filter with brush provided when flow rate becomes too slow.

2. Clean storage unit with soap and filtered water if necessary. Disinfect storage unit and spigot with chlorine bleach, iodine or boiled water after cleaning. Do not pour boiled water directly into the storage container, but allow it to first cool.

Replacement period

The filter element should be replaced every three to five years. Replacement is indicated by a reduction in the recovery rate of filtration upon cleaning, or upon breakage of the filter element. The plastic buckets have a life of 10 years or more. The tap can be replaced if necessary due to breakage or fatigue failure.

Independent Water Quality Testing

Lantagne, 2001

Results:

Review of historical data: In the laboratory, when the receptacles are clean, it can be seen that the filters with colloidal silver remove the majority of the bacteria (Table 2). It is of note that even without the colloidal silver, the filter removes a significant percentage of the bacteria (Jun 2000).

Table 2. CIRA-UNAN Bacterial Removal Data (1999-2001)

Date	# of filters	Description	Percent Removal			
			Total Coliform	Fecal Coliform	Fecal Strep	*E. coli*
Jul 2001	2	2 years old – used in restaurant	100	100		
Jun 2000	3	new – with colloidal silver	100	100	100	100
Jun 2000	3	new – without colloidal silver	90-99.5	82-100	100	82-100
Jun 2000	1	3 months old	98.9	100	85	100
Dec 1999	1	7 years old	100	100		
Aug 1999	8	New	99.9-100	100	100	100
Aug 1999	8	New	98.5-100	99.9-100	99.5-100	99.9-100

Field Data: Fifteen of the 24 pre-filtration samples were positive for *E. coli.* One filter (4 percent) removed total coliform. Six filters (27 percent) removed H2S-producing bacteria (of note is that two filters were not sampled post-filtration). Seven filters (53 percent of the samples that had *E. coli* in the pre-filtration water) removed *E. coli.*

Table 1. Bacterial Removal in 24 Rural Nicaraguan Homes

	Pre-filtration Bacteria		Post-filtration Bacteria		Percent Removal
	Present	Absent	Present	Absent	
Total Coliform	24	0	23	1	4
H_2S-producing	24	0	16	6	27
E. coli	15	9	8	16	53

Conclusions: This study agrees with historical data that shows that the PFP colloidal silver-impregnated ceramic filter design produces a filter capable of removing 100 percent of bacteria and bacterial indicators of disease-causing organisms. Although the ceramic filter itself removes a majority of the indicators, the colloidal silver is necessary to achieve 100-percent removal. However, research in homes using this filter indicates that this effectiveness is not matched in the field. An educational component that includes safe storage, aseptic cleaning procedures, and follow-up to ensure continued usage and replacement of broken pieces is necessary to ensure that the intrinsic effectiveness of this filter is matched in the field.

Table 6-10. Advantages/disadvantages of ceramic pot filters

Advantages	Disadvantages
Easy to use	Highly turbid water can reduce the flowrate to unacceptable levels
Keeps water fresh	Filter element is fragile and easily broken
The ceramic filter element helps keep the water cool	Spigots from some manufacturers are subject to fatigue failure
Ceramic pots are potentially culturally acceptable, as these were seen in certain households in Capiz Province	Ceramic filter element requires regular cleaning to maintain flow rate
The pots can be locally produced	Wood or fossil fuel required for ceramic filter element production (firing of mold)
Clarifies turbid water and makes it look clear and clean	Filter element must be replaced after 3 to 5 years
Water is collected directly from safe storage receptacle for use	
Equipped with a spigot to prevent recontamination	
Colloidal silver in the pore inhibits the growth of biofilm	
One-time purchase provides 3 to 5 years of drinking water for a household	
Inexpensive	
No chemicals added so filter does not affect taste	

Contact

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Coordinator of Ceramic Water Filter Projects

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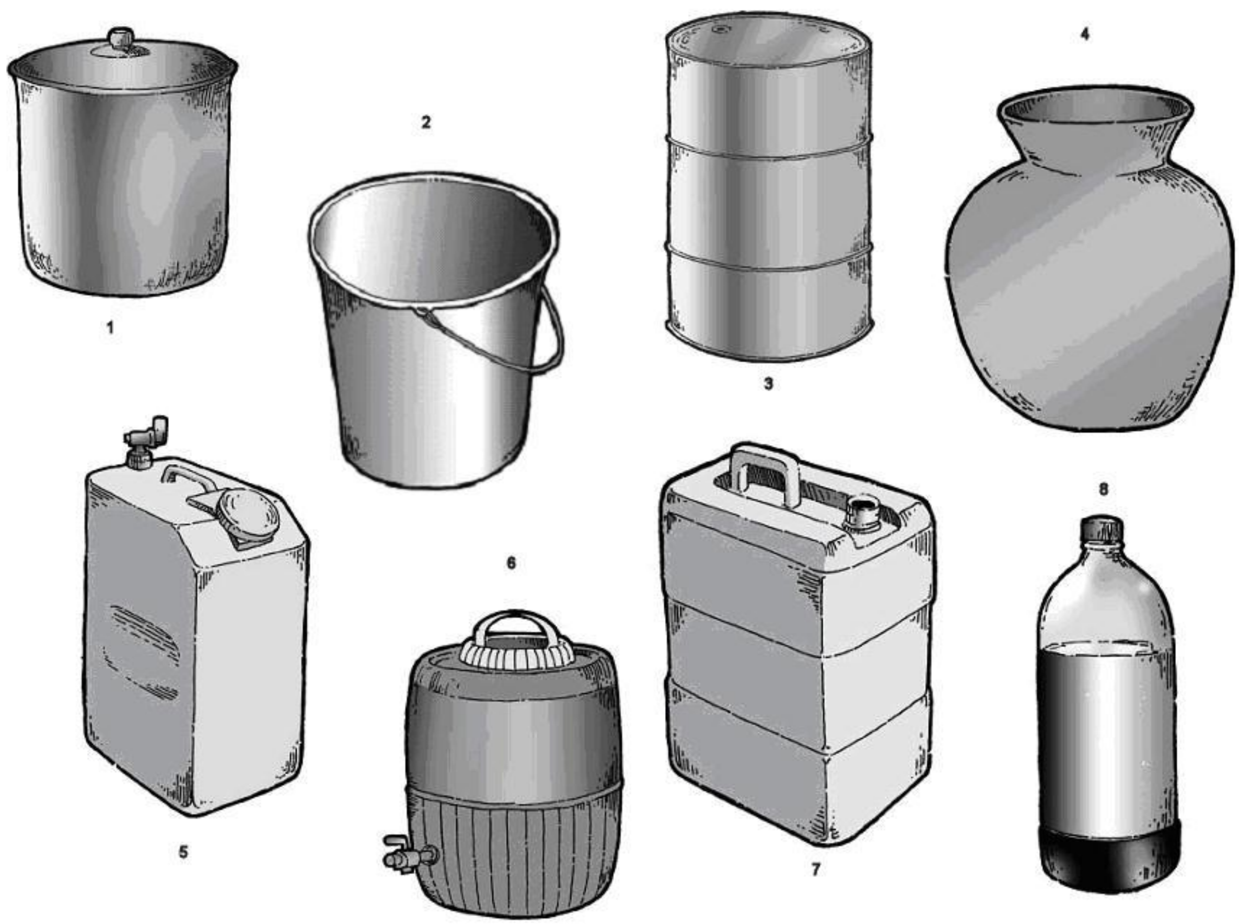
6.3 Safe Storage

Technology Description



By the simplest definition, “safe storage” is a hygienically clean and covered drinking water storage container. According to this definition, vessels #1, 3, 5, 6, 7 and 8 are all potentially “safe storage” containers. A cloth cover or lid could be added to vessels #2 and #4 which would satisfy this simple definition of “safe storage.”

A more rigorous definition of a “safe storage” container is:

- A dedicated container **not** used for water collection or any other purpose but only for water storage
- Made of durable, easy to clean material
- Volume between 10 and 30 liters, with handle(s)
- Inlet diameter between 6 and 9 cm
- Durable spout or spigot allowing a discharge rate of 1 liter per 15 seconds as outlet
- Instructions for use, cleaning container and disinfection of its contents permanently attached to vessel

“Safe storage” as defined by the U.S. Centers for Disease Control (CDC) is the use of a dedicated container for drinking water storage that includes (1) a narrow mouth to prevent the dipping hands or cups into the vessel; (2) a lid to keep the container closed and (3) a spigot or small opening to pour out the water. In many countries, the CDC has promoted safe storage in high density polyethylene (HDPE) plastic vessels. The CDC HDPE vessel is as #5 in the above figure.

In the Philippines, evidence was seen about the use of safe storage in a few households (though this was not the focus of village visits so the extent of the use is unknown) and interviews revealed that drinking water is commonly stored separately from water used for other purposes. Thus, this is promising for promoting the use of these containers, as people will likely already be familiar with the concept and potentially with the containers. Figure 6-2 beside shows an example of the use of a safe storage vessel in one of the village visits.

Figure 6-2. Safe storage vessel use in Cuartero

What contaminants does it remove (based on manufacturer’s claims)?

Safe storage can remove large particles, which can be organic or inorganic.

How does it remove contaminants?

Gravity sedimentation

Capacity (flow rate and/or batch volume)

Variable volumes – a dedicated volume between 10 – 30 liters is recommended, but other volumes, such as 1 to 2 liter PET bottles or 200 liter (50 gallon) drums could also qualify.

Cost of technology per unit

Capital: * will vary in Capiz Province, depending on container choice

O&M: N/A

Effective Household Water Management with this Product

Operation: N/A.

Maintenance/Cleaning: N/A.

Replacement period

Varies with the different types of containers and also depends on patterns of handling and use. Some safe storage containers may last for 5- 10 years if handled properly.

Table 6-11. Advantages/disadvantages of safe storage

Advantages	Disadvantages
Integrates well with other household drinking water management and treatment practices, such as traditional methods of storage, as well as coagulation, filtration or chlorination	Safe storage containers may be more expensive than traditional clay pots or jerry cans. For low-income households, possession of a dedicated safe storage container may be a burden
Potential beneficial health effects	

Type of Implementing Organization

Government agencies, NGOs, commercial

Implementation Approach

Various for-profit, partial cost recovery and charitable approaches

Contact

Centers for Disease Control
Contact Person: Rob Quick, M.D.
Address: 1600 Clifton Road, MS-A38, Atlanta, GA
Telephone(s): 404-639-0231
Fax: N.A.
Email: safewater@cdc.gov
Website: www.cdc.gov/safewater

6.4 Incremental Infrastructure Upgrades

Household treatment and safe storage can serve as an interim solution for ensuring safe drinking water for the people of Capiz Province. While properly used and maintained HWTS can always serve as an additional barrier of protection and safe storage is always good practice. The long term goal must be to increase piped supply of treated/safe water so that all of citizens have access (both upland and lowland dwellers). Thus, it is necessary to develop a strategic plan for incremental improvements and upgrades to both the infrastructure and the management and organization required to maintain the safety of the supplies. Capacity building will be extremely important to move towards adherence to the existing Philippine National Standards for Drinking Water and to the practices and procedures outlined in the Code on Sanitation in the Philippines- Chapter II *Water Supply*. The following section is broken down into three proposed focus areas for the PHO in moving forward after water quality results have been analyzed:

1. The required alignment with the existing Regulatory Framework to enforce monitoring and testing of supplies, along with codes for the construction of new water source infrastructure

2. Management roles clearly defined and enforced, along with training officials to assist in the maintenance and upkeep of supplies

3. Funding to finance improvements in capacity and infrastructure

6.4.1 Required Regulatory Framework

As previously described, the National Department of Health has already created regulatory guidelines for both drinking water quality standards and for implementing rules and regulations of the code on sanitation with respect to water supply.

- Implementing Rules and Regulations of the Code on Sanitation of the Philippines- Chapter II *Water Supply* (1995)
- Philippine National Standards for Drinking Water (2007)

While straightforward in theory, in practice these guidelines require significant local capacity and resources to implement. The number of Sanitary Inspectors per capita in Capiz Province is illustrative of the current gap between needs and the capacity at the provincial level to implement this national framework. That said, Capiz has taken an important first step by establishing a water quality laboratory and most importantly by actually conducting a baseline assessment of water quality around the province. Without this data, the province is not in a position to petition for action at the national level. The water quality results presented in Section 5.3 present a snapshot picture of the current water quality around the province. The data allows the PHO to establish a clear case for why national level support is required to improve the situation for the citizens of Capiz. However, it is necessary for the province to first review the existing regulatory framework and to be able to detail exactly what they need to move forward- in terms of current lack of technical personnel, resources for carrying out educational and local level training sessions, and funds for conducting regular water quality testing, among other capacity building requirements.

In order to align the provincial efforts with the existing regulations, it is recommended that the Provincial Sanitary Engineer develop a strategic plan for incremental improvement of the infrastructure and management of Capiz water supplies for the next 3-5 years. Important items to address are summarized as follows:

1. Procurement of stores of safe storage containers. Citizens should be made aware that they are available, and if they are requested they should either be sold at cost or supplied by the province if funds can be made available. **Boiling or household chlorination for drinking water should be recommended** (as per the Annex in Chapter II *Water Supply*), while the feasibility for introducing and testing other household water treatment systems is explored through the contacts listed in Section 6.2.

2. Development of a schedule for education sessions detailed in Section 6.1. This effort will allow an assessment of the current local capacity, aside from the Sanitary Inspectors, to become involved in monitoring, maintenance and management of water supplies. Official records of the members of the proposed **municipal consortiums** for water safety should be created. Subsequently, a list should be compiled of any gaps in personnel- per municipality- which currently prevent the required frequency of site inspections and collection of water samples for microbiological testing[4]

3. Development of a publicly-accessible database describing the total number, type, and age of public '*barangay* funded' water sources, along with the estimated # of persons served by these sources and the distance from households in each municipality. **A stepwise Water Safety Plan to incrementally increase access to Level 2 and/or Level 3 sources, while relegating doubtful and Level 1 sources to livelihood and non-drinking uses, should be created. Additionally, measures planned to increase access to improved water services for people living in the upland areas should be detailed.**

4. Based on the database and water quality results by source type, **develop a plan for allocating annual funds for source upgrades in the order of need.**

5. Assessment of the technical capacity (personnel, time) within the PHO to analyze water samples from around the municipality, based on both Quanti-Tray® analysis and field-based methods. **Assessment of the funds required to conduct the minimum number of recommended samples per water source type as recommended in the National Standards for Drinking Water** (and *Table 6-3. From Philippines National Standards for Drinking Water (2007)* in Section 6.1.3) **using Quanti-Tray® and/or low-cost, field-based methods**

6. Development of regulations requiring regular water quality sampling and testing of mineral water filling stations. Details should include the pricing structure, permitting and

[4] Using simple, low-cost, field-based methods from Trottier (2010) and Chuang (2010)

enforcement plan and the sampling schedule per municipality (see Section 8 of Chapter II- *Water Supply*).

