FECAL CONTAMINATION OF DRINKING WATER AT POINT OF USE IN JIMMA TOWN, SOUTHWESTERN

ETHIOPIA

BY

AMELEWORK SISAY(BSc)

RESEARCH THESIS SUBMITED TO JIMMA UNIVERSITY, INSTITUTE OF HEALTH SCIENCES , DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIROMENTAL SCIENCE AND TECHNOLOGY

OCTOBER, 2017

JIMMA ETHIOPIA

FECAL CONTAMINATION OF DRINKING WATER AT POINT OF USE IN JIMMA TOWN, SOUTHWESTERN

ETHIOPIA

BY

AMELEWORK SISAY

ADVISORS:

1. **DR.ARGAW AMBELU (Asso.Prof)**
2. **DR. SEBLEWORK MEKONIN (Asst.Prof.)**

OCTOBER, 2017

IMMA ETHIOPIA

ACKNOWLEDGEMENTS

I would like to extend my upper most acknowledgements and special thanks to my advisor Dr. Argaw Ambelu and Dr. Seblework Mekonin who give me a helpful comments, valuable guidance and advice of this study.

I would also like to thank Jimma University for giving this educational opportunity and support for this study.

I have special gratitude to my families specially my father for his motivation and strengthening me for all my way.

Finally, it is also my pleasure to acknowledge the data collectors and all study participants for their fruitful efforts in conducting this study.

ABSTRACT

Drinking Water becomes contaminated with fecal matter due to inadequate treatment of the source, unhygienic practices of water storage, and household water management this is aimed to determine the microbial contamination level of drinking water at point of use among the community served with tap water in Jimma town by using a cross-sectional study was carried out from August -September, 2015 among residents of Awetu Mendera, Ginjo Giduru, Hirmata Merkato, and Mendera Kochi kebeles of Jimma town. 260 households were selected using systematic random sampling for interview, total 121 water samples were (110 from serving cup at household and 11 from household tap) collected and regression analysis was performed to identify factors associated with fecal contamination of drinking water at household level The result shows mean fecal contamination level of water at point of tap and point of use were 7CFU/100ml and 21.9CFU/100ml respectively. The result indicates 72(65.4%) of water samples from point of use were positive for fecal contamination that had a coliform count of one or more and not acceptable by WHO and National standard for drinking water. 55.5% of water sample at point of tap were contaminated at low to intermediate risk level and all samples had no free residual chlorine. Storage material [AOR: 3.5, 95% CI=1.103, 11.20] Water fetching method [AOR: 0.306, 95% CI=0.096, 0.980] Hand washing facility [AOR: 2.858, 95% CI=1.263, 6.468] and inadequacy of water consumption [AOR: 4.875, 95% CI=1.681, 14.14], were significant factor for fecal contamination of drinking water at household then concluded that majority of the water samples did not meet the microbial quality guidelines for drinking water quality set by WHO and national standard and contamination is higher in the household. Bacteriological and related parameter should assess periodically on tap and promoting good handling practice and sanitation are recommended.

Key words: *Drinking water, fecal coliform, contamination, point of use*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF Figures

ACRONYMS

CFU: Coli Form Unit

DPD: Diethyl Phenyl Damien

FDRE: Federal Democratic Republic of Ethiopia

GPS: - Geographic Positioning System

HHs: - Households

HWTS: - Household Water Treatment and Safe Storage

MLSB: - Membrane Lauryl Sulphate Broth

MMD: Media measuring device

NTU: - Nephelometric Turbidity Unit

pH: - power of Hydrogen

PW: - Piped Water

REDWQ: - Rapid Assessment of Drinking-Water Quality

SPSS: - Statistical Package for Social Sciences

WHO: - World Health Organization

CHAPTER ONE: INTRODUCTION

1.1. Background

Safe drinking water is a basic need for good health and it is also a basic right of humans of every citizen (Ahmed, et al., 2013). For this access to water supply and sanitation is a fundamental need to human. Globally 663 million (one in ten) people are without access to improved drinking water sources and 2.4 billion (one in three) are lack of improved sanitation facility (UNICEF&WHO, 2015). However, access to improved water sources alone does not reduce diarrheal diseases significantly. It becomes fecally contaminated by poor handling practice and hygiene behavior in the home (Amenu, et al., 2014)

Lack of improved domestic water supply leads to water born and water washed transmission disease, occurs by drinking contaminated water and lack of sufficient quantities of water for washing and personal hygiene. This can cause the public health problem of diarrhea (WHO&UNICEF, 2000). Diarrhea remains the second leading causes of death among children under five globally (WHO&UNICEF, 2009). Moreover, in 2010, the annual incidence of diarrhea related to unsafe drinking water was 4.6 billion episodes and 2.2 million deaths (WHO, 2010).

In Ethiopia over 60% of the communicable diseases are related to poor environmental health conditions arising from unsafe and inadequate water supply and poor hygienic and sanitation practice. About three forth of the health problems of children in the country are communicable diseases arising from poor water supply and sanitation. About 46% of mortality in children of less than five years is due to diarrhea mainly related to unsafe drinking water (Mengesha et al., 2004).

Diarrhea is a common symptom of gastrointestinal infections caused by a wide range of pathogens, including bacteria, viruses and protozoa and most pathogens are transmitting by fecal-oral pathway (WHO, 2008). The major preventing method of diarrhea are improved water supply quantity and quality, including treatment and safe storage of household water, promotion of hand washing with soap, and community wide sanitation promotion (WHO&UNICEF, 2009).

Microbiological quality of water in vessels in the home is lower than that at the source, suggesting that contamination is widespread during collection, transport, storage and drawing of water (Wright, et al., 2004).

Trying to detect this disease causing bacteria and other pathogens in water requires considerable training, time and expense. The most commonly used indicator microorganisms are *E. coli* and thermo tolerant coliforms which derive almost exclusively from human and animal faces, in common with most waterborne pathogens. Many programmers' that monitor drinking-water quality therefore use thermo tolerant coliforms as proxy indicators, because the results are obtained quickly and cheaply, even though they are only presumptive (Tadesse, et al., 2010).

The microbial drinking water guideline of WHO and Federal Democratic Republic of Ethiopia recommends zero total coliform and fecal coliform/100ml in drinking water. (WHO, 1997), (MoR, 2002).

1.2. Statement of the problem

Recent WHO/UNICEF report it estimates that up to 1.1 billion people still do not have access to "improved" sources of water for drinking , for example, a piped connection or a protected well. They also acknowledge that many of the remaining 5.2 billion people who use an "improved" water source nevertheless drink water which is unsafe, following contamination at source, in the piped distribution system or as a result of unhygienic handling during transport or in the home. Consumption of unsafe water continues to be one of the major causes of diarrheal disease death (Nath, et al., 2006).

Safe drinking-water, as defined by the Guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Those at greatest risk of waterborne disease are infants and young children, people who are debilitated or living under unsanitary conditions (WHO, 2004).

Globally estimate that 1.8 billion people use a source of drinking water which suffers from fecal contamination, of these 1.1 billion drink water that is of at least 'moderate' risk (Bain, et al., 2014).

Consumption of unsafe water is one of the major causes of diarrheal disease and death. These were greatest risks for infants and young children, people who are debilitated or living under unsanitary conditions (Nath, et al., 2006)

Ethiopia is one of the developing countries where only 52% and 24% of the population have access to safe water and improved sanitation coverage, respectively and the diarrhea death attributable to inadequate water sanitation and hygiene is 26,088 (WHO/UNICEF, 2014). Lack of clean drinking water, poor sanitation facilities and lack of community education programs are contributing to continue outbreaks of acute watery diarrhea in some parts of the Ethiopia, 19.4% of children are under age 5 mortality rates due to diarrheal disease (USAID, 2010).

Most people assume the consumption of water from tap or any other protected water sources is to be considered safe for drinking. However, studies indicate that water could be contaminated during transportation, storage and utilization despite the status of the water at the source. In Myanmar (Myint, et al., 2015) 94% of the water samples taken from serving cups had microbial contamination; Study conducted in Arba Minch town (South Ethiopia) (Gezmu, et al., 2015) shows 169 sample taken from cups 137 of them had growth of coliform bacteria and also study conducted in Serbo town (South Western Ethiopia) results shows 87.5% of sources had MPN of *E. coli* above the allowable limit this indicate majority was fecally polluted (Abera, et al., 2011).

The Jimma town water supply system is passess through the treatment plant it uses surface water as a source. However according to Jimma town health administration office reported in 2015, a total of 13,033 peoples were infected with diarrheal diseases from this 6,353 were childrens under the age of 5 years.

Researches were done on microbial contamination of drinking water from tap source to point of use in the home at different places and related risk factors. However, the microbial contamination status of drinking water at point of use in Jimma town had not yet been examined. Therefore, this research determines the level of microbial contamination of drinking water at point of use and its associated risk factor.

1.3. Significance of the study

Undertaking this study will have more paramount importance. The study will help for Water and Sewerage Authority to evaluate the status of their service, and will be taken appropriate action in Jimma town. It will help to undertake intervention mechanisms on the improvement of household water handling practice by health extension workers and other stakeholders. To support other actors by making awareness on how the standard of drinking water at household level in Jimma town.

And the study will also give baseline information for other study.

CHAPTER TWO: LITERATURE REVIEW

2.1. Drinking Water Quality

Drinking water is essential to life and quality of drinking water is a powerful environmental determinant of health, If not it can be a source of contaminants. Drinking water for human consumption must be free from physical, chemical substances and micro organisms in amounts which would provide a hazard to health is universally accepted. Supplies of drinking-water should not only be safe and free from dangers to health, but should also be as aesthetically attractive as possible (WHO, 1958).

