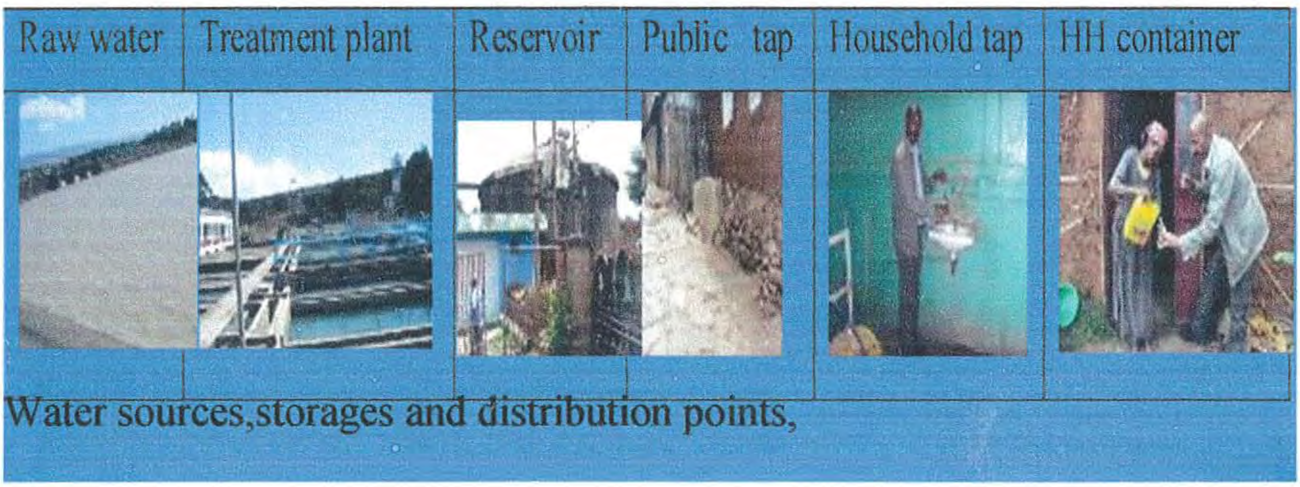
Assessment of the Effects of Water Sanitation on Human Health and Livelihoods in Kechene and Shiromeda areas, Gullele Sub-city, Addis Ababa, Ethiopia



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This is to certify that the thesis prepared by Yihenew Abere Woldesemayat, entitled Assessment of the Effects of Water Sanitation on Human Health and livelihoods in Kechene and Shiromeda areas, Gullele Sub-city, Addis Ababa, Ethiopia. This thesis is submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Water and Development (Water Resources Planning and Management). The thesis complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

The Assessment of the Effects of Water Sanitation on Human Health and Livelihoods was conducted in Kechene and Shiromeda areas, Gullele Sub-city, Addis Ababa, Ethiopia. The assessment was an important problem assessed. The problem was limited access to water, poor sanitation (defecation, urination, and effluents) and hygiene (personal and house cleanliness) that affected water quality or hygiene affected because of limited access. The assessment was to conduct a survey of Knowledge, Attitude and Practice of the households on water supply, storage, sanitation, hygiene, quality and treatment. Assess bacteriological and physico- chemical pollution of water on human health. Assess the effect of water access and pollution on income and livelihoods. Conclude and recommend possible strategies to curb the problems. The methodology employed was household Knowledge, Attitude and Practice (KAP) survey and laboratory test of water. The survey employed 155 questionnaire administration and schedule, 6 key informant interviews and 3 focus group discussions. The laboratory included water sample collection for Physico chemical and bacteriological test. The survey result showed that limited access to water created competing water demands and needs for household activities. It affected water consumption, use and norms. Laboratory test conducted had shown that household connections and storage containers had substances like Iron, Manganese, Chloride, PH, Total Dissolved Solids (TDS), Electrolyte Conductivity (Ec) and turbidity. The presence of total coliforms, E.coli and ammonia was detected in drinking water. The assessment confirmed that water access, sanitation and hygiene have affected the health, income and livelihoods of the people in the study areas.

Keywords: Human Health, Livelihoods, Bacteriological, Physico chemical and Survey

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Dedication

This thesis is dedicated to the late and ever remembered my mother Addee Maamiituu Diirbaabaa Beekaa; equally to my sister Wubitu Abere Woldesemayat for her custodian and all Abere and Maamiituu families and the late ever remembered Obboo Nagassaa Abayoo and Obboo Shoomaa Abbayoo families. All Sakie and Baarriisso village residents and families in Shaambbuu, Horroo Guduru, East Wollega, who had lent me a hand when I was a teenager shouldering family responsibilities.

List of Abbreviations

AAU	Addis Ababa University
AAWSA	Addis Ababa Water supply and Sewerage Authority
AFDB	African Development Bank
AMREF	African Medical Research Foundation
BGB	Brilliant Green Bile Broth
cl	chlorinated
Cl_	Chloride
Cl_2	Chlorine
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
DPD	Free chlorine-Cl_2
E.c	Eshershia coli
Ec	Electrolyte conductivity
EPA	Environmental Protection Agency
Fe	Iron
FGDs	Focus group Discussions
GDP	Gross Domestic Product
GoE	Government of Ethiopia
HHN	Household Number
HHs	Households
HIV/AIDS	Human Immune Virus/Acquired Immune Deficiency Syndrome
JTU	Jackson turbidity unit
KAP	Knowledge Attitude and Practice
KHHN	Kechene Household Number
KIIs	Key informant Interviews

MCM	Million Cubic Meter
MDGs	Millennium Development Goals
Mn	Manganese
MoE	Ministry of Education
MoFED	Ministry of Finance and Economic Development
MoH	Ethiopian Federal Ministry of Health
NGOs	Non-Governmental Organizations
NH_3-N	Ammonia
NTU	Nephelometric turbidity unit
PH	Potential of oxygen
RADWQ	Rapid Assessment of Drinking Water Quality
Sequelae	long-term continued disease outcomes
ShHHN	Shiromeda Household Number
Shiromeda	locality name (district)
TDS	Total Dissolved solids
Uc	Unchlorinated
UN	Untited Nations
UNDP	United Nations Development program
UNESCO	United Nations Education Science Cultural Organization
UTM	Universal Transverse Mercator

WASH	Water Sanitation and hygiene
WHO	World Health Organization
Woreda	District
WSP	Water Safety plans
μs	Micro Simens

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CHAPTER ONE

1. Introduction

1.1 Background and Justifications

One of the Millennium Development Goals (MDGs) was to ensure environmental sustainability. The targets were to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation and by 2020, to have achieved a significant in the lives of at least 100 million slum dwellers. The indicators for monitoring progress were proportion of population with sustainable access to an improved water source in urban and rural areas. In addition, the proportion of urban and rural population with and proportion of households with access to secure tenure access to improved sanitation (MoFED and UN Country Team March 2004).

Government administrative reports indicate rural water supply coverage at 61% to exceed the MDG goal. Functionality is assumed to be between 70 and 80 and an estimated 25% of protected water supplies are contaminated with faecal coliform, whilst in much of the Rift Valley excess fluoride pose a health risk to millions of people. At 93% (DHS 2005), the MDG target for Urban Water Supply has been met, although more should be done in peri-urban areas and smaller towns to ensure universal access to safe drinking water. Behavior change and basic technology has improved sanitation coverage (UN March 2011).

Ethiopia to ensure environmental sustainability is likely to be on track. The GoE definition of sanitation includes 'unimproved toilets' that lack a cleanable slab and therefore government data stating rural sanitation coverage (access) is 53% is not compatible with the MDGs. The 2010 JMP (Joint Monitoring Programme of WHO and UNICEF) update 28 refers to rural monitor the delivery of WASH services remains weak especially at Woreda level. The year on year utilization rate for WASH is at best 70%, and there are major concerns over sustainability and quality. Inadequate access and poor hygiene practices contribute to recurrent outbreaks of acute watery diarrhoea (UN March 2011).

Water is the basis of all life. However, for millions of children, the water they drink can also be a source of persistent illness, leading to an early grave. A child dies of diarrheal disease every 30 seconds and for every child who dies of diarrheal disease, three more children die of other diseases passed along by unwashed hands, or made more deadly by chronic malnutrition resulting from constant bouts of diarrheal disease and intestinal parasites. Thus, every 7 seconds, a child in the developing world dies of WASH-related disease or WASH-related malnutrition. According to the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), 80 percent of all childhood diseases are WASH related. While adults also suffer from WASH-related diseases, 90 percent of those who succumb to them are children under the age of five. Even more alarming, 70 percent of these do not survive the first year of life, and 40 percent do not make it past the first month. Before we can help these children to thrive, we must help them simply to survive. Providing a child with access to safe water, sanitation, and hygiene is one of the most effective ways to ensure his or her survival (World Vision, October 2011).