7. Development of database for drinking water well-drilling companies, both local and provincial companies. This should include details of the measures being taken to move towards enforcement of the permitting, included the required personnel to coordinate this effort. Also**, the steps to develop the legal framework for contractors to adhere to standard construction and operating procedures should be detailed.** These procedures are contained in Section 3.4 of Chapter II- *Water Supply*. Section 4 of the document describes the required 'Drinking Water Site Clearance'.

6.4.2 Management

The management of public Level 1 and Level 2 water sources in Capiz Province occurs at the *barangay* level; whereas, treated water supplies are either managed by the Water District (WD) or by the Local Water Utilities Administration (LWUA). These are both provincial-level organizations that were developed in the 1970's as water management was decentralized in the Philippines (refer to Section 2.3 Government involvement). Research conducted elsewhere in the Philippines concluded that these bodies have considerable technical and financial management skills (WorldBank, 2003). It was not possible to determine the capability of these organizations at the time of the fieldwork in January. However, it is suspected that there is a range of skill levels within these different administrative bodies. One set of interviews revealed a sense of strong community endorsement for the LWUA and their capabilities. Another site visit to a newly developed water treatment system revealed a sense that the operator did not feel that he had the technical know-how to effectively manage the system.

However, Level 1 and Level 2 sources are an entirely different situation, in which even more variability is thought to exist with respect to management. It is recommended that the government organizations (WD, LWUA) are contacted by the PHO to assist the local government management of public water sources, and that officials are trained at the municipal level to act as technicians to service and maintain public water supplies at the municipal level.

6.4.2.1 Government roles

The provincial level water utilities are well-positioned to assist local level efforts at management and organization. Information can be shared about resources for monitoring and inspection, and they can potentially help with setting up a system for record-keeping and a schedule for monitoring. They might also be able to assist with acquisition of spare parts and provision of technical support in repairing/maintaining infrastructure. Case studies from elsewhere in the Philippines have demonstrated the potential for these larger, well-established and better-funded organizations to act as advisors on technical and financial management systems.

While there may be institutional barriers preventing this from becoming an ongoing partnership, it is still recommended that the LWUAs are approached by the PHO and asked to participate in the **municipal consortium** if it is created, or at the very least a meeting to involve them in the local level planning since they are important stakeholders in the communities they serve.

6.4.2.2 Community training

There have also been examples from elsewhere in the world which have shown the potential for local citizens to be trained as water technicians. Successful programs in both Latin America and South Asia demonstrate that it is possible for local citizens to be trained as technical professionals to overcome deficits in access to funds and technical support from higher levels of government.

Specifically, a program originating in the U.S. and successfully piloted in Honduras called 'Circuit Riders' has had great success in training people to travel around to assist in operation and maintenance of rural public water sources. In Honduras, these Circuit Riders provide assistance in both technical and financial management. An NGO provides training for the circuit riders and also organizes general assemblies for the communities involved with the program (Mikelonis, 2008).

In India, women have been successfully trained as handpump technicians by a number of government and non-government organizations. As early as the 1980's, a collaborative between the Government of India, UNICEF and UNDP/World Bank led to the development a community operated and maintained handpump design (Mudgal, 1997). The success of initiatives to make women in charge of the handpump repair and maintenance led to widespread adoption of this practice. In 2009, UNICEF, the Department of Drinking Water and Sanitation and Mahila Samakhya (a major, feminist GO) launched a joint initiative to establish a group of local women mechanics (UNICEF, 2009). WaterAid has also trained women handpump mechanics (WaterAID, 2010).

The examples illustrate the potential for interested citizens in Capiz to become involved in water management at a municipal scale. In every *barangay* visited during fieldwork in January 2010, there was at least one person with experience and technical know-how in repairing water supplies. Moreover, there were people who were willing to contribute to the upkeep and maintenance of supplies. If there was an opportunity for a person(s) to gain a paid position by the PHO to 'ride the circuit' and provide technical assistance for *barangay* water sources, this could enable significant improvements to the current water safety situation around the province. It is recommended that the PHO explores funding routes for creating these municipal level positions, and concurrently seeks the technical advisors it would require to provide training for these technicians through the LWUA or WD.

6.4.3 Funding

Funding will be one of the limiting factors in the pace at which Capiz Province is able to improve and upgrade the water supply infrastructure. However, Capiz can make a strong case with presentation of the sanitary survey results of this thesis (98% in intermediate/high/very high risk levels), the water quality results, the recommended focused strategic plans for meeting regulatory requirements, and through demonstration of the clear initiatives already being taken at the PHO.

It is recommended that the funds be allocated specifically for water infrastructure improvement and repair, and not be allowed to disappear into a general annual budget. The PHO has to work with the provincial government and the LWUAs to ensure that there is accountability for municipal and *barangay* level fund allocation and that clear deliverables have been decided before funds are distributed. This will require the collection of baseline information to understand the current public water sources within each municipality.

The recommended order of importance for funding infrastructure upgrades is as follows:

- Funds to acquire safe storage containers (and disinfection products if required)
- Funds to train and employ technical officials to operate at a municipal level to repair and maintain supplies
- Funds for repairs/maintenance of Level 1 and doubtful sources (public)
- Funds for increasing access to Level 2 sources
- Funds for increasing access to Level 3 sources resulting in decreased cost (economy-of-scale)

Safe storage containers present both an immediate remedial measure and also a sustainable longer term investment. Securing financing for technical support for the upkeep of public water supplies is of primary importance if long-term, sustainable improvements are to be made for the water sources in Capiz. If the infrastructure is not maintained, the money represents a wasted investment for which all parties lose. Once the capacity at the municipal level to maintain and manage water sources has been established, funds to repair and protect Level 1 and doubtful sources from contamination should be provided.

Increasing access to Level 2 sources represents a higher investment and these funds should be made available to different municipalities over time based on need established by current infrastructure and water quality and also by a thorough investigation regarding the new source water quality and quantity to provide a viable, long-term supply of water. The interviews suggested that there are ample, unexplored spring sources located around Capiz and that people thought highly of the quality of these sources. Lastly, interviews with people in areas where Level 3 sources exist revealed that the fees were a heavy burden for many families in Capiz (P300 + per month) and that access was limited. Level 3 service is generally limited by household locations (i.e. only those along the main service road have access) and ultimately by their ability to pay for the service. Thus, there needs to be an effort to explore the potential for various funding routes that will enable fees to be lowered and/or systems to be expanded so an economy of scale can be applied.

7 Conclusions

The fieldwork in Capiz during January revealed both the challenges and the opportunities that exist within the province with respect to water quality and water management. The significant proportion of sources sampled with *E.coli* contamination has and will continue to serve as an importance source of awareness for both local residents and hopefully for officials at the provincial and national level about the need to focus on water safety. Water quality and quantity are incredibly important because of the pivotal role they play in enabling healthy and productive lives. While the Philippines is generally a place of water abundance, the quality of the water largely governs the uses for which it is appropriate and safe to drink. The Philippines has a growing population and Capiz Province has a largely water-based economy, which emphasizes the importance of focusing on water management at this point in the development of the country.

Technical assessments of the sites and sources, as well as the community assessments provided valuable information to make recommendations regarding appropriate and realistic remedial measures for the province to explore. The site assessments generally showed that many hazards are present around public water sources, and that it is highly likely that some of these- specifically septic tanks and animal waste- are contributing significantly to poor water quality. Hazard identification will allow the province to implement appropriate control measures to reduce this risk to acceptable levels. The community assessments provided valuable contextual information which should be taken into account when planning water source upgrades. Given that the local users ultimately determine the use or misuse of water systems, it is critical that their preferences, beliefs and values be taken into account when planning improvements. Key-informant interviews provided different perspectives on water use around the province and showed that currently water management systems are lacking, awareness regarding factors affecting water safety are lacking, and that equal access to sources are lacking (upland areas are poorly served). However, the interviews also showed that significant local capacity, initiative, ideas and interest exist for improving water safety.

Thus, there is a strong foundation in Capiz Province upon which to build a sustainable and effective system for water services provision to all citizens. The first steps are to improve source safety and protection through education, coordination and planned enforcement and monitoring. Training local citizens to act as technicians to repair and maintain existing infrastructure is critical for preventing continued contamination of water sources. The next step is to promote the use of safe storage for drinking water and to explore the potential use of household water treatment for users of private water sources. Longer term plans need to include strategies for aligning and developing systems within the province to existing national level regulations, the development of effective management systems both at the municipal and provincial level, and finally on securing the necessary funding to implement programs and services. Key factors for improving the water quality and management are thought to be citizen engagement and empowerment through the inclusion of community preferences and ideas, as well as through education and training for the many Capizians the author spoke to who already understand the importance of water in their lives and who are interested in making improvements.

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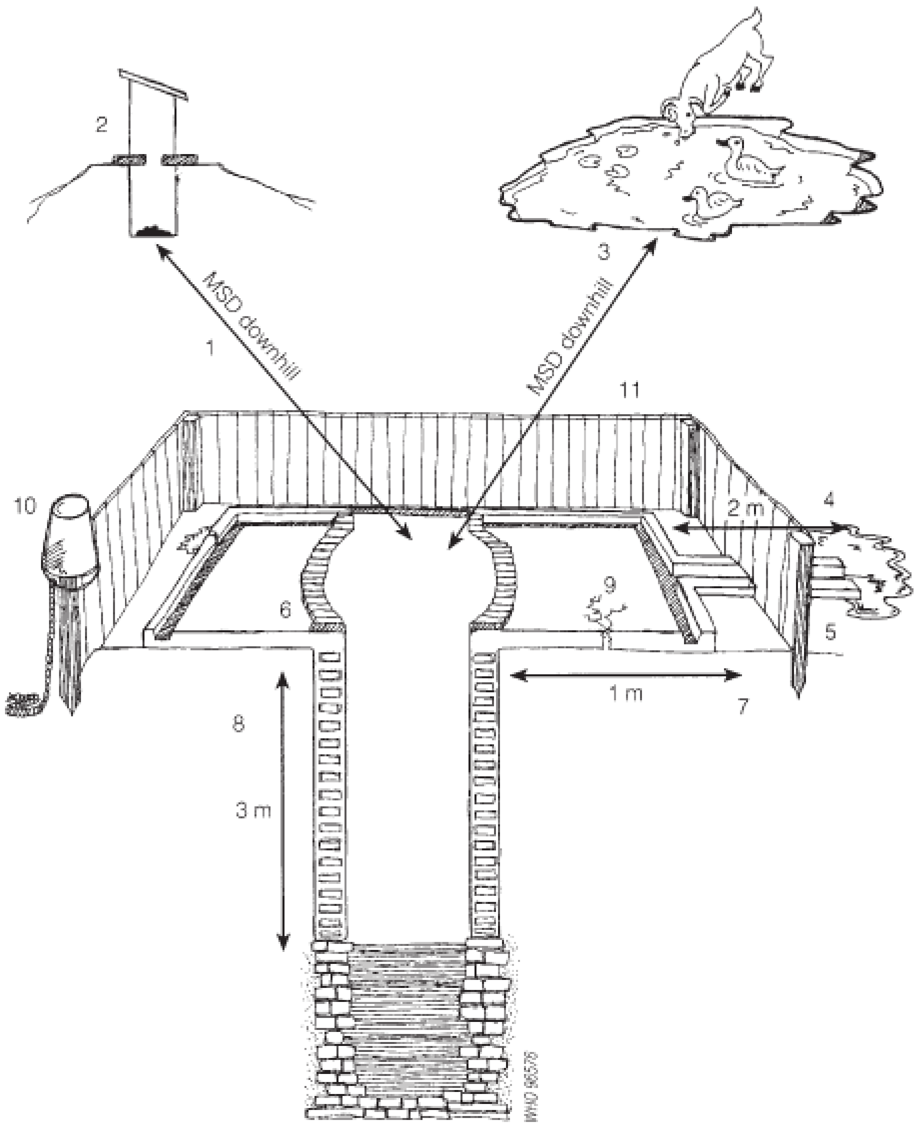
Appendix I

Fig. A2.1 Example of sanitary inspection form for open dug well

Note: MSD = minimum safe distance as determined locally; see section 6.2.2.