Inadequate and unsafe water supply accounts for a variety of diseases transmitted in different ways. Diarrheas, dysenteries, and typhoid are the most prevalent water-related diseases. Diarrheal diseases are limit normal consumption of food and adsorption of nutrients can also cause malnutrition, leading to impaired physical growth and cognitive development, reduced resistance to infection and potentially long-term gastrointestinal disorders (Nath, et al., 2006).

Access to safe drinking water and sanitation is a global concern. However, developing countries, like Ethiopia, have suffered from a lack of access to safe drinking water from improved sources and a water quality concerns are often the most important component for measuring access to improved water sources. According to JMP report until 2012 in Ethiopia only 24% use of improved sanitation facility and 52% use of drinking water from improved sources (WHO/UNICEF, 2014).The WHO has guidelines for the quality of potable drinking water which measuring of physical, chemical and bacteriological parameters. However the guidelines emphasize the over-riding importance of ensuring that drinking water supplies are protected from microbial contamination (WHO, 2004).

The greatest microbial health risks are associated with drinking water that is contaminated with human or animal (including bird) faces. Faces can be a source of pathogenic bacteria, viruses, protozoa and helminthes (WHO, 2008). And people become infected after eating food or drinking water that have been handled by a person who is infected or by drinking water that has been contaminated by sewage containing the bacteria (Ashbolt, 2004).

In developed countries, the disease is found mainly in children under the age of 5 years and in young adults. In developing countries, children fewer than 2 are most affected (Ashbolt, 2004).The most predominant waterborne disease, diarrhea, has an estimated annual incidence of 4.6 billion episodes and causes 2.2 million deaths every year (WHO, 2010).

2.2. Bacteriological quality of drinking water

Globally 1.8 billion of people use a source of drinking water which suffers from fecal contamination. Of this 1.1 billion are in moderate risk (>1ocfu/100ml) (Bain, et al., 2014).

A household survey study in Periurban community in Myanmar reported that the analysis water samples obtained from serving cups 94% (105/112) were contaminated with thermo tolerant (fecal) coliforms which counted one and more (Myint, et al., 2015)

A cross sectional study conducted in Serbo town (South Western Ethiopia) showed 87.5% have presumptive bacteria count above the permissible limits for drinking water (Abera, et al., 2011). And 82% samples which taken from drinking cups had growth of E. coli bacteria in Arba Minch town (Southern Ethiopia) and in this analysis of tap water shows 108/140 of growth of bacteria (Gezmu, et al., 2015).

2.3. Drinking water quality

Drinking water quality management has been a key pillar of primary prevention and control of waterborne diseases. According to World Health Organization (WHO) Drinking Water Quality Guidelines, suppliers should frequently conduct operational monitoring often limited to a set of critical parameters (bacteriological and related parameters) such as pH, residual chlorine, turbidity, and indicator bacteria (Peletz, et al., 2016).

2.3.1. Bacteriological Parameter

Pathogenic and non pathogenic microorganisms are found in water. Nonpathogenic microorganisms may cause taste and odor problems with water supplies, which can influence whether people use the water for consumption, but the principle concern for microbiological quality is contamination by pathogenic species found in drinking water, include species of bacteria, viruses, protozoa and helminthes (Tadesse, et al., 2010).

Testing for every pathogen in water would be time consuming, complicated and expensive. Alternatively, the presence or absence of certain bacterial indicator organisms is used to determine the safety of the water. Bacterial indicator tests have been found to be cheaper, easier to perform and yield faster results compared to direct pathogen testing (Tadesse, et al., 2010).

There is no universal indicator to ensure that water is pathogen free, but there are several types of indicators, each with certain characteristics. Coliform bacteria are most commonly used as indicators because they exist in high ratios to pathogens, are more resistant to disinfection than pathogens, does not multiply in water and distribution systems and easier to detect in a water sample (WHO, 1997).

All of the studies analyzed used one or more of the following three indicator bacteria such as:-

- Total coliforms- which are Gram-negative bacteria that ferment lactose at 35–37 ^{o}C within 48 hour.
- Fecal thermo tolerant coliforms- which are a subset of total coliform bacteria that ferment lactose at 44–45 ^{o}C for 18 hours and
- E. coli - which are exclusively fecal in origin, are a sub-group of the fecal coliforms that produce the enzyme B-galactosidase and not urease.

The WHO guidelines (WHO, 1997) and FDRE ministry of water (MoR, 2002) state that none of these bacteria should be detected in 100ml water sample. Of these bacteria, E. coli are regarded as the most reliable indicator of fecal contamination and total coliforms as the least reliable indicator.

Guideline values for verification of microbial quality according to the WHO guidelines for drinking-water quality are shown the table.

Table 1: Classification of thermo tolerant (fecal) coliforms or E. coli for drinking water supplies, WHO 1997

Mean thermo tolerant(fecal) coliform count /100ml	**Category**	**Remark**	**Comment**
0	A	Inconformity with WHO guidelines	Excellent
1-10	B	Low risk	Acceptable but make regular sanitary check up
10-100	C (yellow)	Intermediate risk	Unacceptable look for correct structural faults and disinfect equipment and source.
100-1000	D	High risk	Grossly polluted look for alternative sources
>1000	E	Very high risk	Grossly polluted look for alternative sources

2.3.2. Physico-Chemical Water Quality

Physicochemical parameters are essential in water quality investigation which related to microbiological test such as.

2.3.2.1. PH Parameter

The pH of water is a measure of how acidic or alkaline (basic) the water is on a scale of 0 to 14. pH measurement below 7 indicates that the solution is acidic containing more H+ ions than OH- ions. Measurement above 7 indicates that the reverse situation exists making the water alkaline. The usual pH for fresh water aquatic system is 6 to 9 with most water ways around pH is an indicator of existence of biological life. The efficiency of disinfection with chlorine is highly pH-dependent: where the pH exceeds 8.0, disinfection is less effective (WHO 1997).

2.3.2.2. Chlorine residual

Drinking-water should be disinfected in emergency situations, and an adequate disinfectant residual (e.g., chlorine) should be maintained in the system. Turbid water should be clarified wherever possible to enable disinfection to be effective. Minimum target concentrations for chlorine at point of delivery are 0.2 mg/liter in normal circumstances and 0.5 mg/liter in high-risk circumstances.

2.3.2.3. Turbidity

Turbidity in water is caused by the presence of fine suspended matter such as clay, silt, colloidal particles, plankton, and other microscopic organisms.

High turbidity may also protect microorganisms from the action of disinfectants and decrease acceptability of water to consumers (R.Boyd, 2006).

2.4. Factoring associated with drinking water quality

In Ethiopia over 60% of the communicable diseases are due to poor environmental health conditions arising from unsafe and inadequate water supply and poor hygienic and sanitation practices (Admassu, et al., 2004).

Access to safe water alone does not reduce diarrheal diseases significantly. Even if the source is safe water become fecally contaminated during collection, transportation, storage and drawing in the home. The study done in northeast Thailand suggested that there was a far greater risk of ingesting fecal coliform bacteria, which have arisen from the cross contaminations occurring within the household than from the fecal pollution of drinking water sources (Amenu, et al., 2014).

Study conducted in South Welo, Tehuledere woreda (North East Ethiopia), Out of 87.5% fecally contaminated household water samples from drinking cups, 30.0% were from safe source (Tiku, et al., 2003).

There is a need to examine three interrelated factors that contribute to the sources of microbiological risk among households with access to improved water sources: water storage, risks specific to piped water supplies and household water management practices. Even when water sources are improved, water-quality risks may still exist at the point of consumption, and this has implications in the use of international targets for safe drinking water access (WHO, 1997).

Handling practice of drinking water at household is also one of the problems of the area, even though water is safe at source it can be contaminated during collection, storage and consumption at household (Berhanu, et al., 2015).

WHO/UNICEF report estimates that 5.2 billion people who use an “improved” water source nevertheless drink water which is unsafe, following contamination at source, in the piped distribution system or as a result of unhygienic handling during transport or in the home. Consumption of unsafe water continues to be one of the major causes of diarrheal disease deaths (Nath, et al., 2006).

Household Water Treatment and Safe Storage (HWTS) systems were developed to provide a first or extra barrier of protection to ensure safe drinking water quality. Such as, Wash of collection container before water collection, Use of covered and narrow opening material for storage, using pour rather than dipping to transfer water, Hand washing before collecting water, Treatment of water before drinking at HH level are the most (Clasen, 2015).

Study from Arba Minch report shows 88.7% used jerry can for storage. From this 60% clean their storage vessels and 72.6% stored their drinking water in closed container and 27.4% stored their drinking water in open container (Gezmu, et al., 2015).

Handling practice on Sidama Zone, Bona District among rural community study shows 64.4% of the community wash their hand and 77.5% wash their container before collection water.26.5% were treat their drinking water and 72.7% of container had cover. 97.4% of community transfers the water by pouring method (Berhanu, et al., 2015).

Study conducted in South Welo, Tehuledere woreda (North East Ethiopia) handling practice shows 54.7% of the households were found to collect water in clay pots and 44.7% in Jerrycan. 92.7% do have cover for their storage containers. Most of them (72%) Drawing water from storage containers used by dipping. 73.4% rinsed their collection containers and 64.1% wash their hands before water collection (Tiku, et al., 2003).