By 2025, nearly two-thirds of the world's population will be living under water-stressed conditions. Water scarcity and poor water quality will increase disease, undermine economic growth, limit food production, and become an increasing threat to peace and security. Today, more than 800 million people lack access to safe water and more than 2 billion to basic sanitation. Inadequate access to water supply, sanitation, and hygiene causes the deaths of more than 1.5 million children each year. Competition over water resources is an increasing source of tension and conflict, and droughts and floods now affect more people than all other natural disasters combined. Climate change will exacerbate all of these challenges (Senator Paul Simon June 2010).

The world's population is growing by about 80 million people a year, implying increased freshwater demand of about 64 billion cubic meters a year (UN, Retrieved on June 22, 2013). The world is on track to meet the Millennium Development Goal (MDG) target on drinking water. Current trends suggest that more than 90% of the global population will use improved drinking water sources by 2015(ibid). The world is not on track to meet the MDG sanitation target. Between 1990 and 2006, the proportion of people without improved sanitation decreased by only 8 percentage points. Without an immediate acceleration in progress, the world will not achieve even half the sanitation target by 2015. Based on current trends, the total population without improved sanitation in 2015 will have decreased only slightly, from 2.5 billion to 2.4 billion (ibid).

Worldwide, good water management is becoming increasingly critical in a world subject to growing scarcity of this resource. Our health, food and energy security and environment all depend on careful management of water. Only wise use of this finite, vulnerable resource will enable us to respond effectively to new emerging challenges such as climate change and assure that future generations have enough water (Helmut Kloos and Worku Legesse, January 2010). Human health depends on resources and good health depends on accessibility to sustainable resources, bad health results from inaccessibility from sustainable resources or exposure to hazards, sustainable resources and hazard exist in the environment, therefore quality of health depends on the environment (Allison Robinson, November 2001).

In Africa, 360 million people had access to improved sanitation facilities in 2006. Coverage increased from 33% in 1990 to 38% in 2006. The African population without access to sanitation increased by 153 million, from 430 million in 1990 to 583 million in 2006. Increases in coverage are not keeping pace with population growth. The rate at which Africans gained access to sanitation, 153 million people since 1990, is insufficient to meet the MDG sanitation target. In 38 countries in Africa, sanitation coverage is less than 50 % (UNICEF, WHO and African Ministers' Council on Water, 2008).

Sub-Saharan Africa is not on track to meet the millennium development goals for water and sanitation (Europeans Court of Auditors 2012). One of the targets of the Millennium Development Goals, promulgated by the United Nations in 2000, is to halve by the year 2015 the proportion of people without sustainable access to a safe water supply and basic sanitation, therefore reducing the burden of associated disease. Unfortunately, recent statistics on water and sanitation do not provide specific evidence about the quality of water being provided to communities, households and institutions (Dagnew Tadesse, 2010). Sanitary inspections are visual assessments of the infrastructure and environment surrounding a water supply, taking into account the condition, devices and practices in the water supply system that pose an actual or potential danger to drinking-water quality and thus to the health and well-being of the consumer(ibid). The causes of the sanitary risks were classified into three categories: poor workmanship or lack of maintenance, poor site selection and failure to minimize sanitary risks and poor sanitary conditions (ibid).

Water Sector and Sanitation Goals for Ethiopia's 80 million people have one of the world's lowest rates of access to safe drinking water, sanitation and improved hygiene practices despite abundant surface and groundwater resources. Ethiopia is classified as a water-stressed country with a per capita safe water availability of 2.5 liters. Almost 84 percent of Ethiopians live in rural areas; only 42 percent have access to safe drinking water (13 percent have access to piped water) and only 12 percent have access to improved sanitation facilities. Diarrhea accounts for approximately 20 percent of all under-five deaths and 88 percent of the total diarrhea cases are attributed to inadequate and unsafe water and poor sanitation (Senator Paul Simon June 2010).

81 million people have one of Africa's lowest rates of access to water supply, sanitation, and hygiene despite surface and ground water sources (USAID, Retrieved on June 2013). In Ethiopia, proportion of population using an improved drinking water sources was 92.8% female, 41.6% male and 50.8% total and proportion of population using an improved sanitation facility were 18.2% female, 6.8% male and 8.8% total (MDG indicators for Ethiopia, 2011). Ethiopia's Millennium Development Goals (MDGs) for improved water and sanitation access are 70% and 56% respectively (USAID, 2011; AfDB, 2010).

Like other sub-cities in Addis, Gullele sub-city, Kechene and shiromeda areas access water from recommended authority. In case of limited access households forced to fetch water from distance, protected distribution points and unprotected sources such as springs, rivers, hand dug hole and roof top rainwater (UNDP, 2004). The water from recommended sources possibly contaminated via intrusion broken pipes by open defecation, unmanaged household solid and liquid wastes, cow dung and poor handling. The unprotected water sources are possible cause of illnesses (FDRE and MoWR, 2004).

All socio economic problems have direct relationship with lack of access to clean water, poor sanitation and personal hygiene. For instance, small hovels housed up to three or more families with up to 15 persons squeezed into incredibly small spaces (AMREF, 2011). It is estimated that an area population by over 30, 000 people had fewer than a hundred latrines, a ratio of 1 to more 3,000 populations (ibid).

Water quality problems in Ethiopia are physical parameters (color, odour, Turbidity, Taste), chemical qualities (iron, hardness, pH, Nitrate, Fluoride, sulfate, Nitrite, Manganese, CO_2, TDS) and microbiological (Total coliforms, E.coli, giardia, Amoebae). The most significant of all the water quality problems is poor microbiological and biological water quality. Most of the ten-top diseases, which affect public health, are the result of water borne and water related diseases (UNESCO -World Water Assessment program 2004).

In Ethiopia, all the waters of the rivers with a few exceptions are of good quality with respect to suitability as source of water for drinking and for irrigation with respect to salinity hazard and chemical pollution. However, treatment will be required against biological contamination and turbidity, which is very high in almost all of the river waters. The exceptions to this general rule are the rivers in the Rift Valley Lakes and River Akaki in the vicinity of Addis Ababa. Most of the Lakes in the Rift Valley are of poor quality owing to the presence of extensive saline and Alkaline springs in the Rift Valley. The rivers flowing out to such lakes are also contaminated. In some cases, the saline springs join the rivers directly and affect their quality. Except for two, Zwai and Lake Cheleleka the waters of all other lakes in the Rift Valley are considered unsuitable for drinking and irrigation (ibid).

In Ethiopia, high fluoride levels in ground water are a particular problem in the Rift Valley regions. Approximately 7.5 million Ethiopians in the Rift Valley area suffer from problems related to high fluoride levels. Nearly 80% of children are affected by dental fluorosis. Many suffer from debilitating skeletal problems later in life (Website Accessed on May 20, 2012). Ethiopia physicochemical analyses of water quality-Rapid Assessment of Drinking Water Quality shows Nitrate- compliance with water-quality standard 96.7 %, minimum 0.06 mg/l, maximum 208.00 mg/l; Iron-92.1 %, minimum < 0.01 mg/l, maximum 4.93 mg/l ; conductivity- 89.9%, mg/l 0.02 mg/l, maximum 37.59 mg/l . Addis Ababa Physicochemical analyses of water quality - Iron (Fe) compliance with water-quality standard 91.3%, minimum < 0.01 mg/l, maximum 4.93 mg/l; Conductivity- compliance with water-quality standard 99.1%, minimum 0.06 (μS/cm), maximum 1.88 (μS/cm); Nitrate compliance with water-quality standard 96.5%, minimum 0.15 mg/l ,maximum 71.00 mg/l (Dagnew Tadesse 2010). According to AAWSA, the most environmental water pollution is depicted in Table 1. However, there are many others, the research focus on few of them.

In the study areas, Addis Ababa Water and Sewerage Authority (AAWSA) were responsible supply and monitor to safe water. However, there was a gap on access, water quality and prompt pipelines breakage fixing. Anecdotal evidence showed that, in the study areas, water coverage provision was very low. Sufficient water was not supplied to users. In addition, residents sometimes doubted its quality. Factors affecting household water provisions in the areas were informal settlement, uphill settlement, increased population, house renters, investment intensification in the city, unsafe waste disposal and poor hygiene (Gullele Woreda administration officers January 2013).