I Type of facility OPEN DUG WELL

1. General information: Health centre ....
   Village ....
2. Code no.—Address ....
3. Water authority/community representative signature ....
4. Date of visit ....
5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II Specific diagnostic information for assessment

		Risk
1.	Is there a latrine within 10 m of the well?	Y/N
2.	Is the nearest latrine on higher ground than the well?	Y/N
3.	Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the well?	Y/N
4.	Is the drainage poor, causing stagnant water within 2 m of the well?	Y/N
5.	Is there a faulty drainage channel? Is it broken, permitting ponding?	Y/N
6.	Is the wall (parapet) around the well inadequate, allowing surface water to enter the well?	Y/N
7.	Is the concrete floor less than 1 m wide around the well?	Y/N
8.	Are the walls of the well inadequately sealed at any point for 3 m below ground?	Y/N
9.	Are there any cracks in the concrete floor around the well which could permit water to enter the well?	Y/N
10.	Are the rope and bucket left in such a position that they may become contaminated?	Y/N
11.	Does the installation require fencing?	Y/N
	Total score of risks	/11

Contamination risk score: 9–11 = very high; 6–8 = high; 3–5 = intermediate; 0–2 = low

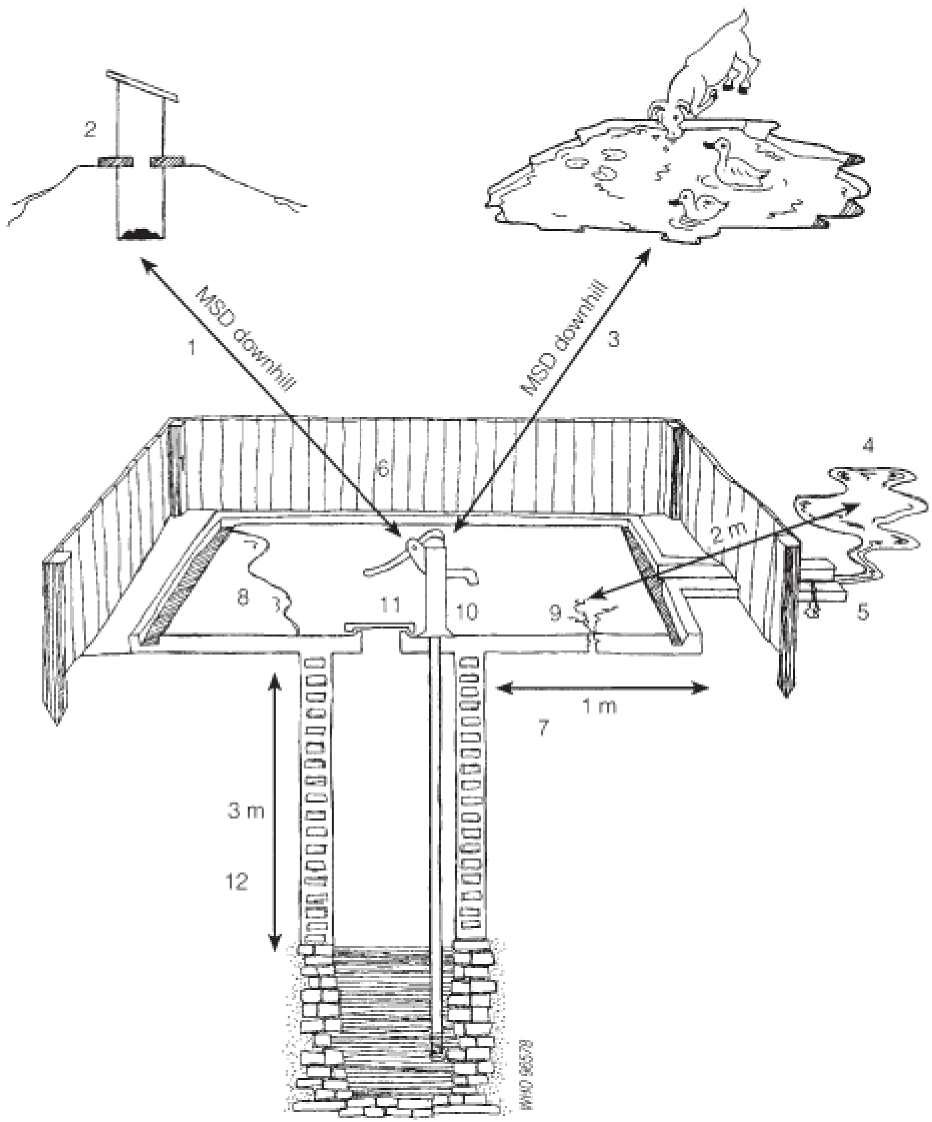
III Results and recommendations

The following important points of risk were noted: .... (list nos 1–11) and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.3 Example of sanitary inspection form for covered dug well with hand-pump

Note: MSD = minimum safe distance determined locally; see section 6.2.2.



I Type of facility COVERED DUG WELL WITH HAND-PUMP

1. General information: Health centre ....
   Village ....
2. Code no.—Address ....
3. Water authority/community representative signature ....
4. Date of visit ....
5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II	Specific diagnostic information for assessment	Risk
1.	Is there a latrine within 10 m of the well and hand-pump?	Y/N
2.	Is the nearest latrine on higher ground than the hand-pump?	Y/N
3.	Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the hand-pump?	Y/N
4.	Is the drainage poor, causing stagnant water within 2 m of the cement floor of the hand-pump?	Y/N
5.	Is there a faulty drainage channel? Is it broken, permitting ponding?	Y/N
6.	Is the wall or fencing around the hand-pump inadequate, allowing animals in?	Y/N
7.	Is the concrete floor less than 1 m wide all around the hand-pump?	Y/N
8.	Is there any ponding on the concrete floor around the hand-pump?	Y/N
9.	Are there any cracks in the concrete floor around the hand-pump which could permit water to enter the hand-pump?	Y/N
10.	Is the hand-pump loose at the point of attachment to the base so that water could enter the casing?	Y/N
11.	Is the cover of the well unsanitary?	Y/N
12.	Are the walls of the well inadequately sealed at any point for 3 m below ground level?	Y/N
	Total score of risks	/12

Contamination risk score: 9–12 = very high; 6–8 = high; 3–5 = intermediate; 0–2 = low

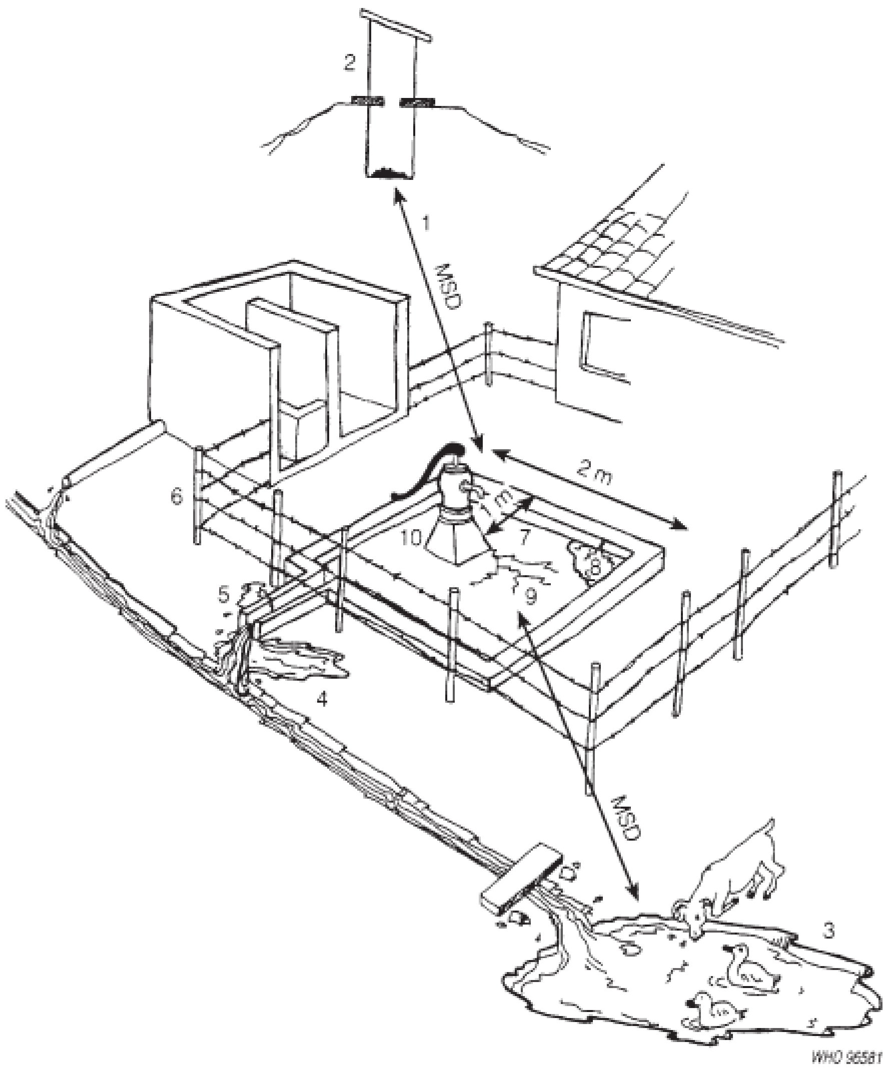
III Results and recommendations

The following important points of risk were noted: .... (list nos 1–12) and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.5 Example of sanitary inspection form for tubewell with hand-pump

Note: MSD = minimum safe distance determined locally; see section 6.2.2.



I Type of facility TUBEWELL WITH HAND-PUMP

1. General information: Health centre ....
   Village ....
2. Code no.—Address ....
3. Water authority/community representative signature ....
4. Date of visit ....
5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II Specific diagnostic information for assessment

	Specific diagnostic information for assessment	Risk
1.	Is there a latrine within 10 m of the hand-pump?	Y/N
2.	Is the nearest latrine on higher ground than the hand-pump?	Y/N
3.	Is there any other source of pollution (e.g. animal excreta, rubbish, surface water) within 10 m of the hand-pump?	Y/N
4.	Is the drainage poor, causing stagnant water within 2 m of the hand-pump?	Y/N
5.	Is the hand-pump drainage channel faulty? Is it broken, permitting ponding? Does it need cleaning?	Y/N
6.	Is the fencing around the hand-pump inadequate, allowing animals in?	Y/N
7.	Is the concrete floor less than 1 m wide all around the hand-pump?	Y/N
8.	Is there any ponding on the concrete floor around the hand-pump?	Y/N
9.	Are there any cracks in the concrete floor around the hand-pump which could permit water to enter the well?	Y/N
10.	Is the hand-pump loose at the point of attachment to the base so that water could enter the casing?	Y/N
	Total score of risks .... /10	

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate; 0–2 = low

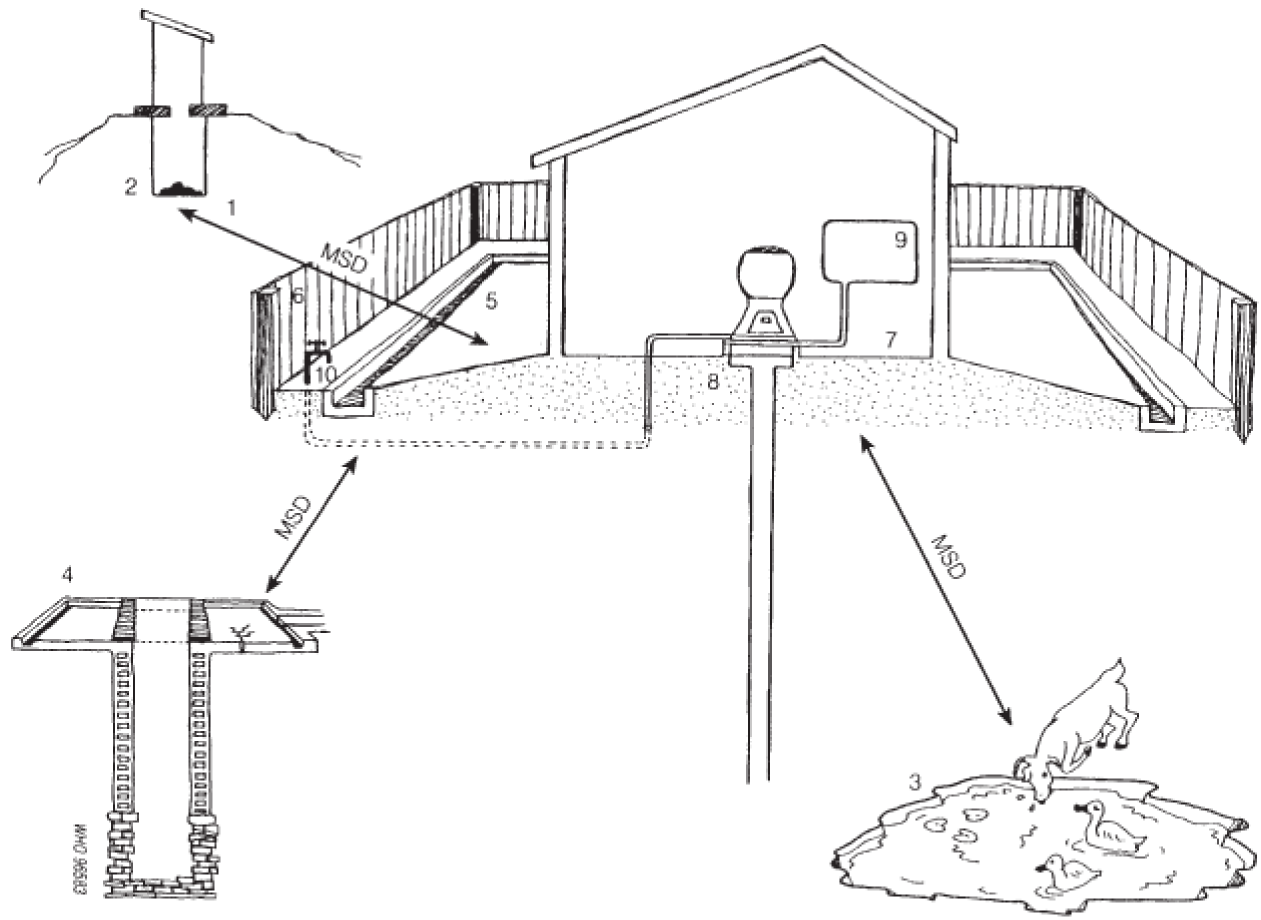
III Results and recommendations

The following important points of risk were noted: .... (list nos 1–10) and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.7 Example of sanitary inspection form for deep borehole with mechanical pump

Note: MSD = minimum safe distance determined locally; see section 6.2.2.