2.5. Conceptual framework

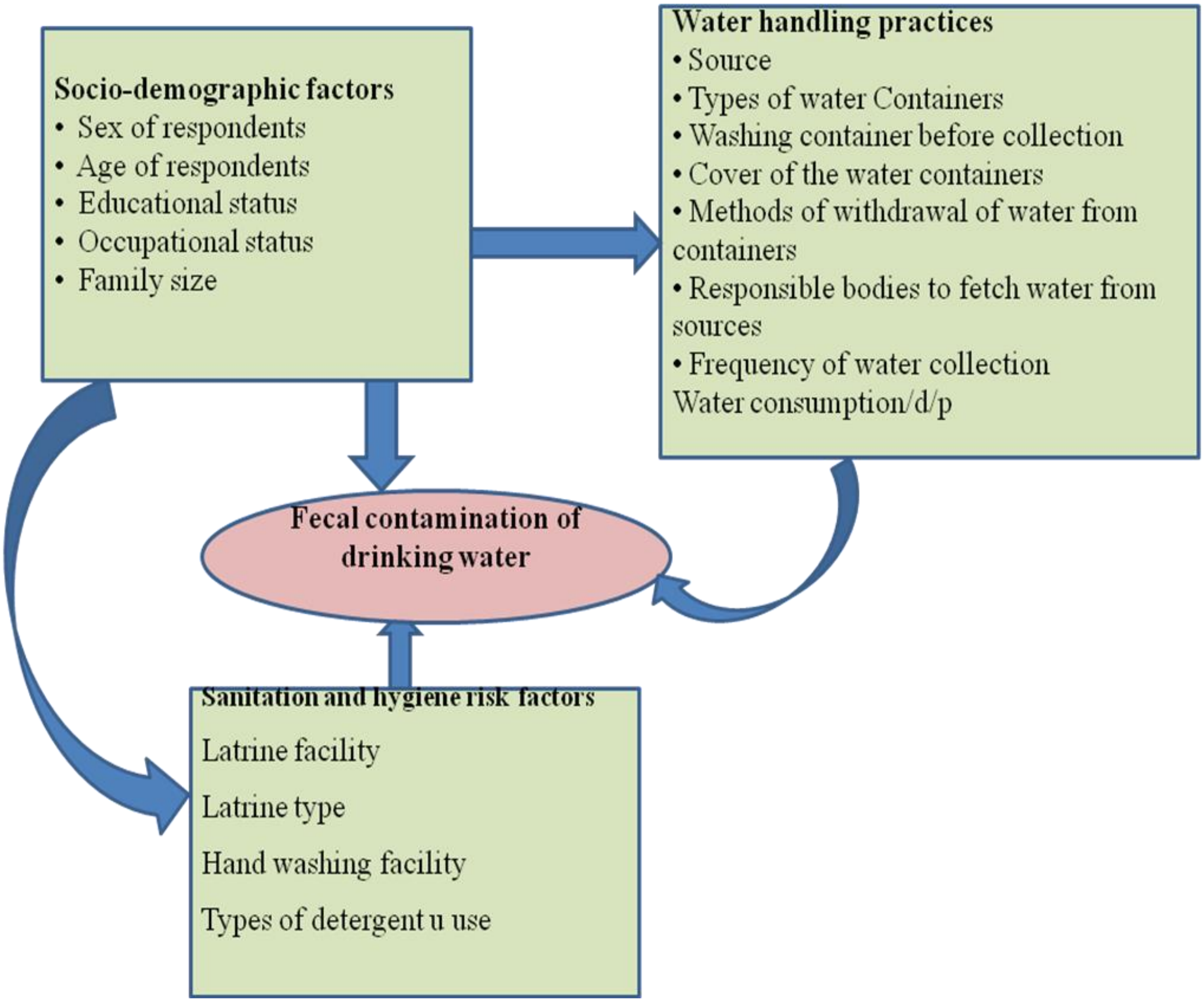

Figure 1: Conceptual framework demonstrate associated factors of bacteriological water quality of drinking water at point of use in Jimma town, 2015.

CHAPTER THREE: OBJECTIVE

3.1. General objective

Determine microbial contamination of drinking water at point of use in Jimma town, south west Ethiopia.

3.2. Specific objective

- To assess drinking water handling practice at household level in Jimma town
- To examine load of fecal contamination of drinking water at point of use in Jimma town.
- Identify type and magnitude of household water treatment methods used at household level in Jimma town.
- To identify factors associated with fecal contamination of drinking water at point of use in Jimma town.

CHAPTER FOUR: METHODS AND MATERIALS

4.1. Study area

Jimma town is located in Oromia National Regional State, in Jimma zone, it's found at a distance 354 Kms Southwest of Addis Ababa. The geographical coordinates are approximately 7^{o}39'N latitude and 36^{o} 50'E longitude. The town has an altitude of 1740m above sea level, temperature range of 20-30 ^{o}C and average annual rainfall of 1477ml.Based on the censuses conducted in 2007 the town has a total population of 120,960 and 32,191 household and the town has 17 kebeles from this 5 are rural kebeles. This study was conducted in four kebeles namely Ginjo Guduru, Awetu Mendera, Hermata Merkato and Mendera Kochi kebeles which ware use the municipality of water supply.

Location of Jimma Town

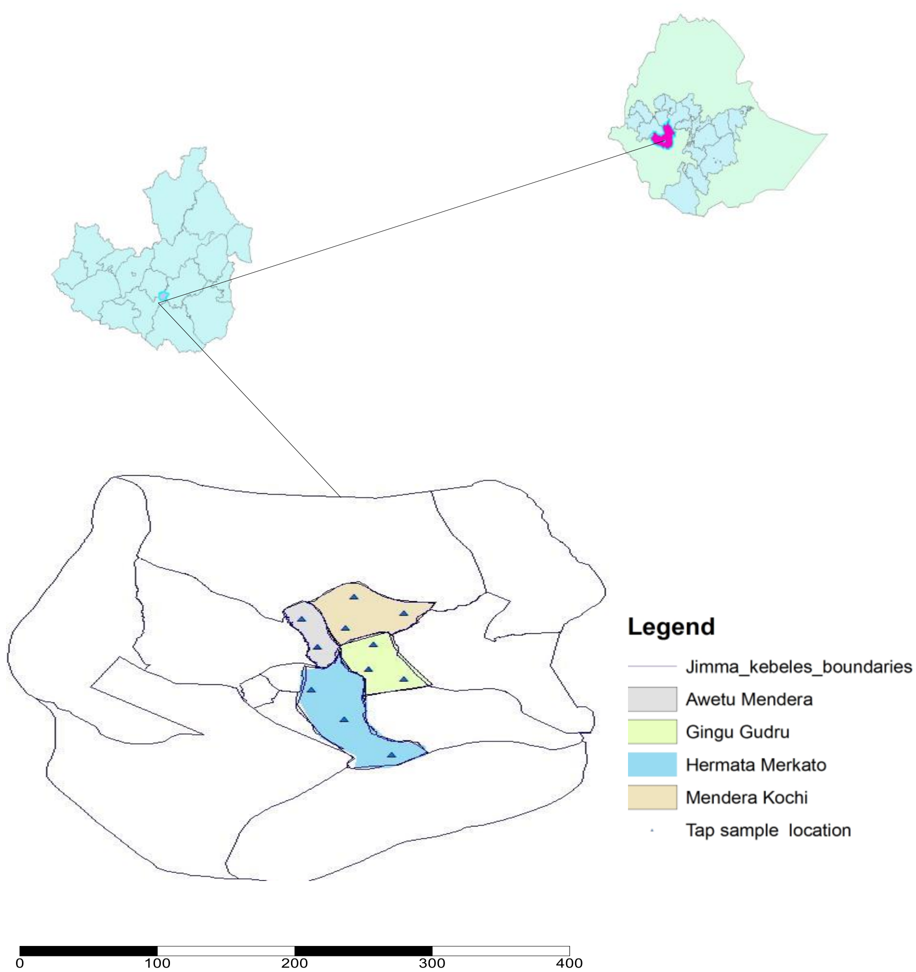

Figure 2: Map of the Jimma town

4.2. Study period

This study was conducted from August - September 2015 in Jimma town, southwest Ethiopia.

4.3. Study design

A Cross-sectional study design was used to determine the load of fecal contamination of drinking water at point of use in Jimma town.

4.4. Population

4.4.1. Source population:

13 kebeles of Jimma town connected with the water distribution system were considered for the source population.

4.4.2. Study population:

Households in the selected four kebeles were study units. Fecal coliform test of serving cups was made in the selected HHs and fecal coliform and related parameters of tap water sources were conducted at different lines in the selected HHs.

4.5. Inclusion and exclusion criteria

Inclusion criteria – for bacteriological and physicochemical analysis HHs which used tap water sources were inclusion criteria and assessing the handling practice of drinking water at households; head of the house or adult person and who have lived for more than six months in the study area were interviewed.

Exclusion criteria- Respondents who were using other water source than tap sources have lived for less than six months and children's in study area were excluded from the study as responses from these respondents might not reflect the situation in study area.

4.6. Sample size determination and sampling technique

4.6.1. Sample size determination

The sample size was calculated using a single population proportion formula.

$$n = \frac{Z^2 * p * (1 - p)}{d^2}$$

Where

n = total number of sample size

Z = reliability coefficient at (95 %CI)

p = Population proportion for fecal contaminations is **81 %** taken from a study conducted in Arba Minch town

d = margin of error (5%)

$$n = \frac{Z^2 * p * (1-p)}{d^2} = \frac{1.96^2 * 0.81(1-0.81)}{0.05^2} = \frac{0.59}{0.0025} = \underline{\mathbf{236}}$$

Considering 10% of non response rate, Total sample size will be

236*10%= 23.6+236=259.6=**260**

4.6.2. Sampling technique

We used multi stage sampling techniques. Households was selected by systematic sampling technique after randomly selected four kebeles from 13 town kebeles and proportionally allocated 260 samples according to number of HHs in the kebele. First the sample interval (k) was calculated as follows:-

K_1=N/n=1707/77=22.1≈22.

K4=N/n=1161/52=22.3≈22

K3=N/n= 1332/60=22.2≈22

K5=N/n=1560/71=21.97≈22

Where

K= sample interval

N= sample size

N=total source HHs

Every HH at 22^{th} interval were taken till the sample size become 260. The first HH was selected by randomly from the first twenty two HHs.