Moreover, sanitation and hygiene was poor in the study areas. According to MDG- Millennium Development Goal indicators, country poverty trends be monitored based on the national poverty lines. The actual population of people living in slums was measured by a proxy represented by the urban population living in households with at least one of the four characteristics: lack of access to improved water supply; lack of access to improved sanitation; overcrowding (3 or more persons per room); and dwellings made of non-durable material (Millennium Development Goals (MDGs), 2008).

All socio economic problems have direct relationship with lack of access to clean water, poor sanitation and personal hygiene. For instance, small hovels housed up to three or more families with up to 15 persons squeezed into incredibly small spaces (AMREF, 2011). Few of these houses had latrines and disposed human excreta in plastic bags-the so-called flying toilet, were common in the narrow and mean alleyways in the Kechene areas. This had something to do with low income, housing conditions, increased number of households and community training strategies. Residents defecated into the plastic bags at night and throw them out into the street, where faces contaminate homestead- where children were playing, road, soil and the whole nearby environment. Children play constantly in filthy alleyways and afflicted by intestinal infections and diarrhea. Children fetched water waking in all these roads, after playing in this faeces contaminated field. It is estimated that an area population by over 30, 000 people had fewer than a hundred latrines, a ratio of 1 to more 3,000 populations (ibid).

1.2 Statement of the Problem

In Addis Ababa, Gullele Sub-city, Kechene-Woreda (07 and 05) and Shiromeda-Woreda (01) access to water and its pollution is an important concern. In the areas, access to water is limited and poor in quality.

The first cause of pollution was poor sanitation that loads wastes to intrude into water sources and distribution canal and affected water quality. These wastes are loaded in to household water containers and utilized.

The second cause of pollution was poor hygiene at household level. Regarding poor hygiene, household members were not practicing good hygiene during water fetching, storage and use. Because of limited access to potable water, households fetched water from unprotected sources that aggravate water-borne diseases incidence. Empty pipes form corrosions and seep wastes from the environment. In the area water supply, sanitation and hygiene is low (AMREF, 2011). Hence, water pollution (poor sanitation and hygiene) affected human health, income and livelihoods.

Above all, it was reported that over 70% of the contagious diseases in the country were water-induced diseases (FMoWE 2001). This could be potential evidence showing underlying causes of waterborne diseases prevalence in the areas.

Therefore, it is critically important to assess water accessibility, sanitation and hygiene practices that affected human health, income and livelihoods in order to reach at feasible conclusions and recommend alternative solutions to curb the problems.

1.3 Objectives

The general objective of the thesis was to assess the effect of limited access to water supply, poor sanitation (facilities and services) and hygiene practices on the household's health, income and livelihoods of the households.

1.3.1 Specific objectives

The specific objectives were to assess:

- the status of Households on Water Supply, Storage, Sanitation, Hygiene, Quality and Treatment;
- The effect of water access and pollution on income and livelihoods;
- The effect of bacteriological and physico- chemical pollution of water on human health;
- Possible strategies to curb the problems

1.3.2 Research Questions

- What is the status of Households on Water Supply, Storage, Sanitation, Hygiene, Quality and Treatment;
- What is the effect of water access and pollution on income and livelihoods;
- What is the effect of bacteriological and physico- chemical pollution of water on human health;
- What could be possible strategies to curb the problems

1.4 Significance

The study is significant in assessing problems in the study areas. Bring the problem to the attention of concerned stakeholders for action. In addition, the study can be used as a baseline for in-depth investigation by other researchers. It is also a piece of contribution that can lead relevant sectors towards feasible actions in addressing the identified community problems.

1.5 Scope of the research

The scope of the study was assessment of water pollution from sources of safe water provision and distributions through water canal from Laga-Dadhii/Diree catchment/dam to households. These were catchment areas, dam, treatment plant, reservoirs/water tank, public taps, group household connections, individual household connections, water fetching utensils, household storage containers and a glass of water used for drinking. In addition, there was unsafe sources like rivers, springs, hand dug wells and roofs to rainwater harvesting.

1.6 Limitations

- Households were not clear about the new kebele naming because of area restructuring. As a result, they tended to tell the older names. To solve the problem, volunteer educators from the areas were used to collect data and information;
- Water sampling was difficult as most of the time, there was no water in the areas. Hence, revisited two or more times for sampling of one trial;
- Comparison of sources of pollution was difficult. Whether it is from household containers or from taps. As a result, frequent visit of taps and household's container was made for sampling.
- Systematic random sampling was proposed to be used, but households were not numbered in a way that samples could be taken accordingly. Households were not numbered in sequences. It was based on the researcher judgment to pick households.
- The same household for survey and water sample was difficult as there was no regular water flow in the tap, but used the next or other households instead;

- If water was not present in one location, it was not for all nearby villages that affected sample replacement. The option was revisiting household for water sampling. This frequent visit has made it time taking.
- It appears to be a confounding factor whether a disease was caused by water or other sources. So, it was necessary to take an in-depth investigation about the cause of the diseases.

1.7 Conceptual Framework

The conceptual framework below is articulating the core problem and its underlying causes of water pollution in the study areas that had negatively affected water quality. Water pollution occurred from sources to households. Water was polluted by bacteriological origin from sources, its distribution points, fetching practices and household containers. Physico-chemical substances occurred outside the household levels and in the empty taps. This was a problem of poor sanitation. Pollution at household level was of bacteriological origin. This was a problem of poor hygiene. However, the effects of pollution that occurred at the sources and in the distribution system were detected in the household containers. There was coincidence in water pollution at public taps and household connections. These were because of poor sanitation of the environment and poor hygiene of the households. Pollution of water at any place affects human health, income, and livelihoods.

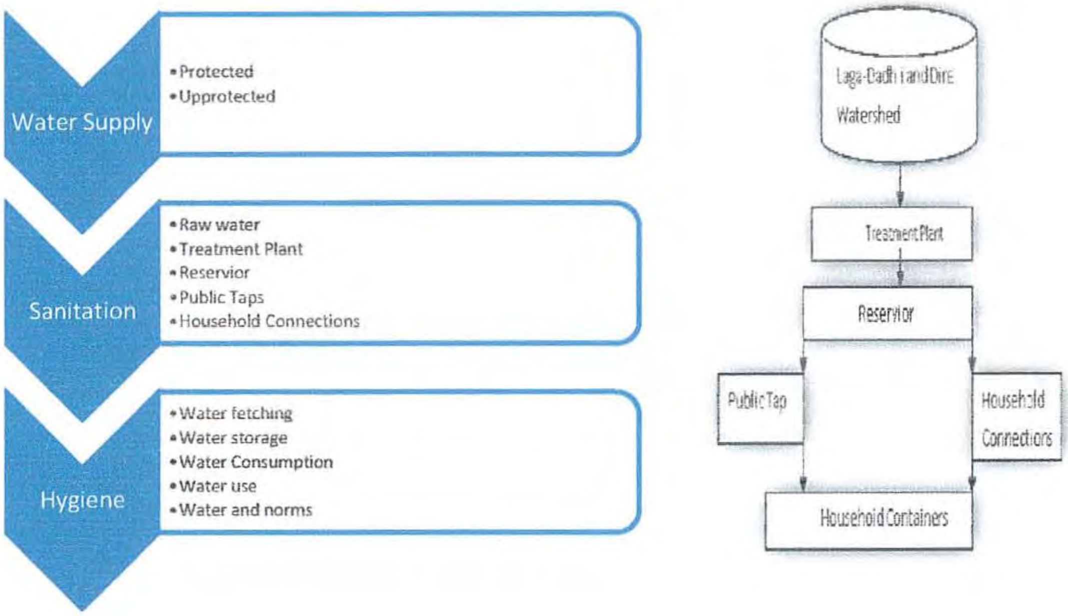

Figure 1. 1 Water supply and its point of pollution

Source: own construction, 2013

CHAPTER TWO

2. Literature Review

2.1 Laga-Dadhii Water Sources and Treatment Plant

Addis Ababa Water Supply and Sewerage Authority (AAWSA) produced 384,000 m^3 of water per day. These are Laga-Dadhii and Diree reservoir 165, 000 m^3 per day, Geferssa reservoir 30,000 m^3 per day and spring and wells 195,000m^3 per day. The study areas were supplied with Laga-Dadhii and Diree water sources was established in 1967. The design capacity of Laga-Dadhii was 48.5 million m^3, but the actual was 42.5 million m^3. The other part of the water was dead water; it was not used for consumption. Backwash water was also used to clean the clarifier compartment. Out of this 37% is non-revenue water. It is either by illegal connection or by wastage due to old infrastructures (AAWSA, 2013).