I Type of facility DEEP BOREHOLE WITH MECHANICAL PUMP

1. General information: Health centre ....
   Village ....
2. Code no.—Address ....
3. Water authority/community representative signature ....
4. Date of visit ....
5. Is water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II Specific diagnostic information for assessment	**Risk**
1. Is there a latrine or sewer within 15–20 m of the pumphouse?	Y/N
2. Is the nearest latrine a pit latrine that percolates to soil, i.e. unsewered?	Y/N
3. Is there any other source of pollution (e.g. animal excreta, rubbish, surface water) within 10 m of the borehole?	Y/N
4. Is there an uncapped well within 15–20 m of the borehole?	Y/N
5. Is the drainage area around the pumphouse faulty? Is it broken, permitting ponding and/or leakage to ground?	Y/N
6. Is the fencing around the installation damaged in any way which would permit any unauthorized entry or allow animals access?	Y/N
7. Is the floor of the pumphouse permeable to water?	Y/N
8. Is the well seal unsanitary?	Y/N
9. Is the chlorination functioning properly?	Y/N
10. Is chlorine present at the sampling tap?	Y/N
Total score of risks	/10

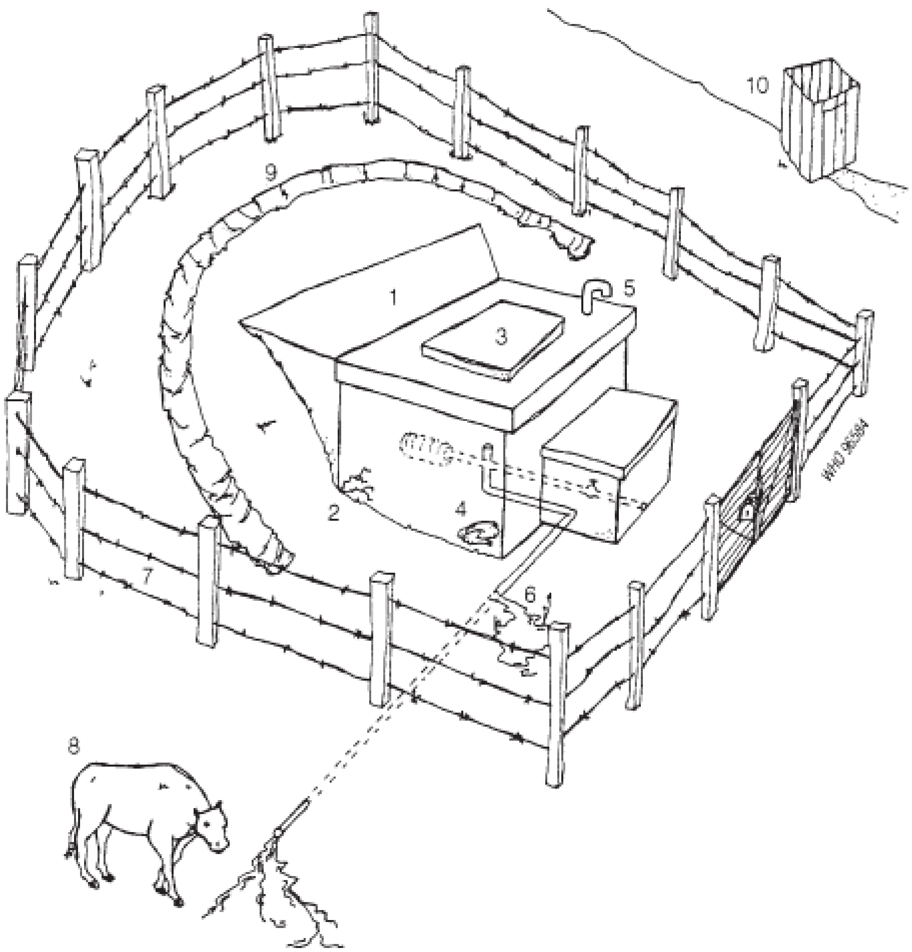
Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate; 0–2 = low

III Results and recommendations

The following important points of risk were noted: .... (list nos 1–10) and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.8 Example of sanitary inspection form for protected spring source



I Type of facility PROTECTED SPRING SOURCE

1. General information: Health centre ....
   Village ....
2. Code no.—Address ....
3. Water authority/community representative signature ....
4. Date of visit ....
5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II Specific diagnostic information for assessment	**Risk**
1. Is the spring source unprotected by masonry or concrete wall or spring box and therefore open to surface contamination?	Y/N
2. Is the masonry protecting the spring source faulty?	Y/N
3. If there is a spring box, is there an unsanitary inspection cover in the masonry?	Y/N
4. Does the spring box contain contaminating silt or animals?	Y/N
5. If there is an air vent in the masonry, is it unsanitary?	Y/N
6. If there is an overflow pipe, is it unsanitary?	Y/N
7. Is the area around the spring unfenced?	Y/N
8. Can animals have access to within 10 m of the spring source?	Y/N
9. Does the spring lack a surface water diversion ditch above it, or (if present) is it nonfunctional?	Y/N
10. Are there any latrines uphill of the spring?	Y/N

Total score of risks .... /10

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate; 0–2 = low

III Results and recommendations

The following important points of risk were noted: .... (list nos 1–10) and the authority advised on remedial action.

Signature of sanitarian ....

Appendix II

Local government (*barangay* councilor)

What are the various needs/uses of water in the community? List

What is the most important use of water?

What are the various sources for acquiring water?

Who is responsible for looking after the water sources?

Who implemented the water sources? When (in what year(s))?

How was the location of the water sources decided?

Was the community asked where the communal water points should be?

Do you think any activities around the water sources could affect the quality of the water?

Does the person responsible have training to maintain the water supplies? Do they feel that they have the things that they need to do this job?

Do all the sources have the same water quality?

Can you get the quality that you need for various uses? What is the different quality needed for different uses? (List)

Could the sources be improved to get the quality higher?

Do all households have access to water? If not, who doesn't? What areas are poorly serviced? Why?

Would you prefer large wells/spring that are shared by the community or that each home has their own source of water?

On Farmers

Do you think the farmers have enough water for their crops?

Do they get the water from one source or multiple sources?

Are there any irrigation systems being used?

Is any river water used to irrigate?

Is the location of irrigation systems convenient for crop watering? For all farmers?

Is there excess water that could be stored?

Is water shared between the farmers?

Is anyone responsible for ensuring equitable distribution?

Are there ever conflicts over who gets the water?

On Household use

Where do most people get their household water? Why do you think they use this/these source(s)?

Do you think the locations of the water sources are convenient for people from the community?

Would there be a better location for water points than there is currently? Where and why?

What do you think the water is used for? (from each identified source)

Bathing/Cooking/Drinking/Animals/Garden/Laundry/Cleaning/Other

Do you think different water quality is needed for different uses?

Do you think people get enough water for their household needs? All year, or just at certain times?

How much water do you think is needed every day for use in a household?

Are there ever arguments over who gets the water?

Do households pay for the water? How much?

Do they buy bottled/purified water?

How much?

What is the cost?

Why do they buy this water?

Farmers

Do you have enough water for your crops?

Do you get the water from one source or multiple sources? If so, why?

Are any irrigation systems in place?

Is there excess water that could be stored?

If there are irrigation systems, how is water shared?

Is anyone responsible for ensuring equitable distribution?

Are there ever conflicts over who gets the water?

Do you pay for the water? How much?

Do you think you should have to pay for the water?

What are the qualities/characteristics of water that are most important for ensuring healthy crops?

on Water Management

What are the various needs/uses of water in the community? List

What is the most important use for water in the community?

What are the various sources for acquiring water?

How were the locations of these public sources selected?

Can the community get quality that they need for various uses? What is the different quality needed for different uses? (List)

Do you think the sources could be improved to get the quality higher?

Do you think any activities around the water sources could affect the quality of the water?

Does everyone have enough water for their needs throughout the year?

Who is responsible for looking after the public water sources?

How was the person selected? Do you think this person has the things that they need to do this job?

Do all households have access to water? If not, who doesn't? What areas are poorly serviced? Why?

Would you prefer that everyone has private wells or that there would be a community supply?

On Household/Women's Use

Where do households get most of their water from? Why from this location(s)?

Do you think the locations of the water sources are convenient for household use?

Would there be a better location for water points? Where and why?

What is the water used for in the home? (from each identified source)

Bathing/Cooking/Drinking/Animals/Garden/Laundry/Cleaning/Other

Do they need different quality for different uses?

What are the characteristics of good quality water for the different needs?

Do women/households have enough water? All year, or just at certain times?

How much do you think they would need every day for household use?

Are there arguments over who gets the water?

Do any households pay for the water? How much?

Do they buy from bottled/purified water?

How much?

What is the cost?

Why do they buy this water?

Women

Where do you get most of your water from? Why from this location?

When was this source(s) installed?

Who maintains the water source?

Are there any other sources you use?

Are the locations of the water sources convenient?

What do you use the water for? (from each identified source)

Bathing/Cooking/Drinking/Animals/Garden/Laundry/Cleaning/Other

What is the most important use for water?

What do you think of the quality? Do you need different quality for different uses?

What are the characteristics of good quality water for your needs?

Do you find it difficult to get the water to where you want to use it?

Do you store it? How do you store it?

Would there be a better location for water points than there is currently? Where and why?

How much do you need every day?

Do you have enough water all year or just at certain times?

Are there arguments over who gets the water?

Is anyone in charge of water distribution when it is shared between households?

Do you pay for the water? How much?

Do you buy from bottled/purified water?

How much?

How often?

What is the cost?

Why do you buy this water?

on Water Management

What are the various needs/uses of water in the community? List

What are the various sources for acquiring water?

When were these sources installed? Who installed them?

Can people quality that they need for various uses? What is the different quality needed for different uses? (List)

Do you think the sources could be improved to get the quality higher?

Do you think any activities around the water sources could affect the quality of the water?

Who is responsible for looking after the water source(s)?

How was the person selected? Do you think this person has the things that they need to do this job?

Does everyone have access to water? If not, who doesn't? What areas are poorly serviced? Why?

Do you think it would be better for every household to have their own well or for there to be community wells that are shared?

on Farmers

Do you think farmers have enough water for their crops?

Do they get the water from one source or multiple sources? If so, do you know why?

Is the location of the water source convenient for crop watering?

Are any irrigation systems in place?

Is there excess water that could be stored?

If water is stored, how is it shared between the farmers?

Is anyone responsible for ensuring equitable distribution?

Are there ever conflicts over who gets the water?

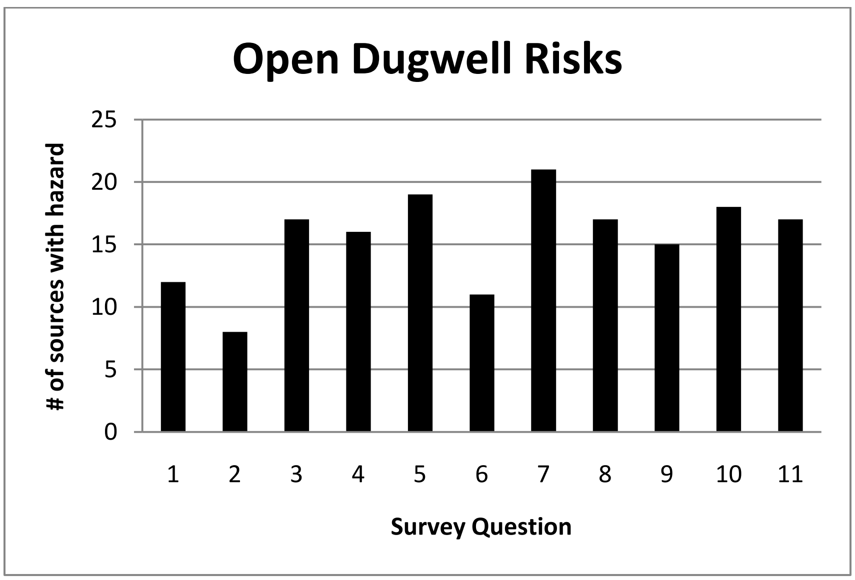
Do farmers pay for their water? (How much? Do you think they should have to pay for the water?)

What sort of water is appropriate for watering their crops? Do you know if there a water source that is more suitable than others?

Appendix III

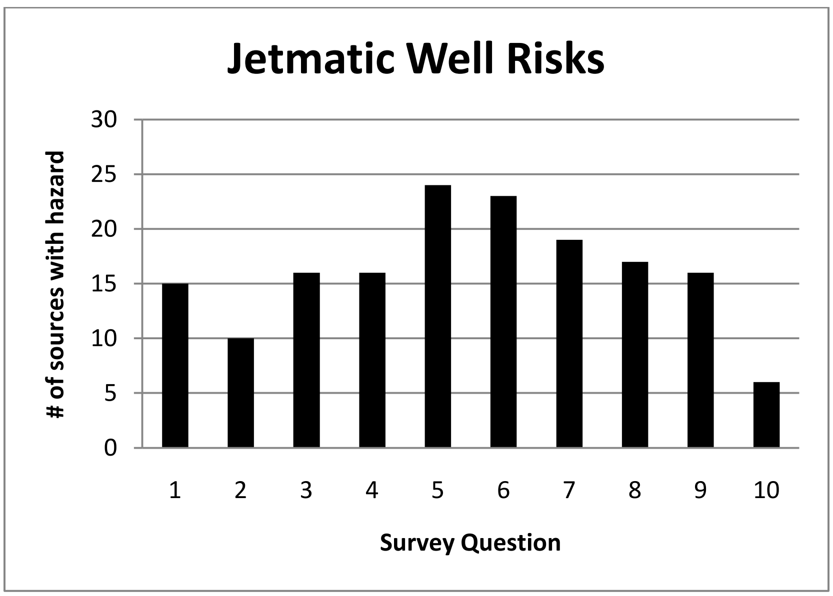
Open Dugwell Sanitary Survey

1	latrine within 10m
2	latrine on higher ground than handpump
3	other sources of pollution (animal excreta, rubbish)
4	poor drainage, stagnant water with 2m of handpump
5	faulty, non-existent, dirty drainage channel
6	inadequate parapet around wellhead
7	concrete floor less than 1m wide around well
8	inadequate wall seal for 3m below ground level
9	crack in concrete floor around handpump or well
10	rope and bucket left open to contamination
11	no wall or fencing around handpump or well (permitting animals)



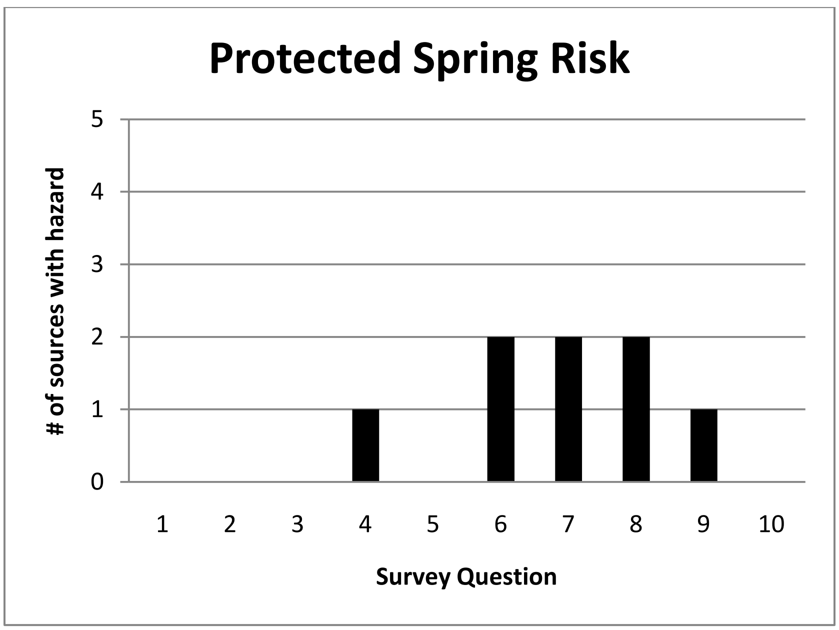
Tubewell with Handpump (Jetmatic)