A total of 121 water samples were collected for laboratory analysis. 110 water samples from the drinking cups were selected by simple random sampling from the interview HHs in the selected Kebele. 11 tap water samples were taken randomly at different distribution lines in the selected kebele.

The following diagram shows the details of sampling procedure

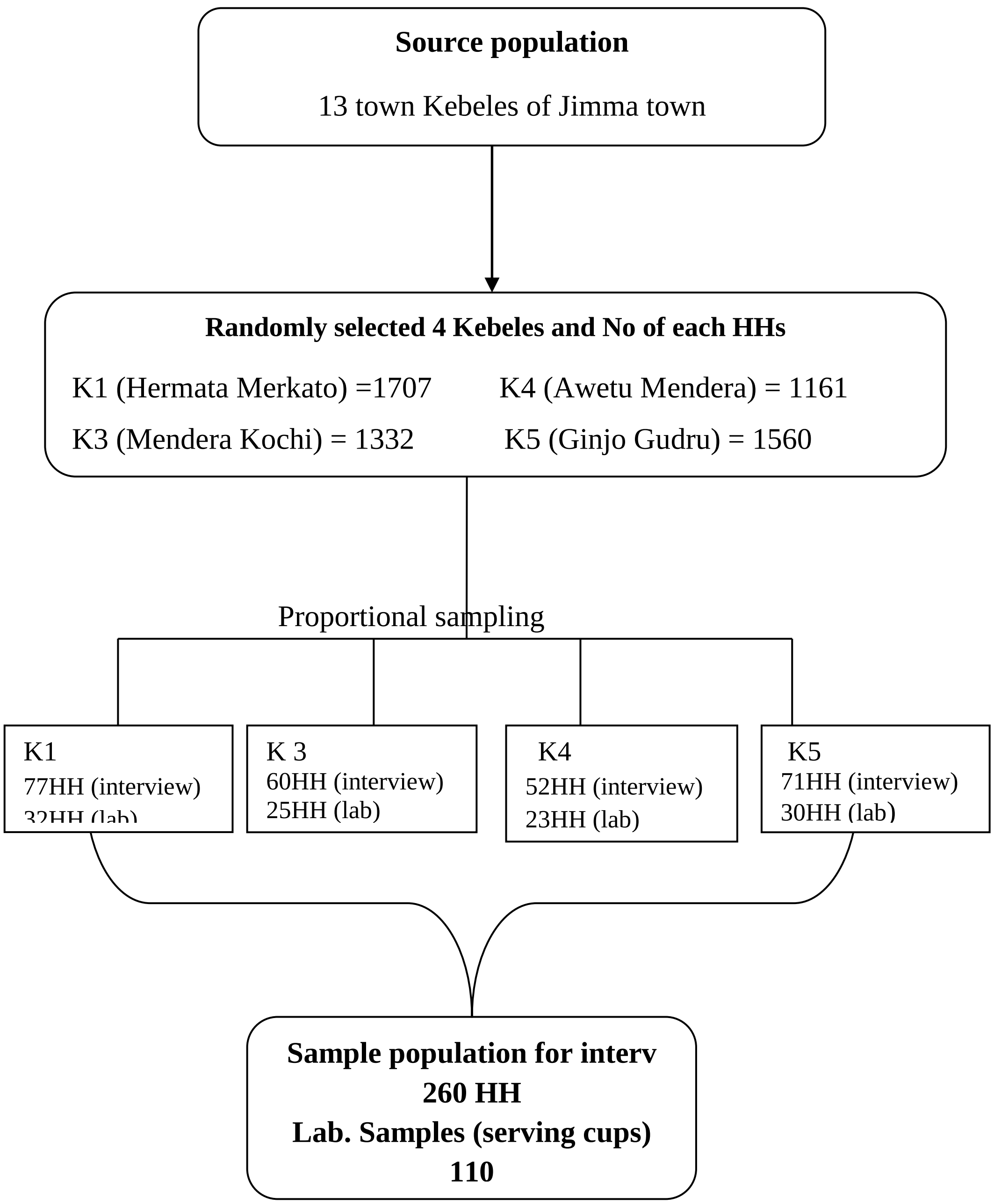

Figure 3: Schematic representation of sampling technique

Data collection method and tools

Structured questionnaire were developed in English language to assess factors associated with fecal contamination of drinking water which included socio-demographic, housing conditions, water collection and handling practices, sanitation and hygiene related questions.

Standardized laboratory equipment and reagents were used to determine the level of fecal contamination by using MPN technique and characterize the quality of drinking water based on WHO standard.

Four trained environmental health professionals BSc degree students were involved in the data collection processes (Interviewers &water sample collectors) and two more professionals from the same department were used as supervisor. The household head were selected to answer the interview questions and if absence of the household head, the second important adult member of the family was interviewed.

4.7. Water sample collection techniques and analysis

4.7.1. Water sample collection

Water samples were collected by using sterile bottle with capacity of 500 ml and used sodium thio sulphate for complete neutralization of residual chlorine (1 ml of 10% $Na_2S_2O_3$), labeled and kept in icebox (<4°C) during transportation to Laboratory. The water samples were then transported to the laboratory for bacteriological analyses.

4.7.2. Data collection technique for physicochemical analysis

All physicochemical analysis were done onsite by using pH meter for measuring pH of sample water, turbidity tube for measuring turbidity of sample water and chlorine comparator for measuring residual chlorine of sample water. The procedure was followed according to (WHO, 1997) guideline.

4.7.3. Bacteriological analysis

The samples were analyzed for fecal coliforms using the membrane filter technique used the procedures of WHO 1997 guide line. Each water sample was mixed thoroughly by shaking. 100ml of the sample was placed on surface of a sterile membrane filter unit with pore size 0.45µm placed on funnel unit of the membrane filter support assembly.

The filtration was facilitated by applying a vacuum pump. Up on completion of the filtration process, remove membrane filter from the filtration unit vacuum by using a sterile forceps and immediately placed to a Petri dish containing the absorbent pad socked with MLSB (Membrane Lauryl Sulphate broth) media and labeled. Finally, the cultures were incubated at 44 ^{o}C for 18 hours. Up on completion of incubation period, typical coliform colonies (yellow color) were seen on the surface of membrane filter paper aid of a magnifying lens see on figure 4 were counted and the results expressed in numbers of "colony forming units" (CFU) per 100 ml of original sample and recorded as fecal coliform.

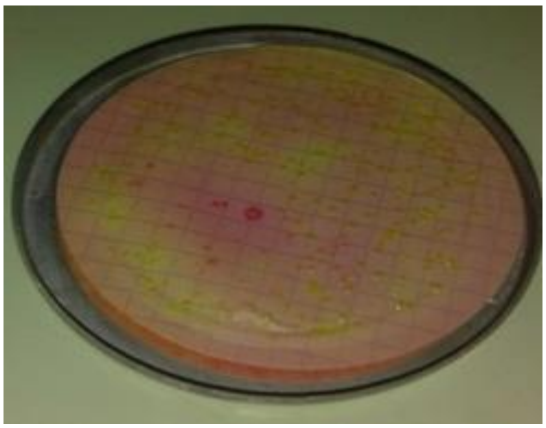

Figure 4: FC counts after incubation time in the laboratory

4.8. Data analysis and presentation

Data were checked for its completeness and edited, cleaned and analyzed using SPSS version 20.0 for windows. The data were processed by using descriptive analysis, including frequency distribution, cross tabulation and summery measures. Chi-squared test was used to see the association between important baseline variables and outcome variable then followed by binary logistic regression. Then finally multiple logistic regressions were performed for some of important variables from the binary logistic regression (P-value less than 0.25) to identify independently associated factors in the final model. Odds ratio with 95% confidence interval was used to see the level of association between independent and outcome variables. P-value of less than 0.05 was considered as statistical significance.

4.9. Study Variables

a) Dependent variable

- Fecal coliform count

b) Independent variables

- **Socio-economic/demographic factors**: age, sex, religion, education, occupation, marital status, place of residence, family income, family size and ethnicity.
- **Water handling practice**: Types of water Containers, Washing container before collection , Cover of the water containers, Methods of withdrawal of water from containers, Responsible bodies to fetch water from sources, Frequency of water collection, Water consumption/l/d/p
- **Sanitation and hygiene: -** Latrine facility, Latrine type, Hand washing facility, Type of detergent you use.

4.10. Operational definition

Tap water: water with a pipe connection system to the protection and disinfection site

Water at consumption: a cup or a glass of drinking water that taken in to the mouth

4.11. Quality Control

Effective training was provided for data collectors and supervisor on the techniques of data collection process and water sample collection procedure by the principal investigator.

The supervisors were closely followed the day to day data collection process and ensure completeness and consistency of questionnaire administered each day. The collected data was registered in to personal computer and analyzed using SPSS for windows version 20.0.

For the data quality regarding to bacteriological water quality the standard reagent was used, during the bacteriological test the quality were assured by close follow up and supervision of the laboratory technician by the principal investigator.

The Petri dish contained the filtering samples were coded as the same to sample bottle to avoid error and number of yellow colonies was counted repeatedly with other member and laboratory technician by using magnifying lens.

Control test was applied analyzed simultaneously with each test to check interference and the limit of detection of the study. The analysis result must be negative result, if not the result would not be acceptable.

4.12. Ethical clearance

Formal letter of permission to conduct study was obtained from Ethical committee of JU to communicate with local administrative body (town municipal and the kebeles). Permission letters were obtained from administrative body of the kebele to communicate with relevant bodies in the kebele.

The objectives of the study were clearly explained to the member of household and verbal permission was obtained from the respondent's before data collection. Each household owner was informed that the information obtained from them to be kept confidential and not to be used for other purpose.