Akaki, Geferssa and Laga-Dadhii reservoirs are the three major sources of ground and surface water for Addis. Laga-Dadhii reservoirs and other booster sources were used to supply the study areas. These were booster shallow wells, deep wells and springs. These were pumped and gravitation was used to distribute to the consumers. There were also two treatment plants and one ground well field: namely Laga-Daadhii, Gafarssa and Hakaakii. Laga-Dadhi Treatment Plant distributed through chain reservoirs served the majority with the combined effect of boreholes pumped to serve community.

Water rationing started in Addis Ababa before a number of decades (AAWSA, 2013). This was primarily because water supply infrastructures were not sufficiently designed- by projection and not updated to meet the current demand posed by investment and population growth. Major water impurities were correlated with rationing. This was because longer time empty tap was the result of water impurities. It was shown that empty tap changed the color of water.

Laga-Daadhii dam/treatment plant received water during rainy season. The dam released water to the treatment plant and the water was treated and released to city reservoirs. In the study the water was analyzed under laboratory, that if any intrusion happens in to the pipe on the way to water users.

2.2 Water Supply, Sanitation and Hygiene

National and Addis Ababa city administration data for this research purpose. Official reports show access to water supply at 68.5 % -- 81.5 % for urban and 65.8% for rural. Access to sanitation facilities was reported to be 60%. The same report highlights hand washing practice at 7% and open defecation at about 15 % (USAID, 2011).

Provision of water for Kechene and Shiromeda community is from recommended water supplier AAWSA, and unprotected sources like rivers, springs, hand dug wells and roof top rainwater. Compared to urban, per urban study area people: women, children, sick and old travel a distance and fetch water from rivers, ponds and springs, which are, unprotected (UNESCO, 2004).

According to (CSA, 2000) open defecation practice in the country was 81.5%, (rural 90.7 % and urban 26.9%), which was one major cause of water pollution by microbes. The morbidity load attached with poor sanitation and hygiene accounts for 60 percent. Access to improved sanitation was as low as (between 6 and 18 percent) per number of households. On the other hand, according to (FMoH, December 2005), nearly 32% of the people have access to clean water (72% in urban areas and 24% in rural areas

2.3 Water Resources and Health Problems

The Federal Democratic Republic of Ethiopia, Ministry of Water Resources and Water Sector Policy revealed that 70% of infectious diseases in the country were waterborne or water based diseases. Cause of most of these illnesses could be traced back to insufficient water supply and sanitation facilities. National water policy asserts that access to clean and adequate water supply and sanitation facilities and improving the performance of this subsector openly reduces the morbidity and mortality rates of the population (FMoWR 2001, 17,18). Illnesses associated with poor environmental conditions account for 75% of all morbidity in the country.

Assurance of drinking-water quality has been a pillar of primary prevention for more than 150 years and continues to be the foundation for the prevention and control of waterborne diseases (FMOH, May 2011). The most predominant waterborne disease, diarrhea, has an estimated annual incidence of 4,600 million episodes and causes 2.2 million deaths every year. In terms of global burden of disease, diarrhea ranks second after respiratory infections. Children under five years of age are most affected: some 1.33 million die each year of diarrhea, representing 15% of overall mortality in that age group. (FMOH May 2011).

There are several variants of the feco-oral pathway of waterborne disease transmission. These include contamination of drinking-water catchment areas (by human and animal feces) and sources (through inadequate disposal of human or animal excreta, or domestic or industrial waste).Transmission can result from contamination in the distribution system (through "leaky" pipes, obsolete infrastructure, and inadequate treatment and storage) and unhygienic handling of stored household water (FMOH, May 2011).

Moreover, millions of people were exposed to unsafe concentrations of chemical contaminants in their drinking water. This contamination linked to naturally occurring inorganic chemicals such as arsenic and fluoride, which cause cancer and tooth and/or skeletal damage, respectively. Alternatively, it linked to a lack of proper management of urban and industrial wastewater or agricultural runoff water, with potentially long-term exposure to pollutants, resulting in a range of serious health implications (FMOH, May 2011). Diarrhea is the second greatest cause of mortality and morbidity in children under five years of age and is a factor in 46% of all childhood deaths. Access to clean water is estimated to be between 10 and 20% of the population and is accompanied by large urban – rural disparities in levels of service. (U.S. Agency for International Development 2000)

The country incorporated in the policy to investigate the possibilities of the spread of water borne diseases because of large-scale water projects during the project formulation stage, and take necessary remedial actions during the implementation phase (FMoWR 2001, 12).

2.4 Diseases Causing Agents in Water Environment

Disease causative agents are bacteria, virus, helminthes and protozoa (Haromeya University 2003). The waterborne zoonotic bacteria are principally those shed in faeces by warm-blooded animals (birds and mammals), although some are also harbored by reptiles (D.O. Cliver and R. Fayer, accessed on 2012).

According to the World Bank 22, diseases are related to improper disposal of solid wastes (World Bank 1999 in (UNESCO, 2004). Between 20 and 30 different infective diseases affected by changes in water supply (UNESCO, 2004). Water related microorganisms causing them usually classify infections or by mode of spread; Examples are:

a. **Water-borne diseases,** Infections spread through water supplies: e.g. Cholera, Typhoid, Infectious hepatitis, Poliomyelitis
b. **Water-washed diseases**, Diseases due to lack of water for personal hygiene: e.g. skin and eye infections (Scabies, Trachoma).
c. **Water -based disease,** Infections transmitted through an aquatic intermediate animal: e.g. Schistosomiasis.
d. **Water related insect vectors,** Infections spread by insects that depend on water: e.g. Malaria, Yellow fever, Trypanosomiasis

In 2001, a review of the scientific literature identified 1415 species of infectious organisms known to be pathogenic to humans, including 217 viruses and prions, 538 bacteria and rickettsiae, 307 fungi, 66 protozoa and 287 helminthes. Of these, 61% were zoonotic and 12% were associated with diseases considered to be emerging with water use (Taylor, Latham & Wool house, 2001) cited in (E. L. WHO 2003) . One gram of faeces can contain 10,000,000 viruses; 1,000,000 bacteria; 1,000 parasite cysts 100 parasite eggs (Water AID and TEAR FUND, February 2002); ingesting one mean inflicted by this disease causing organisms.

People suffering from water-borne diseases occupy half the world's hospital Beds. The World Health Organization says the lives of the 1.8 million children who currently die from water-related diseases each year could be saved by prevention or better treatment. A child dies every 15 seconds from diarrhea, caused largely by poor sanitation and water supply.

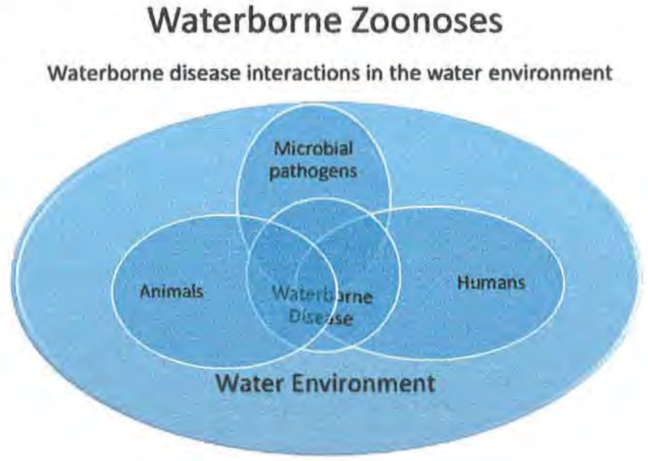

Figure 2. 1 The Water Environment

Sources: WHO, 2004

2.5 Investigations of Diseases Causing Agents

To investigate disease causative agents water was analyzed in the laboratory .To conduct the investigation water was samples were collected. According to (WHO, 1997) piped drinking water sampling depends on number of populations. As the number of population increases number of sampling increases. There are three basic types of water sampling. These are water from a tap in a distribution system or from a fixed pump outlet, etc.; Water from a water-course (river, lake, etc.) or a tank; Water from a dug well, etc., where sampling is more difficult than from an open watercourse (WHO-Guidelines for drinking-water quality, 1997). As opposed to the above standard, this research employs cross sectional study of community water supply among poor urban dwellers. It is a three times sampling for water laboratory analysis and survey method. Sampling was done every 3 months. February, March and April.