1	latrine within 10m
2	latrine on higher ground than handpump
3	other sources of pollution (animal excreta, rubbish)
4	poor drainage, stagnant water with 2m of handpump
5	faulty, non-existent, dirty drainage channel
6	no wall or fencing around handpump or well (permitting animals)
7	concrete floor less than 1m wide around handpump
8	ponding on concrete floor around handpump
9	crack in concrete floor around handpump or well
10	loose handpump at point of attachment to base



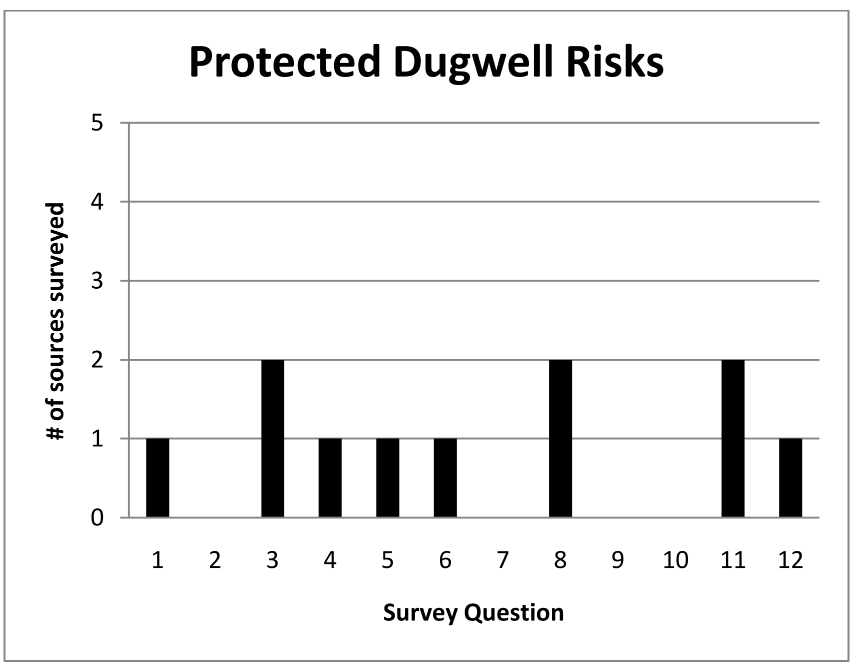
Protected Spring

1	spring source unprotected by masonry or spring box (and thus open to surface contamination)
2	faulty masonry protecting spring source
3	unsanitary inspection cover in the masonry
4	silt or animals in spring box
5	unsanitary air vent in masonry
6	unsanitary overflow pipe
7	unfenced area around spring
8	possible animal access within 10m of spring source
9	lack of surface water diversion ditch above spring
10	uphill latrines

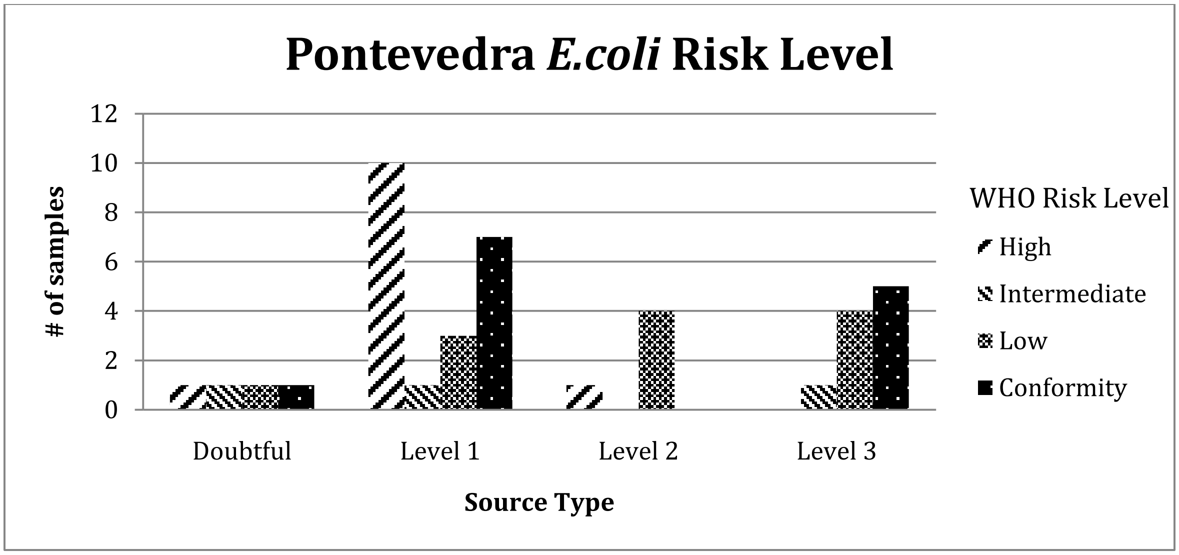


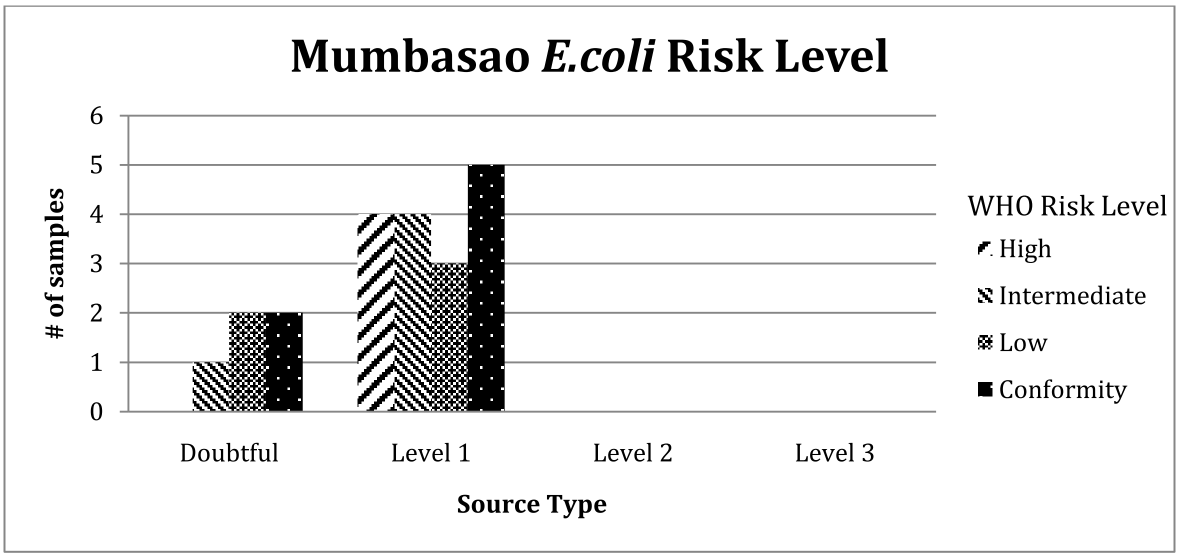
Protected Dugwell

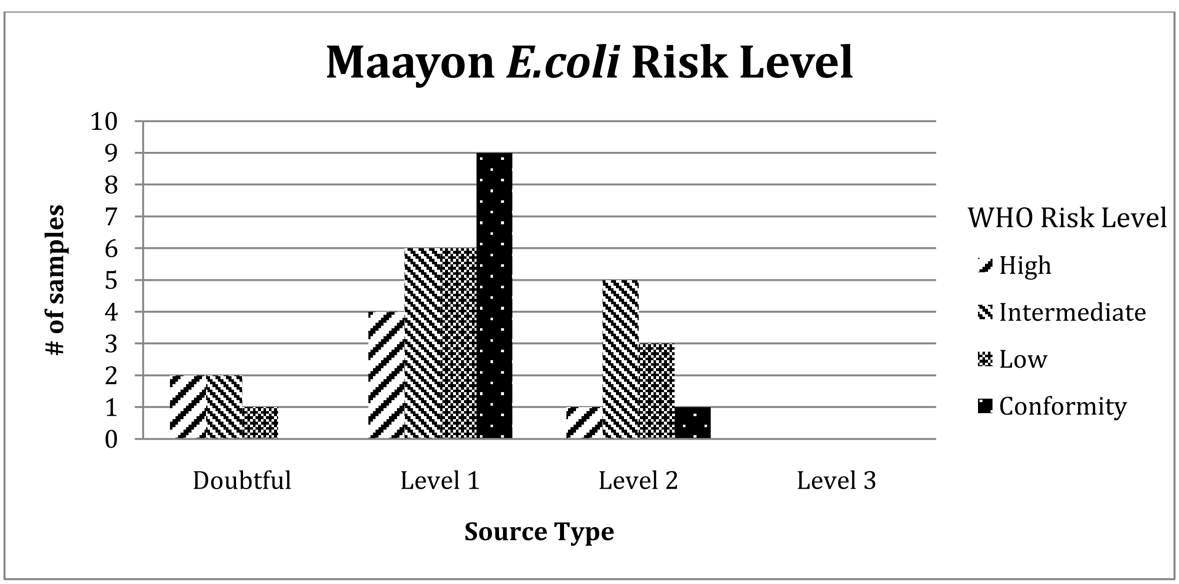
1	latrine within 10m
2	latrine on higher ground than handpump/source
3	other sources of pollution (animal excreta, rubbish)
4	poor drainage, stagnant water with 2m of handpump
5	faulty, non-existent, dirty drainage channel
6	no wall or fencing around handpump or well (permitting animals)
7	concrete floor less than 1m wide around pump
8	ponding on concrete floor around handpump
9	crack in concrete floor around handpump or well
10	loose handpump at point of attachment to base
11	unsanitary well cover
12	inadequate wall seal for 3m below ground level

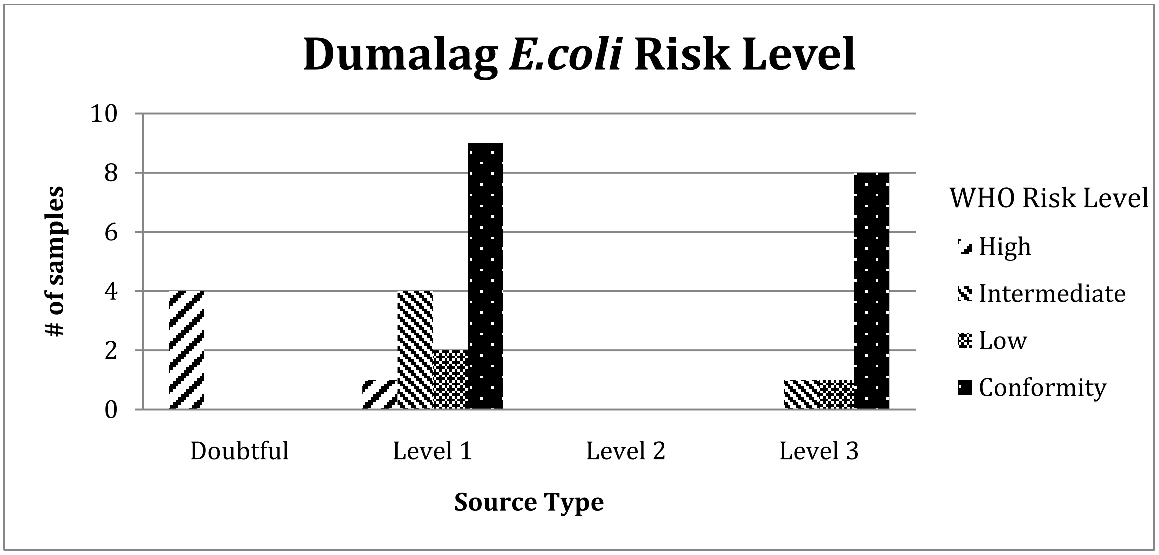


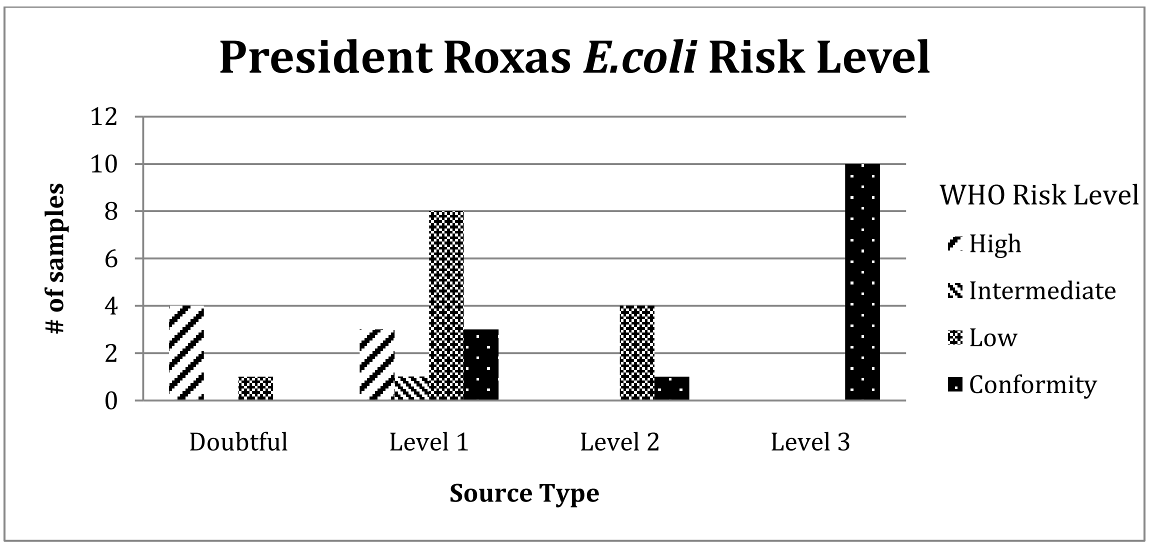
Appendix IV

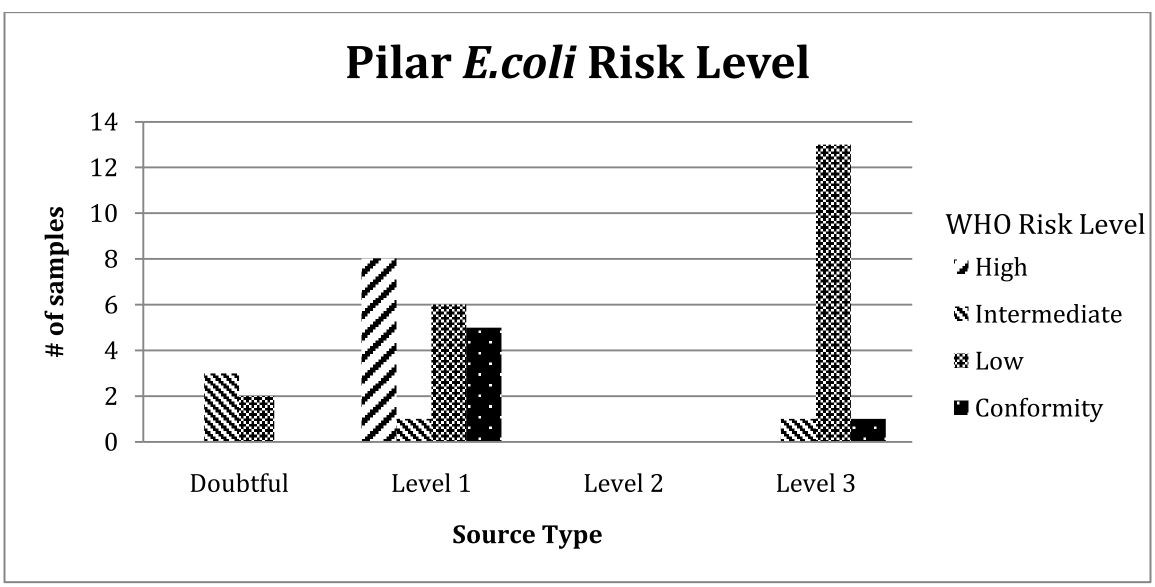

Pontevedra E.coli Risk Level
12
10
8
6
4
2
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