CHAPTR FIVE: RESULTS

5.1. Socio-demographic characteristics of the respondents

Of the 260 household respondents, females constitute 169 (65%), with the mean and median age of 47.46 and 45.00 respectively, with standard deviation of 11.5. Average family size in the study area was 4.15 with standard deviation of 1.58. The dominant ethnic group was Oromo (which constitutes about 43.1% followed by Amhara (20%). Most of the respondents (58.5%) were Orthodox by religion followed by Islam (31.5%). Table 3 summarizes the socio-demographic characteristics of the respondents.

Table 2: Socio-demographic characteristics of respondents in the selected kebele in Jimma Town

Characteristics (n=260)		**Frequency**	**Percent**
Sex of respondents	Female	169	65
	Male	91	35
Ethnicity	Oromo	112	43.1
	Other(kefa, Dawuro,..)	57	22
	Amhara	52	20
	Gurage	39	15
Age of respondents	<30	21	8
	30-39.99	67	25.8
	40-50	108	41.5
	>50	64	24.6
Family size	1-5	209	80.4
	6-9	51	19.6
Religion	Orthodox	152	58.5
	Muslim	82	58.5 31.5
	Protestant	24	9.2
Education	Illiterate	36	13.8
	Read and write	62	23.8
	1-4 grade	8	3.1
	5-8 grade	33	12.7
	9-10 grade	34	13.1
	11-12 grade	26	10
	Collage and above	61	23.5

5.2. Housing condition of the observed HHs

Among the studied houses, 257(98.8%) have corrugated iron sheet roof and the others 3(1.2%) are covered their roof with other materials. About 67.8% of respondents were living in their private house while the rest in rental houses. 212(81.5%) of HHs has a separate kitchen while the rest 49(18.5%) had inside their home. From the total households 67 (25.8%) had domestic animals, among which 46(68.7%) households inhabit the animals inside their house. (Table 4 shows housing condition data in different villages).

Table 3: Housing characteristics of the study households in Jimma town

Housing Conditions (n=260)		Freq	Percent
Nature of house	Own	176	67.7
	Rent	84	32.3
Floor Material	Earthen	99	38.1
	Wooden	4	1.5
	Cemented	157	60.3
Kitchen	Inside	48	18.5
	Separate	212	81.5
Domestic animal	Yes	67	25.8
	No	193	74.2
Separate room	Yes	46	68.7
	No	21	31.3

5.3 Water handling and water treatment practice in the selected HHs

According to our study, the selected households had accessible to improved drinking water source. Approximately, 90.76 %(236) of households had piped water to house or yard and 6.5% (17) used from public tap. The rest 6.5% of the households got their water from protected spring and well (Table 5).

120(46.2%) of the households collected their water by adult woman followed by girl child (17.3%). When we see the frequency of water collection, 92(35.4%) collect 3-5 times per week, while only 24.2% households are collect at any time (Table 4).

Majority the household 214 (82.3%) used Jerri-can to store drinking water, others used bucket or barrel. From this 216(83.1%) of the water containers had cover. And 67.7% were washed before collect water.

226(86.9%) of the HHs fetch the drinking water from storage container by pouring, while 13.1% households were used dipping. From all respondents only 21 households were treated water before they used for drinking, among this 38.1% were used wuha agar and the other percent used boil and water filter (Table 4).

The water consumption litter per day per person in this study was only 13.8% (36/260) of households were compliance with WHO standard (20 and grater litter). Majority of HHs were used less than the WHO standard (Table 4).

Table 4: Water handling practice of drinking water selected HH of Jimma town**.**

Water handling at point of use		**Freq**	**Percent**
Source of drinking water (n=260)	Piped water to house/yard	236	90.76
	Public tap/stand pipe	17	6.5
	Protected spring	6	2.3
	Protected well	1	0.4
Who collect water (n=260)	Adult Women	120	46.2
	Adult Man	11	4.2
	Girl child	45	17.3
	Boy child	12	4.6
	Outside person	22	8.5
	Multiple People	50	19.2
Frequency of water collection/week (n=260)	More than 7 times	63	24.2
	6-7 times	80	30.8
	3-5 times	92	35.4
	1-2 times	25	9.6
Material use to store	Jerrycan	214	82.3
	Clay pot	10	3.8

(n=260)	Bucket(plastic or metal)	11	4.2
	Barrel(plastic or metal)	2	0.8
	Multiple container	23	8.8
Washing container before collection (n=260)	Yes	176	67.7
	No	84	32.3
The containers have a cover? (n=260)	Yes	216	83.1
	No	44	16.9
Method of water fetching	Dipping	34	13.1
	Pouring	226	86.9
Do you treat your drinking water to make safe	Yes	21	8.1
	No	239	91.9
What method do you use(n=21)	Boil	5	23.8
	Wuha Agar	8	38.1
	Use water filter (ceramic, sand etc...)	8	38.1
Water consumption l/c/d	<9.99	105	40.4
	10-19.99	119	45.8
	>20	36	13.8

91.9% of respondents were not use water treatment at home since they were supplied with piped water and they may assume that the water obtained from tap is free from microbial contamination. Water treatment activity was performed only in 21 (8.1 %) households ; 5(23.8%) by boiling, 8(38.1 %) wuha agar, 8 (38.1 %) water filler, The result showed that home water treatment was not common in the community.

5.4 Household sanitation and hygiene characteristics of the respondent

Two hundred sixty households 255(98.1%) had their own latrine facility in/around the compound, 243 (95.3%) are pit latrine type, the other 3.5% are flush toilet and 1.2% have VIP latrine type. The remaining 1.9% doesn’t have a latrine in the compound. However, only 102(39.7%) of latrine had hand wash facility, the other 155(60.3%) had no hand wash facility but they mostly washed their hands before preparing food, and serving meal 252(98.1%) and used soap detergent.

5.5. Bacteriological and physicochemical result from tap water sample

5.5.1. Fecal coliform count result of tap water

When analyzing water sample at point of tap the mean and standard deviation of CFU/100ml were 7 and ± 11.6 respectively. The result showed 45.5% (5/11) water sample complied with WHO and ES standard for drinking and the rest 36.4% (4/11) taps water samples were contaminated at low risk level and 18.2% (2/11) were at intermediate risk.

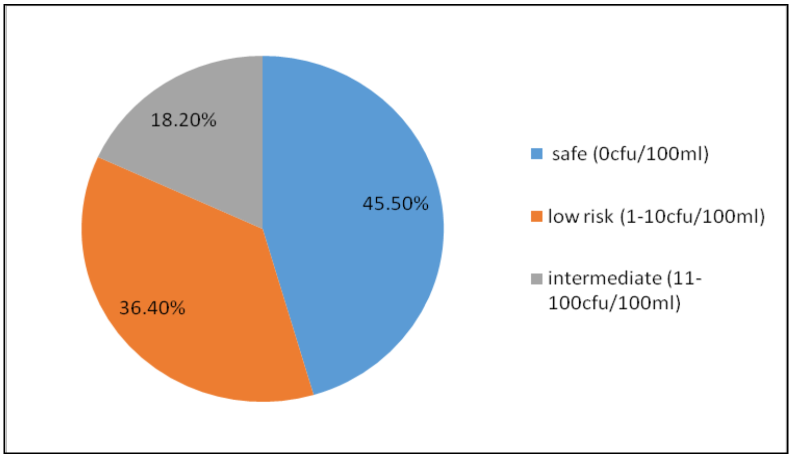

Figure 5: WHO level of fecal contamination at point of tap

5.5.2. pH of water sample

pH was measured on site from the selected tap water sample. From that 95.5% of the sample PH values range from 6.5-8. These can compliance with WHO standard of drinking water. In few point of taps water samples show below and above the standard. 3(2.7%) shows <6.5 and 2(1.8%), >8.

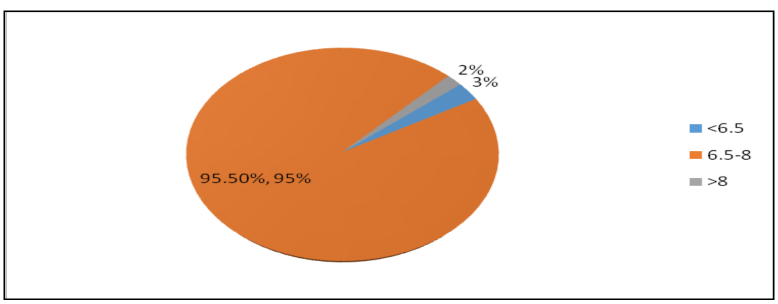

Figure 6: pH results at point of tap

5.5.3. Free Chlorine Residual of tap water

All the water sample was taken at point of tap were below the WHO standard which minimum 0.2 mg/lit and maximum 0.5mg/lit free residual chlorine for drinking water. Result shows <0.1 mg/lit of free residual chlorine.

5.5.4. **Turbidity of tap water**

The mean values of turbidity of tap water were 12 NTU with a standard deviation of 14NTU. The

Result shows 45.5% (5/11) of tap water were <5 NTU which compliance with WHO standard. The rest 55% (6/11) gives above the standard which7NTU-50NTU.

5.6. Fecal coliform count result of drinking water at consumption

When analyzing drinking water sample at consumption the mean and standard deviation of CFU/100ml were 21.9 and $\pm$ 55.5 respectively. The result shows level of fecal coliform contamination in drinking water at HH indicates that 72(65.4%) HHs was positive for fecal coliforms that had a coliform count of one or more. The rest 38(34.5%) were found to be in grade A water quality (zero *CFU* per 100ml) and compliance with WHO permissible limit for drinking water.

This 72 positive samples classified in different levels, 32 (29.1%) drinking water from cups had grade B water quality level (1- 10 cfu per 100ml) and could safely be used for drinking and cooking purpose. The rest 36(32.7%) had grade C and 4(3.6%) had grade D water quality these were unsafe for drinking. Table 5

Table 5: MPN count of fecal coliform from drinking water sample taken from consumption cup in the selected HHs of Jimma town.