Frequencies of sampling should reflect the need to balance the benefits and costs of obtaining more information. Sampling frequencies are usually based on the population served or on the volume of water supplied, to reflect the increased population risk. Frequency of testing for individual characteristics will also depend on variability. Sampling and analysis are required most frequently for microbial and less often for chemical constituents.

This is because even brief episodes of microbial contamination can lead directly to illness in consumers, whereas episodes of chemical contamination that would constitute an acute health concern, in the absence of a specific event (e.g., chemical overdosing at a treatment plant), are rare. Sampling frequencies for water leaving treatment depend on the quality of the water source and the type of treatment (World Health Organization, Guidelines for Drinking Water Qualitys, 2006).

Rapid Assessment of Drinking Water Quality (RADWQ) applies a multi-stage cluster sampling approach to select a nationally representative sample of improved drinking water sources across a country. The selected sources are then tested for relevant drinking water quality parameters and a sanitary risk inspection is carried out for each source.

The main parameters measured were thermo tolerant coli forms, arsenic, fluoride, nitrate, iron, turbidity, conductivity, and free/total chlorine (for piped supplies only). A small proportion (10%) of sources was also tested for faecal streptococci and household piped supplies were tested for copper (UNICEF and WHO, 2011).

Residual chlorine, pH, and turbidity should be tested immediately after sampling as they will change during storage and transport (World Health Organization, Guidelines for Drinking water quality, 1997). Estimates of the numbers of coliform organisms-Escherichia coli and other microorganisms indicative of pollution-should be given in terms of "most probable number" per 100 ml (MPN/100 ml). In reporting chemical analyses, the sensitivity, accuracy and precision of the method should be indicated. This includes the proper use of significant figures and the expression of confidence limits (WHO, International Standards for Drinking Water, 1958).

Sampling equipment, transportation and storage practice were also important. Each sample bottle was provided with an identification label. Information is legibly and permanently written (UNEP/WHO, Water Quality Monitoring. A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes, 1996).

2.5.1 Sampling formula

$n = \frac{Z^2PQ}{E^2}$ = Binomial – Large population sampling

n= $\frac{NZ^2PQ}{E^2(N-1)+Z^2PQ}$ = Hyper geometric – Small population sampling

Equation 1 Formula for Equation of household sampling

Where 'n' is the required sample size; N is the population size; p and q are the population proportions. (If you do not know what these, are set them each to 0.5; Z=1.96 (95% confidence interval) is the value that specifies the level of confidence you want in your confidence interval when you analyze your data.

2.5.2 Water Sampling and laboratory Test

For microbiological analysis, strong, thick-walled, glass sample bottles with a minimum capacity of 300 ml should be used. They should have screw caps of a type that will maintain an effective seal, even after they have been sterilized many times in an autoclave. Some technicians fasten a Kraft paper cover over the bottle caps before autoclaving to protect them from contamination during handling. Alternatively, plastic or aluminum sleeves used. The neck of the bottle should not be plugged with cotton wool. To prepare sample bottles, they should be washed with a non-ionic detergent and rinsed at least three times (five is better) with distilled or deionised water before autoclaving. New bottles require the same preparation. If distilled or deionised water is not available, clean chlorine-free water may be used. If chlorinated water is being collected for microbiological analysis, sufficient sodium thiosulphate should be added to the sample bottles to neutralize the chlorine. The recommended amount is 0.1 ml of a 1.8 per cent solution of sodium thiosulphate for each 100 ml of sample bottle volume; this should be added to the bottles before autoclaving.

Sample bottles should not be rinsed with sample water or allowed to overflow because this would remove the dechlorinating chemical (UNEP/WHO, Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes, 1996).

The multiple-tube technique is applicable primarily to raw and chlorinated wastewater and sediments, and can be used for fresh and marine waters. The membrane filter technique also may be used for fresh and saline water samples, but is unsuitable for highly turbid waters (American Public Health Association, 1999).

There are a number of factors affecting samples. For instance water sample are susceptible to external interferences both microscopic and non-microscopic entities depending on sampling time Sampling frequencies are usually based on the population served or on the volume of water supplied, to reflect the increased population risk. Frequency of testing for individual characteristics will also depend on variability. Sampling and analysis are required most frequently for microbial and less often for chemical constituents. This is because even brief episodes of microbial contamination can lead directly to illness in consumers, whereas episodes of chemical contamination that would constitute an acute health concern, in the absence of a specific event (e.g., chemical overdosing at a treatment plant), are rare. Sampling frequencies for water leaving treatment depend on the quality of the water source and the type of treatment (World Health Organization, Guidelines for Drinking Water Quality, 2006).

The principal methods used in the isolation of indicator organisms from water are the membrane-Filtration (MF) method, the multiple-tube (MT) or most probable number (MPN) method and presence–absence tests (World Health Organization, Guidlines for Drinking water quality, 1997). For the confirmatory test, a more selective culture medium is inoculated with material taken from the positive tubes. After an appropriate incubation time, the tubes are examined for gas formation as before. The most probable number (MPN) of bacteria present can then be estimated from the number of tubes inoculated and the number of positive tubes obtained in the confirmatory test, using specially devised statistical tables. This technique is known as the MPN method (World Health Organization, Guidlines for Drinking water quality, 1997).

A cross sectional prospective study was conducted in Bahir Dar City from October to December 2009. Thirty-five private taps and 35 household water containers were randomly selected from 11 Kebeles. Bacteriological and physicochemical quality of water at tap and household water containers were analyzed in three rounds. The hygiene and sanitation practices of the consumers were also assessed. In support of bacteriological analysis, 250 ml of water sample was collected with sterile glass bottle and transported to the laboratory in a cold box. The number of total coli form and thermo tolerant coli form was determined with the membrane filtration methods using Lauryl Sulfate-Broth (Blulux laboratories Ltd., India) medium. The determination of total coli form and thermo tolerant coli form, incubation was carried out at 37°C and 44°C, respectively(Milkiyas etal, Accessed on July 12 2012).

The turbidity and pH of each sample was determined using HI 93703 Microprocessor turbidity Meter (Portugal) and a pH meter CE 370 (EU), respectively, within one hour of collection. The temperature of each sample was determined immediately after collection with a digital thermometer (Multi Thermometer ST-9269, EUROLAB). Free chlorine residual, for each chlorinated sample was determined at the sampling site with a Lovibond 1000 Comparator system (France) using a [1]DPD n°1 chlorine tablet. Moreover, consumers' hygiene-sanitation practices were assessed during interview. The interview questions and sanitary assessment forms were adapted from WHO and assessment of the situation of household water containers was acquired through inspection checklist. The quantity of coli form and hygiene-sanitation inspection rating, risk to health matrix scores was compared with the standard set by "WHO (Milkiyas etal, Accessed on July 12 2012).

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[1] DPD is chemical used to check presence of chlorine residue in water(tap, containers, reservoir, etc.)

2.5.3 Biological Parameters

Escherichia coli are abundant in human and animal feces, where numbers may attain 10^9 per gram of fresh feces. It is found in sewage, treated effluents, and all natural waters and soils subject to recent faecal contamination, whether from humans, farm animals, or wild animals and birds. The presence of *E.coli* in water always indicates potentially dangerous contamination requiring immediate attention. Complete identification of *E. coli* is too complicated for routine use; hence, certain tests have been evolved for assessing this organism rapidly with a high degree of certainty. Some of them are the subject of international and national standards and have been accepted for routine use, whereas others are still being developed or evaluated (WHO, Guidelines for Drinking- Water Quality, 1997).

Table 2. 1 Bacteriological water test

Sn.	Micro organisms	Laboratory Media	Re-marks
1	Bacteria	Lactose media	
2	Total coliform	BGB media	
3	E. coli	Ec media	

Source: (AAWSA, 2013)

2.5.4 Physico- Chemical Parameters

Table 2. 2Physico- chemical test

Sn	parameters	WHO recommendation	Measurement Unit
1	*PH*	6.5-8.5	No unit
2	EC	2000	µs/cm
3	TDS	1000	Mg/l
4	Chloride	250	Mg/l
5	NH_3-N	1.5	Mg/l
6	Iron	0.3	Mg/l
7	*Manganese*	0.4 and 0.1	Mg/l
8	Turbidity	5	NTU
9	Taste	Non objectionable	
10	Odor	Non objectionable	
11	color	Non objectionable	

Sources: Guidelines for Drinking-Water Quality, WHO 4th edition 2011

CHAPTER THREE

3 Materials and Methods

3.1 Descriptions of the study Areas

Addis Ababa Water Supply Authority was consulted for the areas to access water supply, Sanitation and hygiene. It was reported by the authority that Gullele sub-city (kechene and Shiromeda) is the most water shortage areas. Thus, the study was conducted in three Woredas/districts. The current 3 Woredas (named as Woreda 01, 05, 07) or the previous 12 kebele (currently named as kebele 01, 02, 03, and 04; 15, 16, 15 and 14; 04, 13, 14 and 22) was part of the assessment.