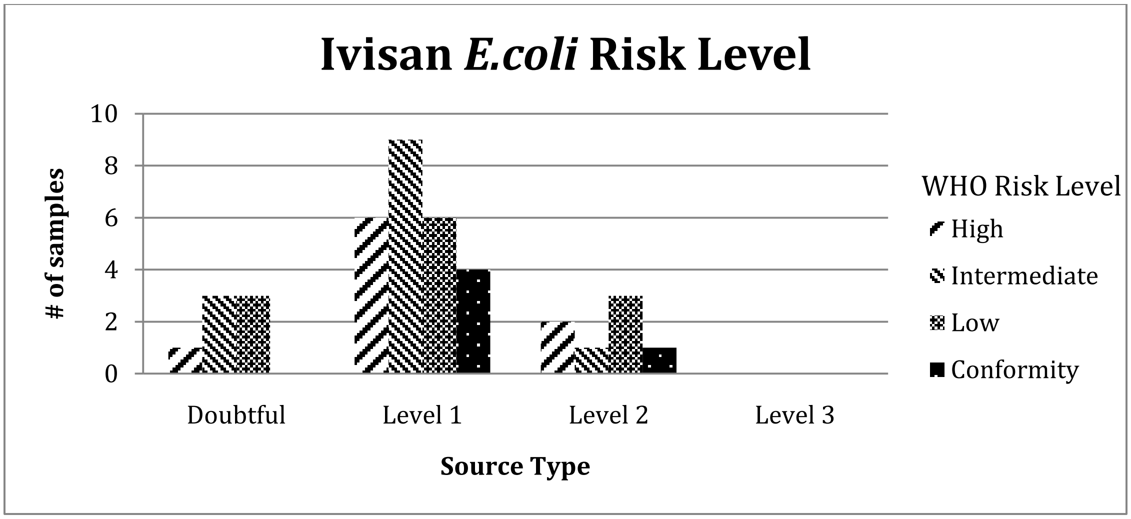

Mumbasao E.coli Risk Level
6
5
4
3
2
1
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

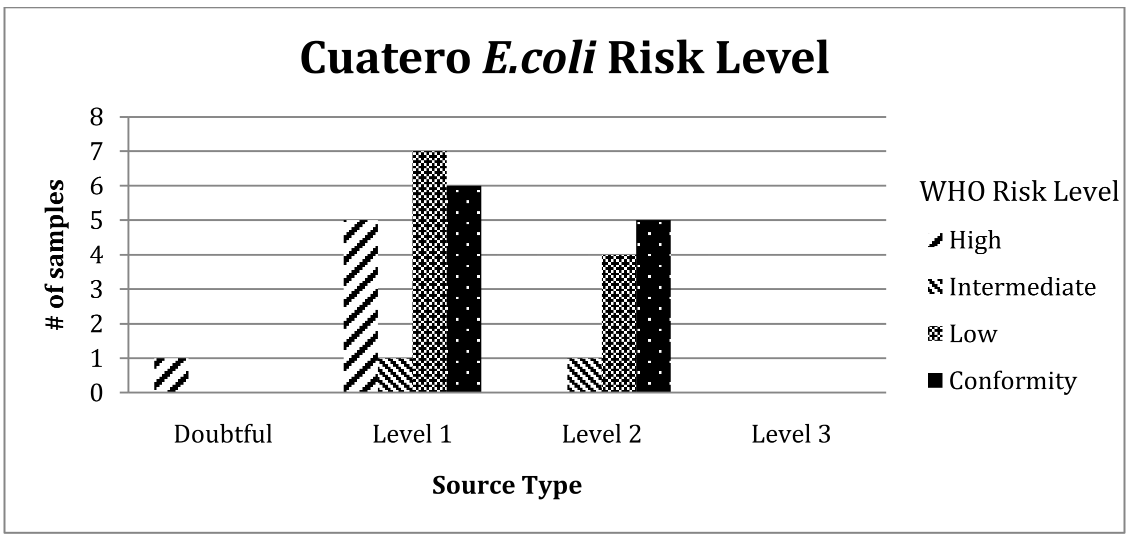

Maayon E.coli Risk Level
10
9
8
7
6
5
4
3
2
1
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

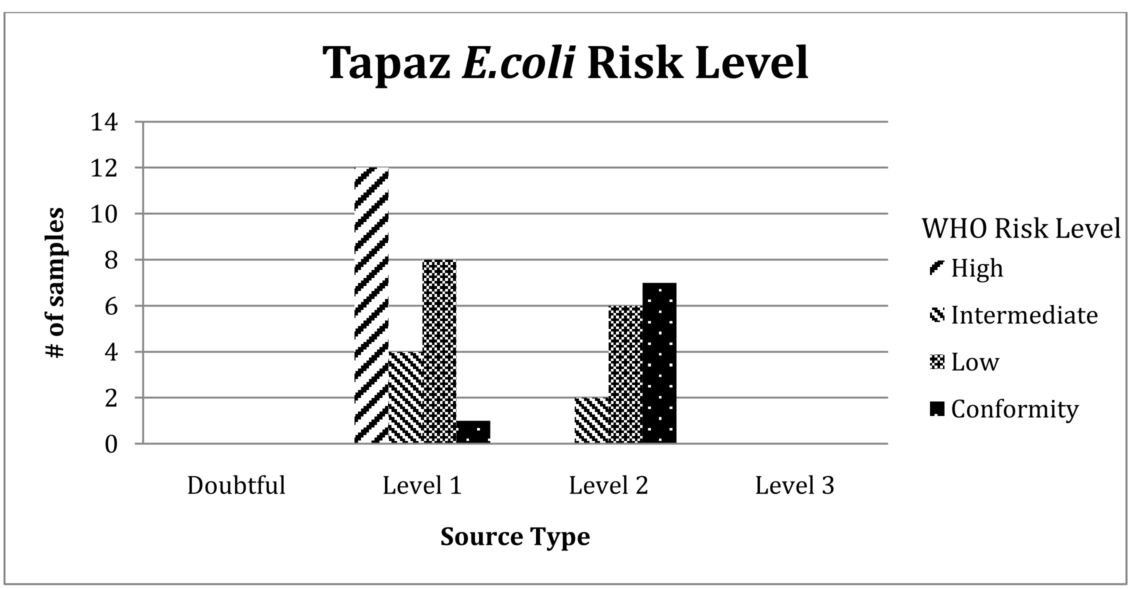

Dumalag E.coli Risk Level
10
8
6
4
2
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

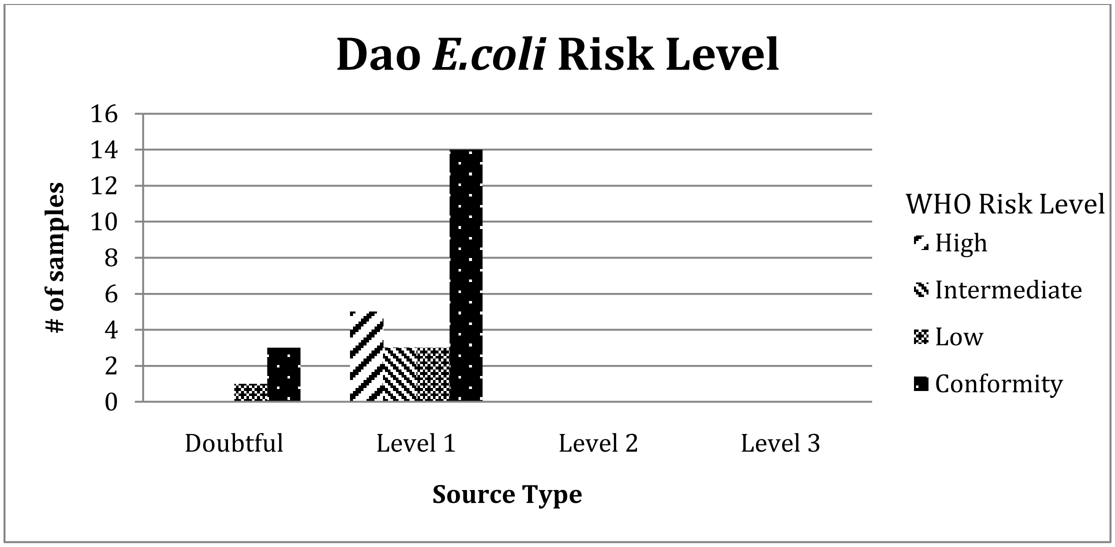

President Roxas E.coli Risk Level
12
10
8
6
4
2
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity


Pilar E.coli Risk Level
14
12
10
8
6
4
2
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

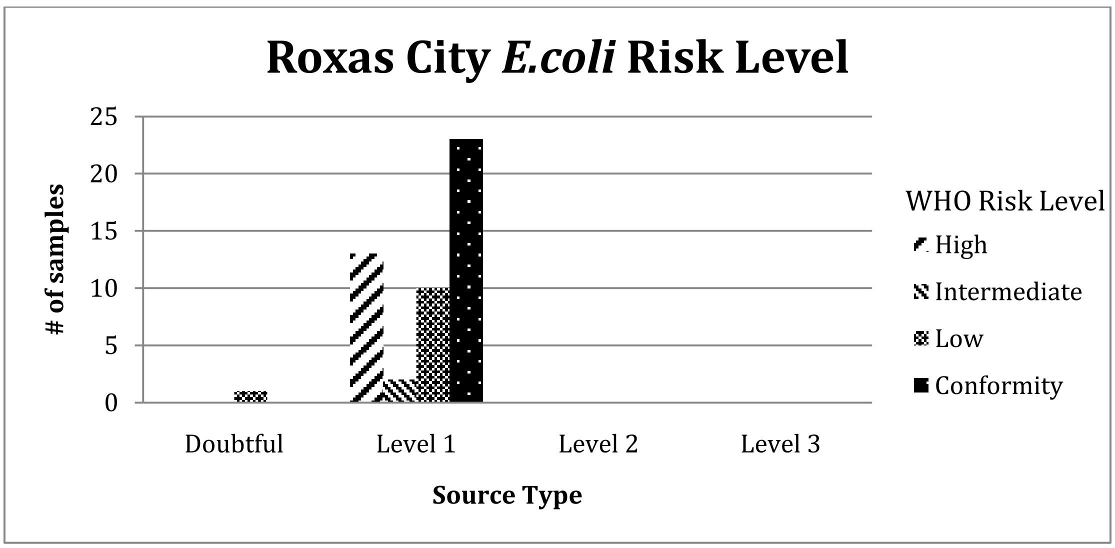

Ivisan E.coli Risk Level
# of samples
10
8
6
4
2
0
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity


Cuatero E.coli Risk Level
# of samples
8
7
6
5
4
3
2
1
0
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

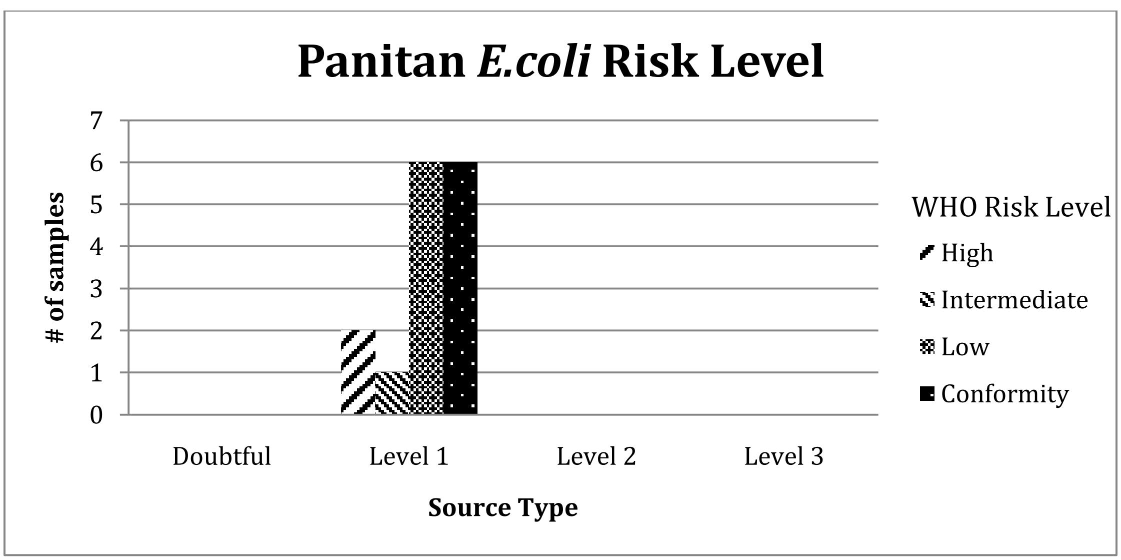

Tapaz E.coli Risk Level
# of samples
14
12
10
8
6
4
2
0
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity



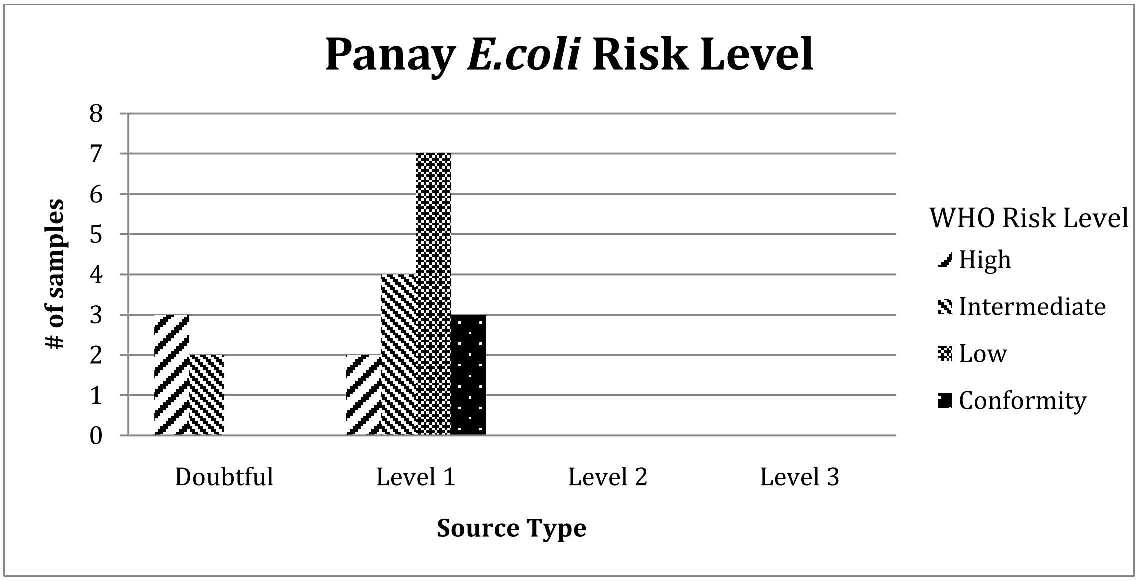
Dao E.coli Risk Level
16
14
12
10
8
6
4
2
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

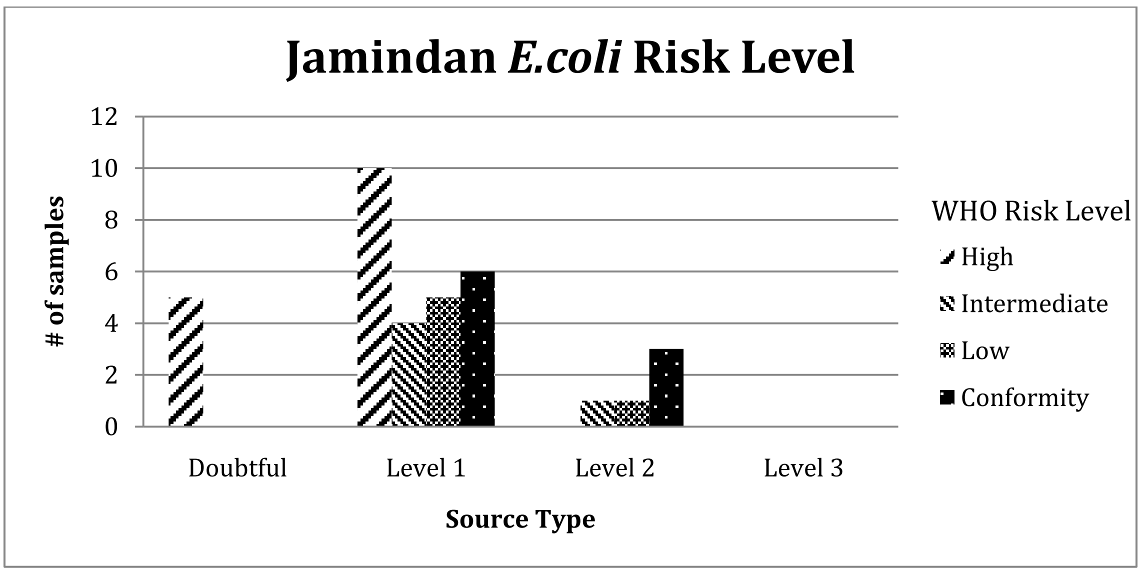


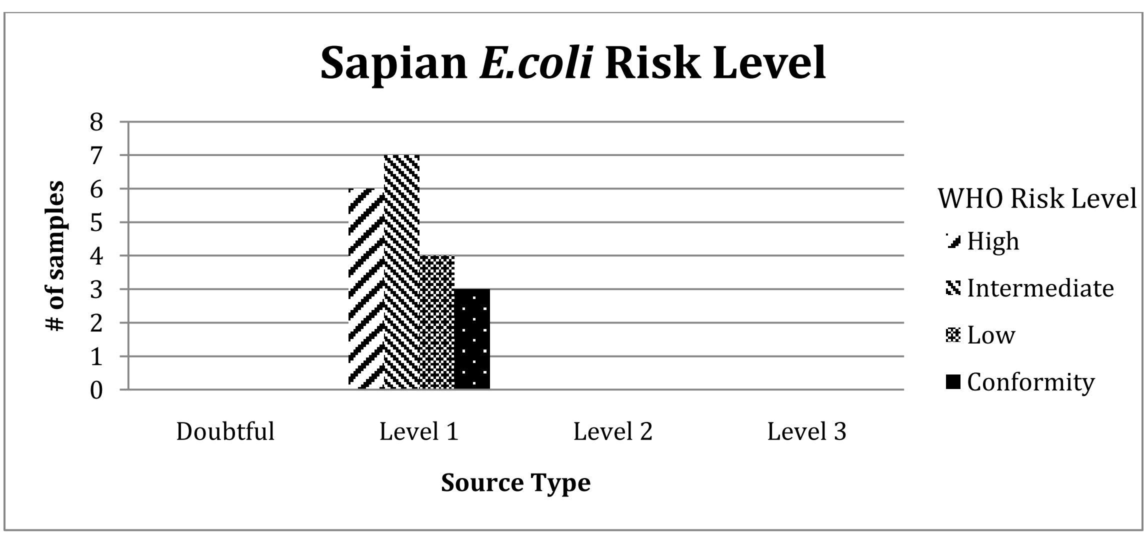
Roxas City E.coli Risk Level
25
20
15
10
5
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

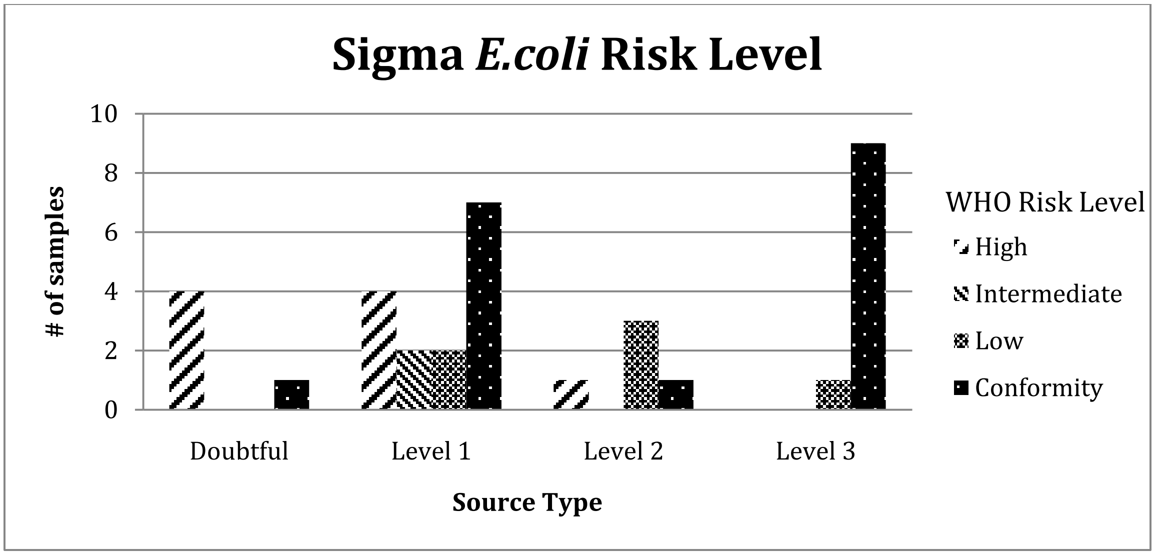


Panitan E.coli Risk Level
7
6
5
4
3
2
1
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

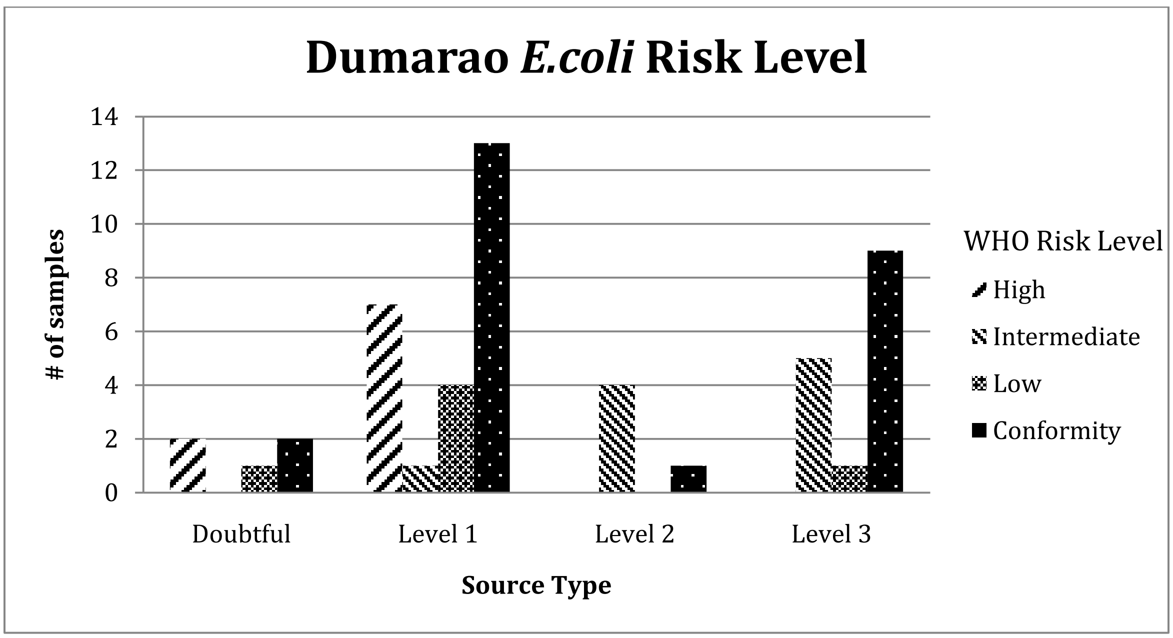

Panay E.coli Risk Level
# of samples
0
1
2
3
4
5
6
7
8
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity


Jamindan E.coli Risk Level
# of samples
0
2
4
6
8
10
12
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity


Sapian E.coli Risk Level
# of samples
0
1
2
3
4
5
6
7
8
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