WHO Guide Line	CFU count	Percent	Grade	Quality Remark
0	38	34.5	A	Compliance with WHO guide line (safe)
1-10	32	29.1	B	Low risk to human health
11-100	36	32.7	C	Intermediate risk to human health
101-1000	4	3.6	D	High risk to human health

5.7. Health risk level of fecal contamination at tap and at consumption water

45% of Samples taken from tap water were safe for health; its result was greater than sample at consumption of drinking water. (34.5%). Figure 7 shows, when the risk level increases the percentage of sample at consumption result become greater than samples at the tap.

Table 6: Health risk level of fecal contamination at tap and consumption water in the selected HHs of Jimma town.

WHO Guide Line	Tap water sample	water sample from serving cups	Grade	Quality Remark
	Percent	Percent		
0	45.5	34.5	A	Compliance with WHO guide line (safe)
1-10	36.4	29.1	B	Low risk to human health
11-100	18.2	32.7	C	Intermediate risk to human health
101-1000	0	3.6	D	High risk to human health

According to WHO, 1997

5.8. Binary logistic regression factors association with FC contamination

Of the 110 laboratory result 39(35.5%) of samples were non contaminated (0CFU/100ml) and 71(64.5%) were contaminated at different risk level. According to marital status married families were 1.5 times more contaminated than unmarried families. And related to this also family size which have greater (>5) family member were more contaminated than less family size. Regarding to education illiterate respondents households were 1.7 times more contaminated than literate (read and write – collage and above) household respondents. However, according to binary logistic regression analysis socio-demographic variables were not significant association with fecal coliform contamination of drinking water at point of use in the HH (Table 8).

According to average water consumption families who used below the standard were more contaminated than who used >20 L/c/p [COR: 4.875, 95%CI: (1.681, 14.14)]. Regarding to storage material HHs who used Jerri can (narrow necked) container for drinking water storage were less fecal contamination than who used bucket (wide necked) container [COR: 3.515, 95%CI: (1.103, 11.20)].Storage container which had a cover was less contaminated than open container. And washing their container before collection water was less contaminated. Households who had hand washing facility after toilet were less contaminated than which had no at p= 0.014, [COR: 2.8, 95%CI: (1.236, 6.342)]

Table 7: Binary logistic regression analysis of variables

Characteristics		Fecal Coliform			
		Non contaminated	**Contaminated**	**P value**	**COR 95%**
Variables		**No (%)**	**No. (%)**		
Sex	Male	15(35.7)	27(64.3)	0.791	1.114(0.501,2.476)
	female	26(38.2)	42(61.8)	1	1
Age	<35	6(40%)	9(60%)	0.668	1.350(0.343,5.315
	35- 44	9(47.4%)	10(11.9%)	1	1
	>45	26(34.2%)	50(65.8%)	0.21*	1.731(0.626,4.788)
Marital status	Married	31(35.2%)	57(64.8%)	0.377	1.532(0.595,3.948)
	Un married	10(45.5%)	12(54.5%)	1	1

Characteristics		Fecal Coliform		P value	COR 95%
		Non contaminated	Contaminated		
Variables		No (%)	No. (%)		
Family size	<5	35(38%)	58(62%)	1	1
	>5	6(33.3%)	12(66.7)	0.706	1.228(0.423,3.568)
Education	illiterate	4(26.7%)	11(73.3%)	0.365	1.754(0.520,5.921)
	literate	37(38.9%)	58(61.1%)	1	1
Frequency collection	>7	15(42.9%)	20(57.1%)	1	1
	<7	26(34.7%)	49(65.3%)	0.409	1.413(0.622,3.213)
Storage material	Jerri can	37(42.5%)	50(57.5%)	1	1
	Bucket(wide necked container)	4(17.4%)	19(82.6%)	0.034*	3.515(1.103,11.20)
Container cover	Yes	33(36.3%)	58(63.7)	1	1
	No	5(26.3)	14(73.7)	0.207*	0.527(0.105,0.621)
Washing container before water collection	Yes	25(39.7%)	38(60.3%)	1	1
	No	16(34.0%)	31(66.0%)	0.545	1.275(0.580,2.799)
How do u fetch	Dipping	4(18.2%)	18(81.8%)	0.046*	3.265(1.028,10.447)
	pouring	37(42.0%)	51(58.0%)	1	1
Water consumption	1-19.99	28(30.8)	63(69.2)	0.004*	4.875(1.681,14.14)
	>20	13(68.4)	6(31.6)	1	1
Latrine facility	Yes	40(37.4%)	67(62.6%)	1	1
	No	1(33.3)	2(66.7%)	0.886	0.838(0.074,9.534)
Type of latrine	Pit	38(36.9%)	65(63.1%)	0.599	0.585(0.079,4.322)
	flash	2(50%)	2(50%)	1	1
Hand wash facility	Yes	21(53.8%)	18(46.2)	1	1
	No	20(29.4%)	48(70.6%)	0.014*	2.800(1.236,6.342)

NB: *- * P value ≤ 0.25 is consider as significant to be candidate for the multiple logistic regression.*

5.9. Multiple logistic regreesion of the factor affecting water quality

Water storage container of the respondents was significantly associated with bacteriological quality of drinking water, HHs who were used Bucket (wide necked) container for water storage were 3.5 times more likely contaminate their drinking water with fecal coliforms than those who were used Jerri can [AOR:3.5,95% CI=1.103,11.20]. This was also significant after adjustment.

Method of water withdrawal were Statistical significant with fecal coliform contamination of drinking water in the house, and the risk was almost 3 times higher [AOR: 3.265, 95%CI: (1.028, 10.447)] who were using dipping than pouring. This was also significant after adjustment.Water consumption of a household was significantly associated with fecal coliform of drinking water contamination. The respondent who used <19.99lt per person per day were 5times contaminated than who were used 20 and above litter [AOR: 4.875, 95%CI (1.681, 14.14]. This was also significant after adjustment.

Presence of hand washing facility near the latrine was significantly associated with fecal coliform contamination of drinking water in the house. HHs who don't have a hand wash facility near a latrine were 3 times [AOR: 2.8, 95%CI (1.236, 6.342)] more contaminated than who have. This was also significant after adjustment.

Table 8**. Significant Factors of water handling and hygiene practice with fecal coliform load and comparison between groups of variable in the selected area of Jimma town, 2015.**

Characteristics Variables		**Fecal Coliform**			
		Non contaminated	**contaminated**	**P value**	**AOR 95%CI**
Storage	Jerri can	37(42.5%)	50(57.5%)	1	1
	bucket	4(17.4%)	19(82.6%)	0.034	3.515(1.103,11.201)
Water fetching	Dipping	4(18.2%)	18(81.8%)	1	1
	pouring	37(42.0%)	51(58.0%)	0.046	0.306(0.096,0.980)
Water consumption	<19.99	28(30.8)	63(69.2)	0.004	4.875(1.681,14.14)
	>20	13(68.4)	6(32.6)	1	1
Hand wash facility	Yes	21(53.8%)	18(46.2)	1	1
	No	20(29.4%)	48(70.6%)	0.014	2.858(1.263,6.468)

NB: *- P value ≤ 0.05 is considered as significant association.*

CHAPTER SIX: DISCUSSION

The bacteriological study was based on improved water sources for their drinking (yard/public tap). However improved water sources doesn't mean safe for drinking (Myint, et al. 2015). WHO defines safe drinking water "does not represent any significant risk to health over a life time of consumption, including different sensitivities that may occur between life stages" (WHO, 2004).

According to bacteriological analysis study most of the samples shows the presence of fecal coliform contamination (one and more) for their consumption cups, this were above permissible limits of the WHO guidelines for drinking water quality (WHO, 1997) and Ethiopian standards (CES, 2013). The result shows more than half of the drinking water sample had number of fecal coliform per 100ml of drinking water in the household. 3.6 % (4/110)cfc/100ml were dangerous for health and needs urgent intervention , 32.7% (36/110) cfc/100ml have intermediate health risk and needs high intervention action and 29.1% show reasonable quality and needs low intervention action. Only 34.54% (38/110) cfc/100ml had none fecal coliforms per 100ml of water sample which were compliance with WHO guideline of drinking water quality standards that is zero coli form/100ml of water. This result is in agreement with the studies conducted in Periurban community in Myanmar, Behardar, Arbaminch and Serbo town 94%, 87.8%, 81% and 87%. And much higher contamination RADWQ study in Nigeria, 53 of 160 (33%) household samples tested had a thermo tolerant coliform count of >1 cfu/100 ml (Ince, et al., 2010).

In this study 55.5% of tap water sample were contaminated at low to intermediate risk category. This result was similar study conducted in Arbaminch town 77% (Gezmu, et al., 2015) and also in Behardar cities study result 40% of water at tap source were contaminated.

The absence of free chlorine residual in the tap result indicates the distribution system possibilities need post-treatment (WHO 1997). Regarding to the free residual chlorine none of the water sample was compliance with WHO standard. For effective chlorination, free residual chlorine value 0.2 mg/l as normal and at maximum0.5mg/l (Tadesse, et al., 2010).

The similar results have also been reported by (Ahmed, et al., 2013); they found 0 mg/l residual chlorine in all water in drinking water supply of Badin City, Pakistan and In the RADWQ survey for Nigeria only 3 of the 71 samples tested had a free chlorine value >0.1 mg/l (0.26 mg/l, 0.88 mg/l and 0.42mg/l); in most, no free chlorine was detected ((Ince, et al., 2010) also study conducted in rural community, Bona district in Sidima zone shows the free chlorine residual of study protected source had 0.1 mg/l (Berhanu and Hailu 2015). Behardar city study reported has better quality 31.4% of the tap sample had 2-0.5mg/l (Tabor, et al., 2011).