Table 3. 1Population and Household size of the study areas

Woreda/districts	Kebele				Populations	Household size	HHs size sample
Woreda 07 Kechene	04	13	14	22	56,000	11,200	70
Woreda 05 Kechene	15	16	17	18	24,483	4,897	35
Woreda 01 Shiromeda	01	02	03	04	35,000	7,500	50
					115,483	23,097	155

Source: Gullele, Woreda 01, 05 and 07 Administration office, 2013

Addis Ababa city water supply sources were from surface and ground water. AAWSA own two surface water treatment plants, Gafarssa and laga-Daadhii. The ground water sources were Akaki well field. The 79 dug wells are distributed all over the city. In addition, Akaki well field was 44. Totally, there were 123 dug wells supplying water to the city. Most of the wells were serving the periphery of the city. Only one dug well was connected to the Laga-Daadhii channels and other springs and wells were directly distributed to the public. In addition, there are four springs (AAWSA 2013).

Laga- Daadhii-Dire reservoirs catchment is one and the largest of the three main water supply sources of Addis Ababa city. It is located 22kms to the eastern side of the city and approximately lies in geographic coordinates of 481.3 kms East to 507.7kms East of UTM and 996.32 kms north to 1019.42kms north. A range of volcanic mountains rising to elevations range from 2,460 and 3,200 m.a.m.s.l characterizes the region. The major physiographic units found in the catchment area are mountains, dissected side slopes of mountains, hills, steep to undulating foot-slopes, gullies, valleys, and undulating plains and flat to almost flat plains. The main units of the catchment area are: small villages surrounded by Eucalyptus wood, intensively and moderately cultivated land, Eucalyptus woodland (young and matured), shrubland, Eucalyptus grass and natural vegetation, Grassland, bare soil and built-up areas (paved road, dam, concrete buildings in Sendafa town, and water bodies) (Taye Adugna 2009).

Laga-Daadhii was constructed in 1967. The Laga- Daadhii and Dire catchments were 207.3 m^3 and 77.5 m^3 respectively. The average annual surface water potential was 86 million centimeter cube and 50--million-centi meter cube respectively. (AAWSA Master plan Review, 2011).

Laga-Dadhii is surface water from its catchment. There are two dams (Laga-Dadhii and Dire). The altitude is 2500 meter. The Dire size is 78 km^2 and Laga-Dadhii is 2500 km^2. The size is 205 m^3. The depth is from 67 to 70 meter.

Treatment of the water made at the highest dose in the Laga-Daadhii treatment plant. There was no booster treatment at the chain reservoir, but booster water and pumping at stations.

Hence, its chlorine content decreases from 0.8mg/l to trace level as the course of time increases and reach high chlorine demanding areas. Households near the treatment plant were expected not to treat water. Nevertheless, households far from the treatment plant were expected to treat the water. This was because the concentration of chlorine residue decreases as time goes.

There was seasonal variation in the watercourse. The dam inflow was in rainy season. The dry season was a time of no in water inflow in to the dam. Hence, during March, April and half June was a time the dam was critically low to supply the city. Turbidity also increases from 300 NTU to 1600 NTU in dry and wet season respectively. This days algal blooms were very high and hence copper sulphate was used to remove the algal growth. Aluminum sulphate was used to enhance coagulation. The limitation for Laga-Dadhii is treatment was done finally at the treatment plant.

Hence, it was the household responsibility to treat at home because of pollution in the course of distribution. This was why awareness was very important at the community level. The perception of Government water was clean no need to treat was a serious concern to be underlined (AAWSA, 2013).

In addition, according to (Tamiru Alemayehu, et al, 2001) supply coverage of water by AAWSA was 70% of the population of Addis Ababa. This may probably imply 30% of the city population was without safe water.

The catchment areas residents were competing on water scarcity. They had nearly eight hand-dug wells. They have reported that these shallows were dried. This was the result of deep well excavation by other mega investors.

Table 3. 2Actual and Projected Population Density in the Catchment Areas

		1994(Census)		1999(Census)		2010(Census)	
Catch-ment Ba-sin	Area (km^2)	popula-tion	Average population Density (Per-sons/km^2)	population	Average population Density (Per-sons/km^2)	population	Average pop-ulation Densi-ty (Per-sons/km2)
Lege Dadi	206	20,000	98*	23,000	112	32000	156
Dire	78	6,000	77	7,000	90	9000	116
Total	284	26,000	88	30000	101	41000	136

Sources: AAWSA, 2009

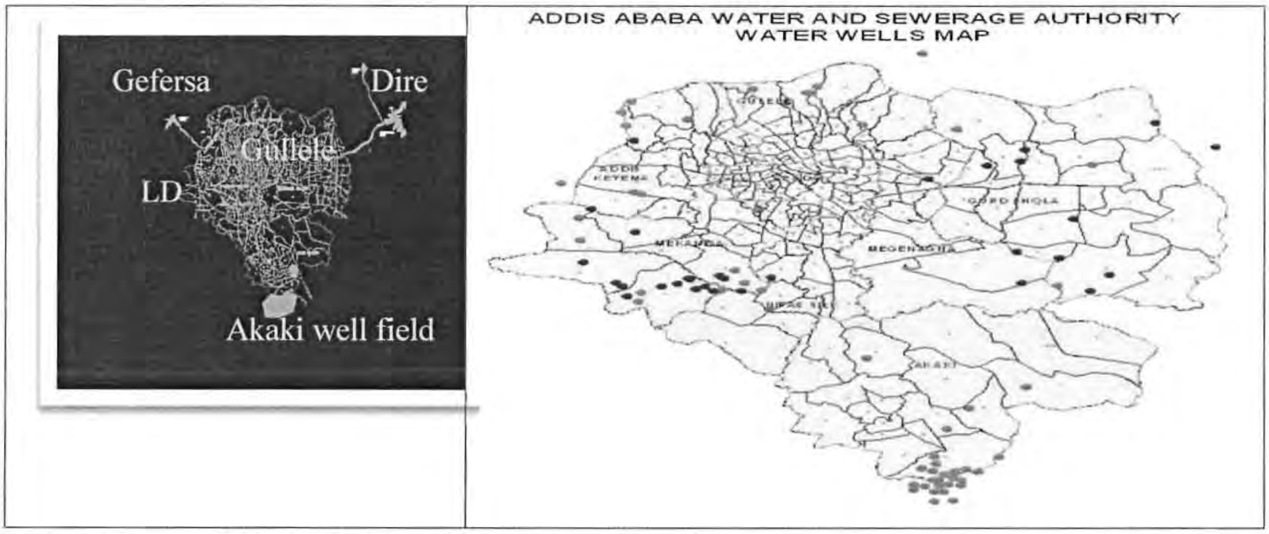


Figure 3. 1 Water distribution from Laga-Daadhii (LD) Treatment plant to study areas

Sources: (AAWSA, 2013)

3.2 SAMPLING

3.2.1 Household Sampling

The assessment was cross sectional Knowledge, Attitude and Practice (KAP) survey study households. In the study, three Woreda were selected purposefully. The three Woreda had 12 kebeles among which three kebeles were selected by simple random sampling. The most difficult part of sampling was to identify one kebele from the other because of GoE restructuring the administration in to Woredas. It was difficult to know Kebele/district population. For this study, woreda officer's data was taken. To select household's, the first task was identifying the villages. After identifying the villages; systematic sampling (SS) was used. Thus, 155 households were responded to questionnaires. Three focus group discussions from the community were selected from eight to twelve numbers of people in each group. Six key informant interviews were conducted from woreda administration, AAWSA, Hidassie health center, NGOs, and community educators.

The total Woreda population was 115,483. The populations of each Woredas/districts were as follows: Woreda 01 Shiromeda 35, 000, Woreda 05 Kechene 24,483 and Woreda 07 Kechene 56, 000 respectively. The household's sizes were 7, 000; 4,897 and 11,200 respectively. The total household size was 23,097. The household sample sizes taken from each Woreda was 50, 35 and 70 respectively.