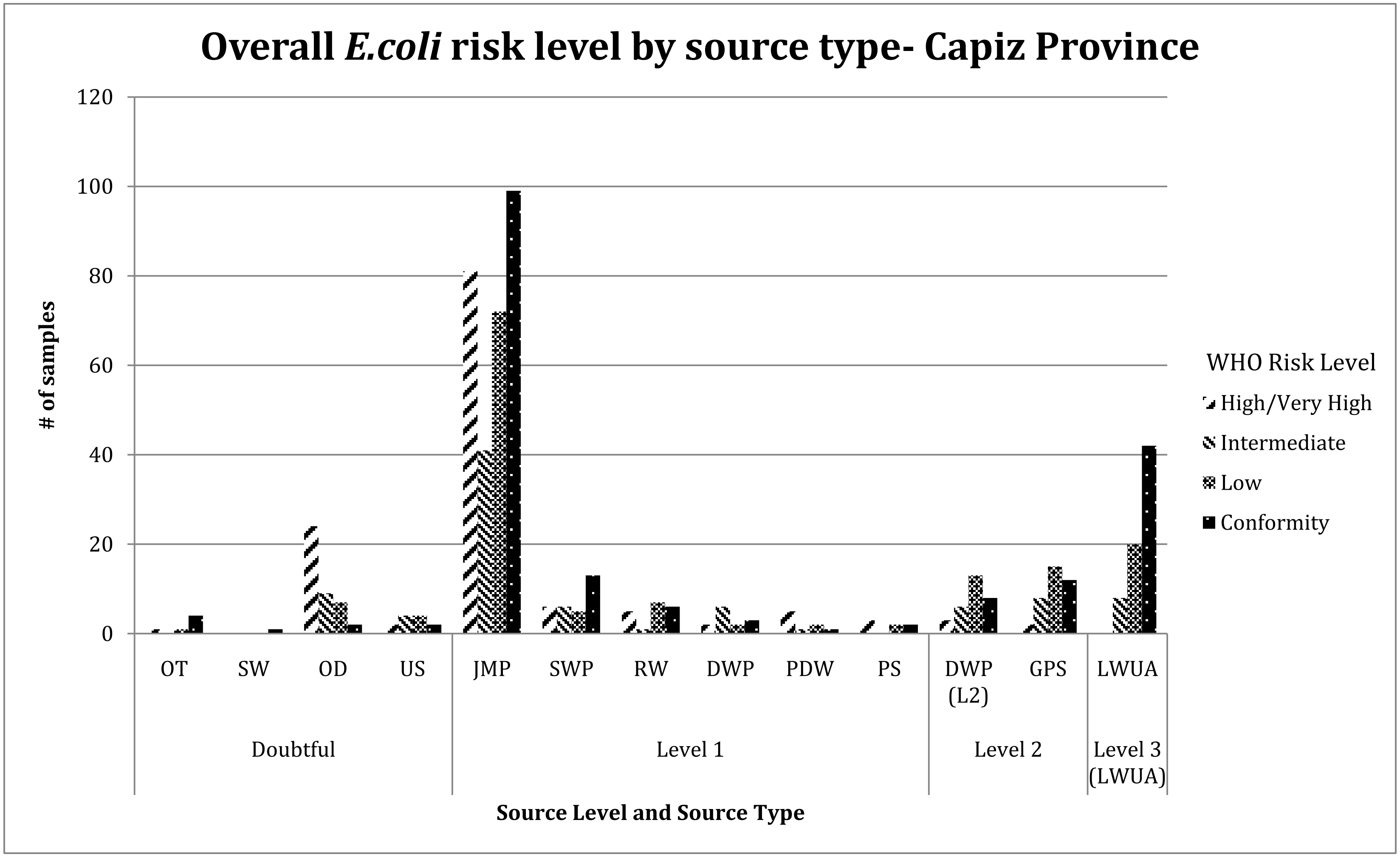


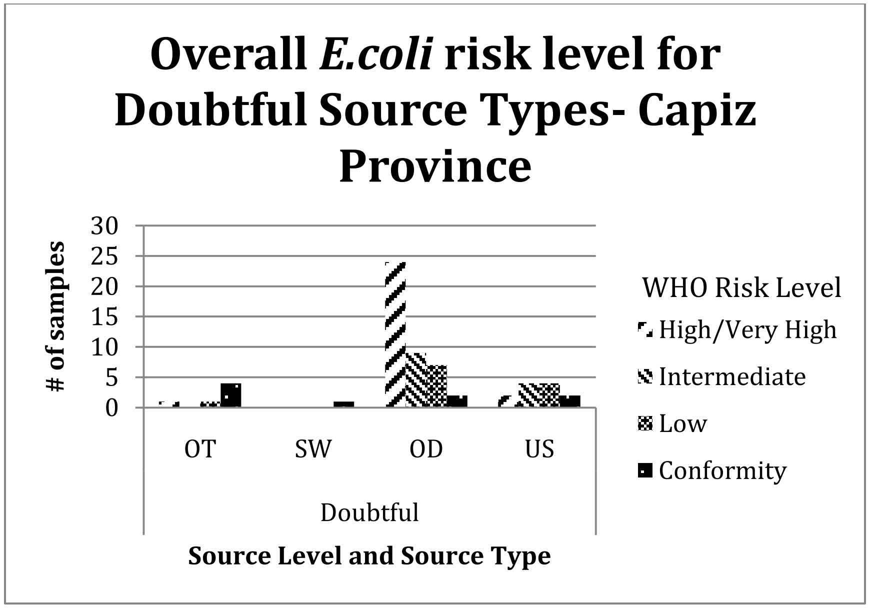
Sigma E.coli Risk Level
10
8
6
4
2
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

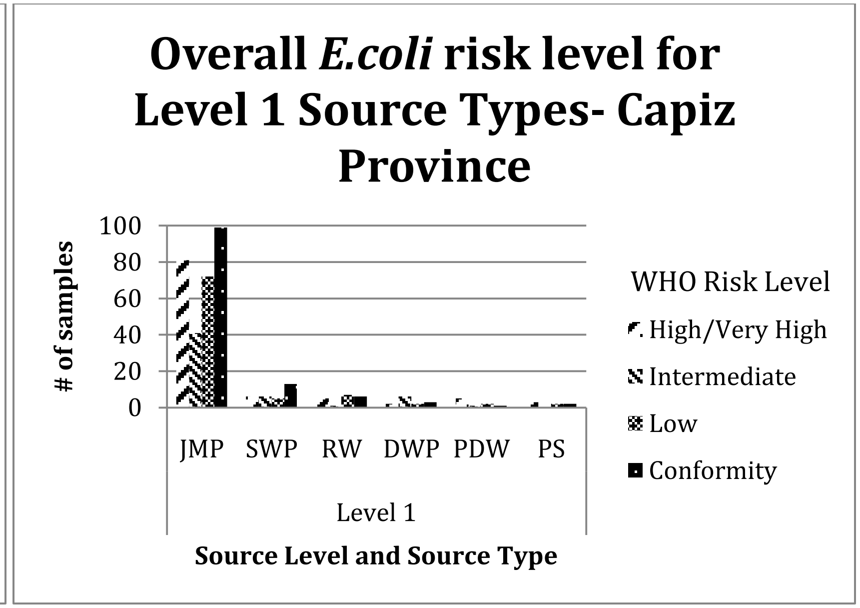


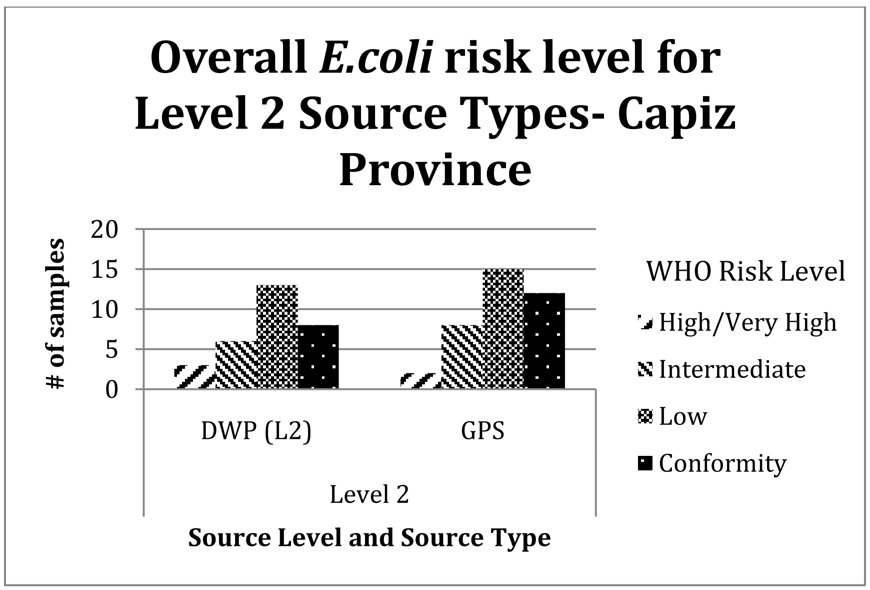
Dumarao E.coli Risk Level
14
12
10
8
6
4
2
0
# of samples
Doubtful
Level 1
Level 2
Level 3
Source Type
WHO Risk Level
High
Intermediate
Low
Conformity

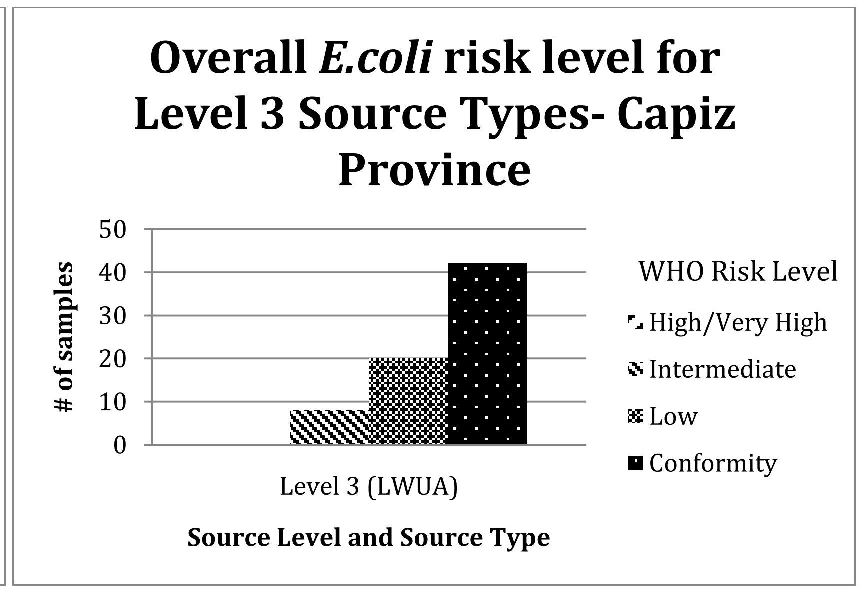
Appendix V


Overall E.coli risk level by source type- Capiz Province
120
100
80
60
40
20
0
# of samples
OT
SW
OD
US
JMP
SWP
RW
DWP
PDW
PS
DWP (L2)
GPS
LWUA
Doubtful
Level 1
Level 2
Level 3 (LWUA)
Source Level and Source Type
WHO Risk Level
High/Very High
Intermediate
Low
Conformity


Overall *E.coli* risk level for Doubtful Source Types- Capiz Province
# of samples
30
25
20
15
10
5
0
OT
SW
OD
US
Doubtful
Source Level and Source Type
WHO Risk Level
High/Very High
Intermediate
Low
Conformity


Overall *E.coli* risk level for Level 1 Source Types- Capiz Province
# of samples
100
80
60
40
20
0
JMP
SWP
RW
DWP
PDW
PS
Level 1
Source Level and Source Type
WHO Risk Level
High/Very High
Intermediate
Low
Conformity


Overall *E.coli* risk level for Level 2 Source Types- Capiz Province
# of samples
20
15
10
5
0
DWP (L2)
GPS
Level 2
Source Level and Source Type
WHO Risk Level
High/Very High
Intermediate
Low
Conformity


Overall *E.coli* risk level for Level 3 Source Types- Capiz Province
# of samples
50
40
30
20
10
0
Level 3 (LWUA)
Source Level and Source Type
WHO Risk Level
High/Very High
Intermediate
Low
Conformity

Appendix VI

Infrastructure Control Measures

Following a sanitary inspection, it is typical that a number of infrastructure control measures are introduced, in order to bring risk to an acceptable level and to increase the safety of the water source. The following are specific infrastructure control measures for some types of water sources typically found in rural areas in the Philippines.

Dugwells are often much more subject to contamination than other point sources, such as boreholes and protected springs, because the lining of the well is often permeable and the means of withdrawing water can often introduce contamination (Howard, 2002). They should be covered with a locking sanitary lid and water should be withdrawn with the use of a handpump, as opposed to individuals using their own buckets to collect the water. The use of a windlass in an open dugwell is also an improvement; however where a community well has a windlass, only one bucket should be used and left suspended over the opening. A concrete plinth should be constructed around the well, which should then be surrounded by a concrete apron with a drainage channel to prevent water from pooling around the source. The top of the well should be at least 30cm above the apron. It has been found that the most common sources of contamination to dugwells are from cracks or other damage to the concrete plinth or drainage channel (WHO, 1997ii).

Tubewells and Boreholes with handpumps or mechanically operated pumps and a sanitary cover are an improvement to open dugwells. A concrete ring should be built around the top of the pipe and then a plinth for the handpump to rest on; the pipe should extend into the base of the pump to create a seal. The concrete apron surrounding the plinth should be at least 2m in diameter and sloped towards the drainage channel (Howard, 2002). A *communal faucet system* where water is piped from the source to various outlet taps can be improved by ensuring that the pipe remains buried and that the tap is supported with the use of a plinth or metal support (see Figure below). The joints of the pipes are easily damaged when the tap riser is not supported and is moved around during use.

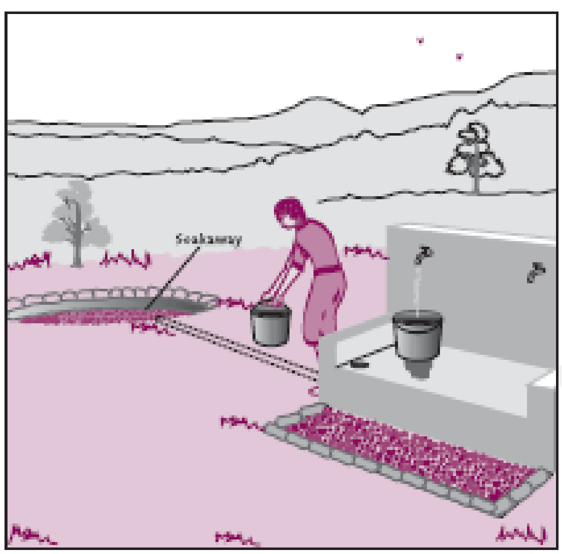


Figure 0-1. Communal standpost(Brikké & Bredero, 2003)

Springs require encasements with the following features to minimize hazards:

- A watertight spring box with a lockable inspection box: which intercepts the source and extends down to an impermeable layer OR a number of pipes which collect the water and lead to a storage tank;
- A protective cover;
- A protected overflow outlet;
- A connection to a distribution system or another supply;
- An impermeable layer above the spring box and the eye of the spring to prevent the entrance of contaminants. This should be concrete or clay, and should be underlain by graded gravel to act as a filter for water entering the collection system;
- A drainage channel to prevent pooling water and lead surface water from above the spring away from the source (MacDonald, Davies, Calow, & Chilton, 2005).

Rainwater collection systems should be protected by regularly cleaning the roof and gutters, and by ensuring the roof, gutter and tank are thoroughly cleaned at the beginning of the wet season (Skinner, 2003). Additionally, for the first 5-10 minutes of rains occurring after extended dry periods, it is recommended that the water be diverted to allow contamination and debris to wash away. This water can be used for purposes other than drinking. A screen or mesh can also be installed at the end of the gutter length to prevent large debris from entering, however this has to be checked regularly (WHO, 1997ii).

Adapted from (WHO, 4.Water Safety Plans, 2003ii)

Control Measure	*Recommended*
Dugwell/Tubewells	
Install locking sanitary lid	
Use dedicated bucket for withdrawing water	
Install windlass + dedicated bucket for water withdrawal	
Recommended handpump installation	
Build concrete plinth around well	
Build concrete apron around plinth (2m diameter)	
Fix cracks/faults in concrete lining around well	
Build drainage channel	
Ensure no faults in drainage channel and that is draining away from well	
Communal Faucet	
Bury piping	
Build tap riser support with metal or concrete plinth	
Spring	
Build watertight spring box with a lockable inspection box: which intercepts the source and extends down to an impermeable layer OR a number of pipes which collect the water and lead to a storage tank	
Build a protective cover	
Protect overflow outlet	
Construct a connection to a distribution system or another supply	
Build an impermeable layer above the spring box and the eye of the spring to prevent the entrance of contaminants. (should be concrete or clay, and should be underlain by graded gravel to act as a filter for water entering the collection system)	
Build drainage channel to prevent pooling water and lead surface water from above the spring away from the source	
Rainwater Systems	
Clean tank thoroughly	
Clean roof	
Build diverter for first 5-10 minutes of rainfall	
Install a screen/mesh to keep large particulates out of tank	
Site Protection	
Build protective fence around source (locked fence)	
If possible, move animal watering, latrines to 30m (10m minimum)	
Move waste collection facilities to 30m from source	