The efficiency of disinfection with chlorine is highly pH-dependent: where the pH exceeds 8.0, disinfection is less effective (WHO 1997). In our study PH value of almost all the drinking water sample were 6.5- 7.9 which were compliance with WHO and the national standards.

Turbidity measurement result of the tap water sample shows only 45.5% were <5NTU which were compliance with the WHO standard. The other 55.5% were greater than the standard. Turbidity can affects both the acceptability of water to consumers, and efficiency of treatment processes, particularly the efficiency of disinfection with chlorine since it exerts a chlorine demand and protects microorganisms and may also stimulate the growth of bacteria. These study results were much less than the country report of FDRE which 93.6% piped supplies had the highest level of compliance. In Ethiopia, color and turbidity problems with drinking-water have been common in almost all regions (Dagnew, et al. 2010).

In our study the fecal contamination of drinking water were increased at point of use in the HHs than the tap source which has significant difference variation of P= 0.032 value. High counts of thermo tolerant coliforms at the house hold drinking water indicates that the water has been fecally contaminated.

Initially acceptable microbial quality often becomes contaminated with pathogens during transport and storage. Especially during storage, contamination can occur if the water containers are not fully covered, as found in periurban study (Myint, et al. 2015). In this study 83.5% of the collection material had cover and 16.5 % had not. Similar study done in Arbaminch indicated 72.6% stored in a closed container and the rest 27.4% were not. The reduction of contamination by covering vessels implicates hands and cups being dipped in water as a probable source of contamination. This study has similar concept from systematic review of developing countries report (Wright, J et al., 2004).

Respondents who were preferred wide necked container (bucket, Barrel) increase the risk of fecal coliforms than those who were using narrow necked container (Jerrycan), as our study 82.3% of the respondents were used Jerrycan and the rest used plastic bucket and barrel containers to collect and store water and (67.7%) 176 of them were wash their container before collection their drinking water. This study result was less from study conducted in Arbaminch indicates 88.7% and Simida in South Gonder reported 95.5%. And respondents who used Bucket for water storage were 3.5 times more likely contaminate with fecal coliforms compared to those who were used Jerrycan [AOR:3.5,95% CI=1.103,11.20]. This was also significant after adjustment. However, majority of respondents who were used Jerrycan storage container had contamination, this may be it is difficult to clean inside the storage.

Transfer water used by pouring instead of dipping cups were good usage to minimize possibilities of post contamination. And the water withdrawal method of the study area show 85% used pouring system and the rest 14% used dipping methods. This can continue for good water handling practice and this can also significant association after adjustment with fecal contamination.

Drinking water treatment at home level is very important activity to prevent recontamination water. Household water treatment (HWT) interventions may play an important role in protecting public health where existing water sources, including those delivered via a piped network or other improved sources are untreated, not treated properly or become contaminated during distribution or storage (UNICEF and WHO, 2009). Drinking water treatment activity in the home was performed only in 8.1 % of households this study were much less than study conducted in Arbaminch town which 78.3% of households were treat their drinking water and 21.7% were not (Gezmu, et al., 2015). The result showed that home water treatment was not common in the community. This is because the community believed the water obtained through pipe line (tap source) was free from contamination.

The mean per capita-per day conception of water in the study area was 12.5 L/c/d which is less than the minimum water consumption recommended by WHO 2005 which are 20 L/c/d to meet basic access for domestic needs (i.e. consumption and hygiene). Hence it shows that most of the respondents do not have access to adequate water supply. This insufficient water consumption had statically significant relationship with contamination of drinking water and a respondent who use <20 L/c/d water were 5 times more contaminated than an HHs who were used more.

Majority of the respondents had their own latrine. However few of them have a hand wash facility. HHs who has a hand wash facility near the latrine was significantly associated with fecal coliform contamination of drinking water. An HHs who don't have a hand wash facility near a latrine were 3 times [AOR: 2.8, 95%CI (1.236, 6.342)] more contaminated than who have. This was also significant after adjustment. Hygiene behaviors are important for health; according to JMP 2016 surveys, hands washing with soap behavior are low, especially in sub-Saharan Africa, where coverage is at most 50% in the 38 countries (WHO&UNICEF 2016).

CHAPTER SEVEN: CONCLUSION AND RECOMMENDATION

7.1. Conclusion

Microbial contamination of drinking water at point of serving cups and at point of use were grossly contaminated with fecal bacteria and not compliance with WHO permissible limit for drinking water that had counts one and more.

Contamination level of drinking water in the household is increasing than the tap source. The significance difference was became the involvement of material storage they use, the way of water fetching, insufficient water consumption in the HH and hand washing facility after toilet practices were the main factor.

Drinking water treatment at household is not practiced in the community; only few of the respondents were practiced, since the communities consider tap water is free from contamination.

7.2. Recommendation

Based on the finding, the following recommendations are forwarded.

- Jimma town Water and Sewerage Authority should make assessment on bacteriological and related parameter (residual chlorine, pH and turbidity) Perdically and take an intervention action at tap source.
- Sufficient chlorination could be practiced in the water supply system to prevent microbial growth by providing free residual chlorine for long time.
- Health extension workers should give regular water handling practice, improved sanitation and hygiene condition to improvement water quality at household level.
- The concerned body promoted household water treatment after collection will improve the quality of drinking water.
- This study was bacteriological water-quality of drinking water from tap and its point of use at household level, further study including bacteriological with related parameter analysis from treatment plant to distribution line is recommended.

REFERANCES

Abera, Solomon, Abera Zeyinudin, Biruktawit Kebede, Amare Deribew, Solomon Ali, and Endalew Zemene. “Bacteriological analysis of drinking water sources. Vol. 5. African Journal of Microbiology Research, 2011.

Admassu, Mengesha, Mamo Wubshet, and Gelaw Gelaw. A survey of bacteriological quality of drinking water in North Gonder. Gonder: Ethiop.J.Health De, 2004.

Ahmed, Aziz, Tarique Mahmood Noonari, Habibullah Magsi, and Amanullah Mahar. "Risk Assessment of Total and Faecal Coliform Bacteria From Drinking Water Supply of Badin City, Pakistan." Journal of Environmental Professionals Sri Lanka 2 (2013): 52-64.

Amenu, Desalegn, Sissay Menkir, and Tesfaye Goben. microbiological quality of drinkingwater sources and water handlingpractices among rural communities of dire dawa administrative council. Vol. 3. 1 vols. Dire Dawa: Int. J. LifeSc. Bt & Pharm. Res, 2014.

Ashbolt, Nicholas John. Microbial contamination of drinking water and disease outcomes in developing regions. Australia, 2004.

Bain, Robert, Ryan Cronk, Jim Wright, Hong Yang, Tom Slaymaker, and Jamie Bartram. Fecal Contamination of Drinking-Water in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. Vol. 11. PLOS Medicine, 2014.

Berhanu, Abebe, and Dejene Hailu. "Bacteriological and Physicochemical Quality of Drinking Water Sources and Household Water Handling Practice Among Rural Communities of Bona District, Sidama Zone-Zouthern, Ethiopia." *Science Journal of Public Health* (online), no. ISSN: 2328-7950 (October 2015): 782-789.

CES. Drinking water and Specifications. Ethiopian Standards Agency, 2013.

Clasen, Thomas. "Household Water Treatment and Safe Storage to Prevent Diarrheal Disease in Developing Countries." Curr Envir Health Rpt (Springer International Publishing AG), January 2015: 69–74.

FDRE Ministory of Water Resource. Ethiopian Guidelines, Specification for Drinking Water Quality. . Ethiopia, 2002.

Gezmu, Tigist, et al. Faecal Contamination of Drinking Water in Arba Minch Town,Gamo Gofa Zone, South Ethiopia. Vol. 35. Arba Minch: www.iiste.org, 2015.

Ince, M, et al. Rapid assessment of drinking-water quality in the Federal Republic of Nigeria. country report of the pilot project implementation in 2004-2005, World Health Organization and UNICEF 2010, Nigeria: WHO press, 2010.

Kifle, Sofonias, and Tsegaye Gadisa. "Microbial quality of Jimma water supply." 2 (2006).

Mohsin, Muhammad, Samira Safdar, Faryal Asghar, and Farrukh Jamal. "Assessment of Drinking Water Quality and its Impact on Residents Health in Bahawalpur City." *International Journal of Humanities and Social Science* 3 , no. 15 (August 2013).

Myint, Su Latt Tun, Thuzar Myint, Wah Wah Aung, and Khin Thet Wai. Prevalence of household drinkingwater contamination and of acute diarrhoeal illness in a periurban community in Myanmar. Myanmar: East Asia Journal of Public Health, 2015.

Nath, KJ, Sally Bloomfield, and Martin Jones. Household water storage, handling and point-of-use treatment. IFH, 2006.

Peletz, Rachel, Emily Kumpel, Mateyo Bonham, Zarah Rahman, and Ranjiv Khush. "To What Extent is Drinking Water Tested inSub-Saharan Africa? A Comparative Analysisof Regulated Water Quality Monitoring." Int. J. Environ. Res. Public Health, 2016.

R.Boy, David. The Water We Drink:An International Comparison Of Drinking Water Standards and Guidlines. David Suzki Foundation, Canadian Cataloguing, November 2006.

Roohul-Amin, Syed Shahid Ali, Zubair Anwar, and Jabar Zaman Khan Khattak. "Microbial Analysis of Drinking Water and Water Distribution System in New Urban Peshawar." Curr. Res. J. Biol. Sci, 2012: 731-737.

Tabor, Milkiyas, Mulugeta Kibret, and Bayeh Abera. "bacteriological and physicochemical quality of drinking water and hygiene sanitation practices of the consumers in bahir dar city, ethiopia." *Ethiop J Health Sci.* 21 (March 2011).

Tadesse, Dagnew, Assefa Desta, Woldemariam Girma, Solomon Fisseha, and Oliver Schmoll. "Rapid assessment of drinkingwaterquality in the federal democratic republic of ethiopia." country report of the pilot project implementation in 2004-2005, Ethiopia, 2010.