The total number of households in the study areas was estimated to be 23,097. Accordingly, based on the adopted formula calculation (Evan Morris, 2008), the samples to be taken were 378. It was believed that conducting laboratory analysis in line with survey was critically important to understand the problem clearly and consider the thesis as problem solving piece of work, Hoinville.et al.1978 in (Martyn Denscombe, 2003). Thus, It was a subjective judgment to take a sample size 155 and gave due weight for laboratory test. The laboratory test was conducted under careful supervision of AAWSA procedures and WHO guidelines.

3.2.2 Laboratory Water Sampling

The researcher did the water sampling. AAWSA laboratory field chemists and biologists supported it. The sampling process included all water distribution systems from raw water to household containers. The physico- chemical water quality test was done using the procedure proposed by HACH-ISO 9001, 1997.

Table 3. 3 sampling of water

Sn	Sample Sources	Duration	Number of samples	Physico-chemical	Bacteriological
1	Raw water	3 months	3 samples	3 times	3 times
2	1 treatment plant(TP)	3 months	3 samples	3 times	3 times
3	6 reservoir	3 months	18 samples	18 times	18 times
4	10 public tap	3 months	30 samples	30 times	30 times
5	10 households	3 months	30 samples	30 times	30 times
Total	Subtotal sample size		84 samples	84 times	84 times

3.3 METHODS OF DATA COLLECTION

The assessment was targeted 155 respondents via survey questionnaires comprising of 39 questions 3 focus group discussions from 3 Woreda/districts comprising of 24 participants and 6 key informant interviewees comprising of 9 questions. Three Woreda head officers, Woreda/district Health Center Pediatric Nurse and Health officer, and Addis Ababa Cheshire Organization manager from an NGOs observations and picture taking was employed.

The water sampling was collected from Laga-Dhaadhii/dire raw water, treatment plant, reservoirs, public tap/household tap and household water vessels/containers. Water sampling glasses were collect water sample for bacteriological and clean plastic bottles were for physico chemicals.

The physico- chemical analysis method had selected parameters based on the environmental pollution intensity in the study areas. PH (Hydrogen Ion Concentration), Turbidity, TDS (Total Dissolved Solids), Electrolyte conductivity, Chloride, Ammonia (NH3-N), Iron (Fe) and Manganese (Mn).

Statistical Packages for Social Science Students (SPSS) was used to analyze the collected data from the field. Data collection, entry, edition, deletion and correction were done. Tables, graphs, charts and narrations were presented. A picture taken from the field and laboratory was done.

3.4 METHODS OF DATA ANALYSIS

3.4.1 Thematic Summary of Respondents

Household questionnaires were analyzed using SPSS frequency table, graphs and charts. Focus group discussions were summarized in to thematic areas. Key informant interviews were used to triangulate the data obtained by other methods.

3.4.2 Laboratory Test

The researcher has done closely undergo/attend all laboratory test procedure in Addis Ababa Water Supply and Sewerage Authority Laboratory. The authority was requested to perform the test. AAWSA has said anything that can benefit the community was welcome. Hence, the authority's chemists and biologists were approached support the laboratory analysis. Laboratory procedures were co-recorded as per the standard of the laboratory guideline under the authority. Accordingly, 84 samples were tested in 3 months. Eight Physicho chemical and one bacteriological parameters were tested (WHO-Guidelines for drinking-water quality, 1997).

3.4.2.1 Bacteriological Test

Most Probable Number (MPN) was used to analyze the bacteriological pollution of water. Under MPN method, Lactose, BGB and E.c. media was used to test the water sample. Multiple tube method- most probable number: Schematic outline of presumptive, confirmed and completed phases for total coliform detection was made. The test for indicators of faecal pollution was made (thermo tolerant (faecal) coliform (WHO-Guidelines for drinking-water quality, 1997) and (Edited by Lenore S. Clesceri, 1998) and AAWSA procedures.

3.4.2.2 Physico-Chemical Test

PH, TDS, EC and turbidity: for all parameters, the equipment was plugged to a house supply electric power. PH- measured by HORIBA equipment fixed in the laboratory room. A sensor electrode was immersed in to the water sample after rinsing the electrode with sterile/distilled water. PH read and recorded after the machine makes the reading ready. TDS and EC were read by similar machine. HACH CO 150 was used to measure both parameters. Usually TDS is half of EC. TDS unit is NTU-Normal Turbidity Unit and Micro Simense measured EC. Turbidity measurement was made by HACH 2100 AN turbid meter. 10-ml of sample was set in to the equipment. After a while, the NTU be read and recorded.

PH increases means alkalinity salt increases. For effective disinfection with chlorine, the pH should preferably be less than 8; however, lower- pH water (approximately pH 7 or less) was more likely to be corrosive. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water pipes in household water systems (WHO, 2011).

Turbidity in water was caused by suspended particles or colloidal matter that obstructs light transmission through the water. It was caused by inorganic or organic matter or a combination of the two. Microorganisms (bacteria, viruses and protozoa) were typically attached to particulates, and removals of turbidity by filtration will significantly reduce microbial contamination in treated water (WHO, 2011). It was measured by NTU (Nephlo Metric Unit). The WHO guideline indicated that turbidity must be below 5NTU.

TDS (Total Dissolved Solids)- the palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/l was generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances (WHO, 2011).
Electrolyte conductivity was good indicator of water quality problem. High value indicates poor taste, consumer complaint and dissatisfaction.

CHLORIDE: Mercuric Nitrate Method (10-8000 mg/l as cl^-) was used to analyze the presence of chloride in the water. The procedures in the laboratory were adopted from the reference. Calculate: digits required* digit multiplier mg/ chloride (HACH Company, 1997).
CHLORIDE-High concentrations of chloride give a salty taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation and were in the range of 200–300 mg/l for sodium, potassium and calcium chloride. Concentrations in excess of 250 mg/l were increasingly likely was detected by taste, but some consumers may become accustomed to low levels of chloride-induced taste. No health-based guideline value was proposed for chloride in drinking water

CHLORINE-most individuals were able to taste or smell chlorine in drinking water at concentrations well below 5 mg/l, and some at levels as low as 0.3 mg/l. The taste threshold for chlorine was below the health-based guideline value of 5 mg/l

AMMONIA: Ammonia (NH3-N)-the threshold odour concentration of ammonia at alkaline pH was approximately 1.5 mg/l, and a taste threshold of 35 mg/l has been proposed for the ammonium cation. Ammonia was not of direct relevance to health at these levels, and no health-based guideline value had been proposed. However, ammonia does react with chlorine to reduce free chlorine and to form chloramines. Methods of Analysis and procedures: Nessler Method. Nitrogen, Ammonia (0 to 2.50 mg/l NH_3-N.

IRON: Iron (Fe)-Anaerobic groundwater may contain ferrous iron at concentrations up to several milligrams per liter without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown color to the water. Iron also promotes the growth of "iron bacteria", which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on the piping. At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures. There was usually no noticeable taste at iron concentrations below 0.3 mg/l, although turbidity and color may develop. No health-based guideline value was proposed for iron. Methods of Analysis and Procedures: FerroVer Method-Iron Total (0 to 3.00mg/l): the HACH machine read minimum zero and maximum three.

MANGANESE: Manganese (Mn)-At levels exceeding 0.1 mg/l, manganese in water supplies causes an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking water, like that of iron, may lead to the accumulation of deposits in the distribution system. Concentrations below 0.1 mg/l were usually acceptable to consumers. Even at a concentration of 0.2 mg/l, manganese often forms a coating on pipes, which may slough off as a black precipitate. The health-based value of 0.4 mg/l for manganese was higher than this acceptability threshold of 0.1 mg/l.

Manganese, LR (0 to 0.700mg/l): the HACH machine read minimum zero and maximum 0.700.

Therefore, it was the mix of household survey and laboratory test work that was designed to employ. This could lead us to assess problems, derive conclusions and recommend mitigation measures. This was believed to benefit the study area communities.

CHAPTER FOUR

4 Results and Discussions

4.1 Knowledge, Attitude and Practice of the Households on Water Supply and Storage

Water supply in the study areas were determined by housing status, source and distribution of water, frequency of taps yielding water, distance travelled and time allocation of water fetching and responsibility of households for fetching water.