Tiku, Seid, Worku Legesse, Hailu Endal, and Kebede Faris. "Factors Affecting Drinking Water Quality From Source To Home In Tehuledere Woreda, Northeast Ethiopia." *Ethiop J Health Sci* 13, no. 2 (July 2003): 95-106.

UNICEF&WHO. 25 years Progress on Drinking Water and Sanitation – 2015 update and MDG assessment. 20 Avenue Appia, 1211 Geneva 27, Switzerland: WHO press, 2015.

USAID. "Ethiopia Water and Sanitation Profile." 2010.

WHO. Guidelines for drinking water quality, surveillance and control of community water supplies. 2nd Edition. Vol. III. Geneve, 1997.

WHO. Diarrhoea: why children are still dying and what can be done. Geneva, World Health Organization: New York, United Nations Children’s Fund, 2009.

WHO&UNICEF. Global water supply and sanitation assessment 2000 report. United States of America: World Health Organization and United Nations Children's Fund, 2000.

WHO. Guidelines For Drinking-Water Quality: Second Addendum To Third Edition. 3rd. Vol. I. Geneva, 2008.

WHO. International standards for drinking-water. Geneva : s.n., 1958.

Wright, Jim, Stephen Gundry, and Ronan Conroy. Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. Vol. 9. Tropical Medicine and International Health, 2004.

ANNEXES

Annex 1

Questionnaire

Dear Sir/madam;

My name is -------------- and I ‘m from Jimma University. We are conducting an assessment on fecal contamination of drinking Water due to utilization at household level among Jimma Town. You are kindly requested to be included in the assessment which has great importance in improving community health. The interview will take a maximum of 10-15 minutes. No information concerning you as an individual will be passed to anther individual or institution. Your participation will be based on your willingness and you have the right not to participate fully or partially. Are you willing to participate in the study?

Yes_____ No______

If yes, we will continue the interview

If no, thank you!

Thank you for your cooperation!

Name of the interviewer ------------------------ Date -----------

Name of the supervisor ------------------------- Date ------------- Signature ------------

Town_________

1.2 Kebele__________

1.3 Zone _____________

1.4. House number _____

1.5. Nature of the House Own______ Rent__________ Other (Specify) _____

1.6. Respondent's gender _____________ Age in years ___________

2. Socio-Demographic Characteristics

Relationship	Religion	Education	Marital status	Occupation
1. Head	1. Muslim	1.Illiterate	1. Married	1.Gov't employed
2. Spouse	2. Orthodox	2. Read and write only	2. Single	2. Merchant
3. Son/daughter	3. Catholic	3.1-4 grade	3. Divorced	3. Farmer
4. Other relatives	4. Protestant	4.5-8grade	4. Widowed	4. House wife
5. Non- relatives	5. Other	5. 9-10 grade		5. Daily laborer
		6. 11-12 grade		6. Student
		7. College and above		7. Others (specify) ___

Ethnicity
1. Oromo
2. Amhara
3. Guragie
4. Kefa
5. Dawuro
6. Other

3. HOUSING CONDITION

3.01	Main material of the roof	1. Thatched 2. Corrugated iron sheet 3. Other, specify_____________
3.02	Main material of the floor	1. Earthen 3. Cemented 1. Wooden 4. Other, specify_______
3.03	Kitchen Site	1. Inside home 2. Separate 3. Other, specify_________
3.04	Do you have domestic animals?	1. Yes 2. No
3.05	If yes, do they have a separate room from living house?	1. Yes 2. No

4. WATER COLLECTION

4.01	Who is the main person who usually collects water for your household?	*(Multiple choices possible)* 1. Adult woman in household 2. Adult man in household 3. Girl child in household 4. Boy child in household 5. Outside person 6. Other: ___________________
4.02	How often does someone usually go to collect water for this household in a typical week**?**	*(Only one answer is allowed!)* 1. More than 7 times per week (more than once per day) 2. 6-7 times per week (once every day) 3. 3-5 times per week 4. 1-2 times per week 5. No water collection (has household tap)
4.03	What material do you use to store water?	1. Jerrycan 2. Clay Pot 3. Bucket (plastic or metal) 4. Barrel (plastic or metal)

		5. Other specify__________
4.04	Do you wash the container before collect the water?	1. Yes 2. No
4.05	Do the containers have cover?	1. Yes 2. No
4.06	How do you fetch water from the container (please observe)	1. Dipping 2. Pouring 3. Other specify ___________
4.07	How much water did you fetch **before yesterday** (please ask what were the containers used and write the total water fetched in liters) ______________**Lt**_________	
4.08	How much water did you fetch **yesterday**(please ask what were the containers used and write the total water fetched in liters) ______________________Lt___________	

5. WATER SOURCE INVENTORY

5.01	What type of source does u use for drinking?	1. Unprotected well 2. Unprotected spring 3. Protected well 4. Protected spring 5. Rainwater tank 6. Piped water to house or yard 7. Public tap/standpipe 8. Water vendor/ Sold from cart 9. Other *(describe)*
5.02	Do you ever treat this water to make it safe for drinking?	1. Yes 2. No
5.03	*If yes*, What method did you use?	1. Boil 2. Bishangari/Wuha Agar/PUR/ bleach/chlorine 3. Strain it through a cloth 4. Use water filter (ceramic, sand, etc.)

		5. Let it stand and settle 6. Solar disinfection 7. Moringa seeds or other herbs 8. Other (specify)/______________________ 9. Don't Know

6.WATER QUANTITY INVENTORY

6.01	Do you feel the water quantity you use for this household for all purposes is sufficient for the needs of your family?	**a)** No **b)** Yes **c)** Don't know
6.02	*If no*, What is the main reason **you** can't get sufficient water?	*(Only one answer is allowed!)* 1. Not enough at source 2. Source is not functioning 3. WASHCOM limits amount 4. Source is too far (too much time) 5. Not enough manpower to collect enough 6. Not enough time to collect 7. Sources have bad quality 8. Drought 9. Other: ___________________

7. SANITATION AND HYGIENE CHARACTERISTICS

7.01	Is there latrine facility in the compound?	1. Yes 2. No
	If yes, what type?	1. Pit 2.Flush toilet 3. VIP 4. Other, specify________
7.02	Is there hand washing facility near to the latrine?	1. Yes 2. No
7.03	What detergents you use for hand washing in addition to water?	1. Ash 3. Other (Specify) _____ 2. Soap

7.04	When do you wash your hand?	1. after using toilet, 2. before serving meal, 3. before preparing food

8.WATER SAMPLE COLLECTION

Finally, I would like to take some water from your drinking water supply to test the quality. Do I have your permission please?

1. Yes 2. No

Can you please give me some water for drinking?

Instructions to enumerator

First label the sample bottle with the HOUSEHOLD ID number. Then ask the respondent to pour the water into the bottle as if they were giving you water in a cup to drink. That means, using whatever method they use to serve water for drinking (dipping a cup in, pouring, etc). Seal the bottle and place it in the cold box.

8.02	*OBSERVE: What type of container is it?*	1. Clay pot 2. Jerrycan 3. Metal container 96. Other: ____________________
8.03	*OBSERVE: What type of opening does the container have?*	1. Wide neck (can fit a hand inside) 2. Narrow neck (cannot fit a hand inside)
8.04	*OBSERVE: How did they give the sample?*	1. Poured directly from container into bag 2. Dipped cup in container 3. Dipped long-handled cup or spoon in container 96. Other: _______________________
8.06	**When was this water fetched?**	1. Today 2. Yesterday 3. Before yesterday 4. Other (specify)------------------------------

8.07	**Did you treat this water to make it safe to drink?**	1. No 2. Yes 3. Don't know
8.08	*If yes*, **What method did you use?** *(Note – DO NOT READ the list aloud for the respondents, LISTEN and record corresponding code.*	1. Boil 2. Bishangari/Wuha Agar/PUR/ bleach/chlorine 3. Strain it through a cloth 4. Use water filter (ceramic, sand, etc.) 5. Let it stand and settle 6. Three pot system 7. Solar disinfection 8. Moringa seeds or other herbs 9. Alum 10. Other (specify)/________________________ 11. Don't Know

We have finished, Thank you!

Annex 2

Procedures in laboratory test

- **Determination of pH**

Apparatus

Pocket pH meter

Procedure

- Clean the electrodes carefully with distilled water.
- Press on to switch and dip the electrode into 2-3cm of the sample and rotate gently and wait for the reading to stabilize
- Press hold to store the reading on the display. Rinse

- **Measurement of Residual Chlorine in Water**

Apparatus

Contour comparator

Reagent

DPD (Diethyl Phenyl Damien)

Procedure

- rinse tubes with sample leaving a few drops in the measurement tubes
- Add one DPD 1 to the sample tube and crush to a paste.
- Add sample to the tube to the 10ml mark and dissolve any remaining particles.
- Place the tube in the measurement position
- Facing a good light source and rotate the disk until the colors match and record the result from the lower rights hand window immediately as mg/l cl_2

.

Annex3

- **Preparation of culture media**

Required

- 38.1g membrane lauryl sulphate broth (MLSB)
- Media measuring device (MMD)
- 100ml distilled water
- PH meter

- Autoclave
- Heat source

Procedure

- Sterilize the MMD at 121^{o}C for 10 minutes and remove, allow cooling.
- Take ten level spoonfuls of media from 38.1g of MLSB and add to the MMD
- Fill the MMD with sterilized water should have 7.2-7.6 PH level to the lower lips.
- Shake the MMD to dissolve the MLSB and bright/pink liquid will be produced
- Sterilized the liquid by using Autoclave at 121^{o}Cfor 10 minutes
- Remove the MMD and allow cooling and storing in a cool place until ready to use.