4.1.1 On Water Supply

The study had shown that households were aware on water supply problems. They believed that limited access to water affected their water consumptions, uses and norms. Consumption was to mean drinking, cooking, local drink preparation, pottery making, house building, etc. Use was to mean hand washing, morning and evening care, mouth care, bathing, laundry, utensil washing, cotton bleaching etc. Norm/custom was to mean burial care, childbirth care, confinement care, gift of water for drink to guests, the sick, children, the old, the beggar, and to neighborhood etc. Moreover, HHs needed water to drink during mealtime and reduced risk of choke while swallowing food.

Thus, HHs fetched safe water from far places and or access unprotected sources for domestic and drinking purposes. They preferred to use unprotected sources and opted to get inflicted with disease than suffering from limited access.

Water supply had direct correlation with housing status. House ownership was a precondition to claim water pipeline from AAWSA. Based on the Municipality prescribed dwelling right, AAWSA provides water for individual households, small group households, large group households, and the community at large.

In the study areas, very poor households managed to access water through small groups (3 to 6) households tap connections funded by aid agencies. These households were not willing to sell water for fear that the tap yield may not meet their group water needs or demands.

Water need was for basic life sustaining utilities like drinking and cooking for household members and demand was for household income activities like pottery, cotton bleaching, diary product-cow washing and watering purposes.

For house renter's water consumption, use and norms depends on the house owners' decision to allow them or not. That means, the owner controlled renter water consumption, use and norms. Renters were those who suffered more in water fetching than house owners.

Informal settlers/squatters and residents at the edge of Entoto Mountain suffered from empty taps. This was because informal settlers were not connected with water pipelines. Uphill dwellers suffered from limited access due to pumping problems. Downhill dwellers were more fortunate in water access than uphill dwellers. That means, housing position had something to do with water access (Table 4.1).

As indicated in Table 4.1, 20(12.9%) of renter households suffered from limited access to water than their house owner counterparts. These people were those without household tap connections. Household tap water connection required legality in housing. Those who suffered from limited access, even though the house had tap connections were 133(85.5%). In case of empty tap (no water), both renters and owners suffered from limited access to water equally. In case of limited access to water from the tap, renters suffered more than owners did.

Table 4. 1 Water access and housing status

Response	Frequency	Valid Percent
rented house	19	12.3
own house	55	35.5
shared house	1	.6
homeless	1	.6
Kebele house	77	49.7
others	2	1.3

Water distribution in the study areas were not even. Some access water better than others did. This was because water pipes valves usually leaked and supply downhill dwellers. This scenario was a concern among the households in the area.

The United Nation's Human Development Index notes that 78 percent of people in Ethiopia do not have access to improved water sources (Fintrac Inc., 2011). However, AAWSA recommended 110 liters/day/person. In the study areas, access to water on time, good in quality and quantity was found to be one of the pressing problems.

As indicated in Figure 4.1, 96(61.9%) own treated households tap connections, 39(25.2%) own treated public tap, 16(10.3%) fetched from other villages, 2(1.3%) fetched from protected ponds, 1(0.6%) got from treated public taps and river (0.6%) from improved springs etc. The majority of households own water pipeline connected to their houses. However, the tap was usually empty and yielded dirty water. There was a positive correlation between household size and taps connection.

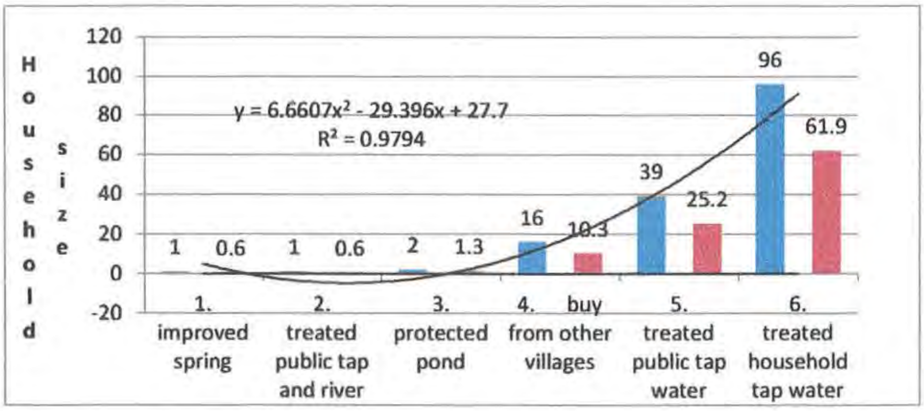


Figure 4. 1 Sources of water and distribution points

When access to water decreased, time gap of empty tap in the household increased. Increased time gap of empty tap increased water pollution potential in the households. This was by seepage of wastes to the water pipe during the empty tap and loading wastes to the households by the time the tap yielded water. As indicated in Figure 4.2, 31 (20.0%) accessed water once in a week 19 (12.3%) accessed water once in two months, 25(16.1%) accessed water once in every two weeks, 3 (1.9%) accessed water every 5 days, 4(2.6%) accessed water every 10 days, 1(0.6%) accessed water while they have already slept and did not manage water collection.

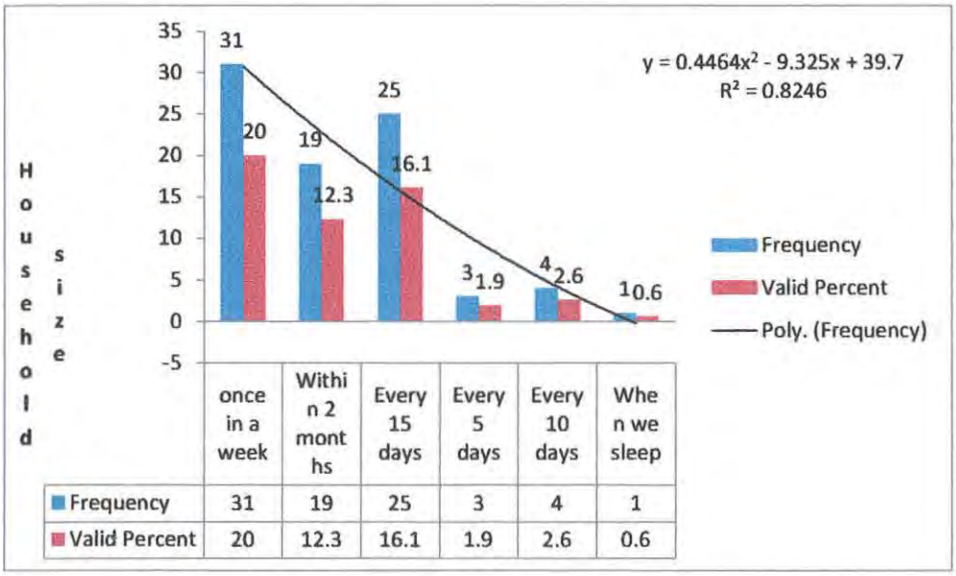


Figure 4. 2 Frequencies of tap water yielding

The study had shown that mothers and girls share the lion's share of water fetching responsibilities. Sometimes, water-fetching responsibilities shifted to men in case of distance travelling, carrying heavy water vessels, long queues and night fetching. This could happen if children and women traveled to the usual water points and water absence was reported. As indicated in Table 4.2, 67(43.2%) mothers fetched water, 47(30.3%) of all household members fetched water, 11(7.1%) girls fetched water, 9(5.8%) boys fetched water, and only 5(3.2%) fathers fetched water. This indicated the role of water fetching was female dominated but shared with males as a result of difficult access to water.

Table 4. 2 Responsibilities of water fetching

Who fetched water	Frequency	Valid Percent
Mothers/ Fathers	2	1.3
Fathers	5	3.2
house maid	6	3.9
others	8	5.1
Boys	9	5.8
Girls	11	7.1
All	47	30.3
Mothers	67	43.2

Time allocation for water fetching increased in case of empty taps. This had shifted time allocated for other homestead activities. Limited access to water shifted time allocated for other activities and increased time for water fetching. It means time allocation for other productive activities had been negatively affected.

As indicated in Figure 4.3, 7(4.5%) of the households fetched water in their dwelling compounds. These were group taps, hand dug wells, roof top rainwater. Twelve (7.7%) travelled zero distance to fetched water. This was to mean in the house or the tap water was yielding always. Very few 1(0.6%) travelled less than 5 minutes, 4(2.6%) travelled between 5 to 10 minutes, 4(2.6%) travelled between 10 to 15 minutes, 24(15.5%) travelled between 15 to 30 minutes, 24(15.5%) travelled less than 60 minutes, 54(34.8%) travelled less than 90 minutes, 22(14.2%) travelled less than 120 minutes and 3(1.9 travelled greater 120 minutes and awaited for queue line.

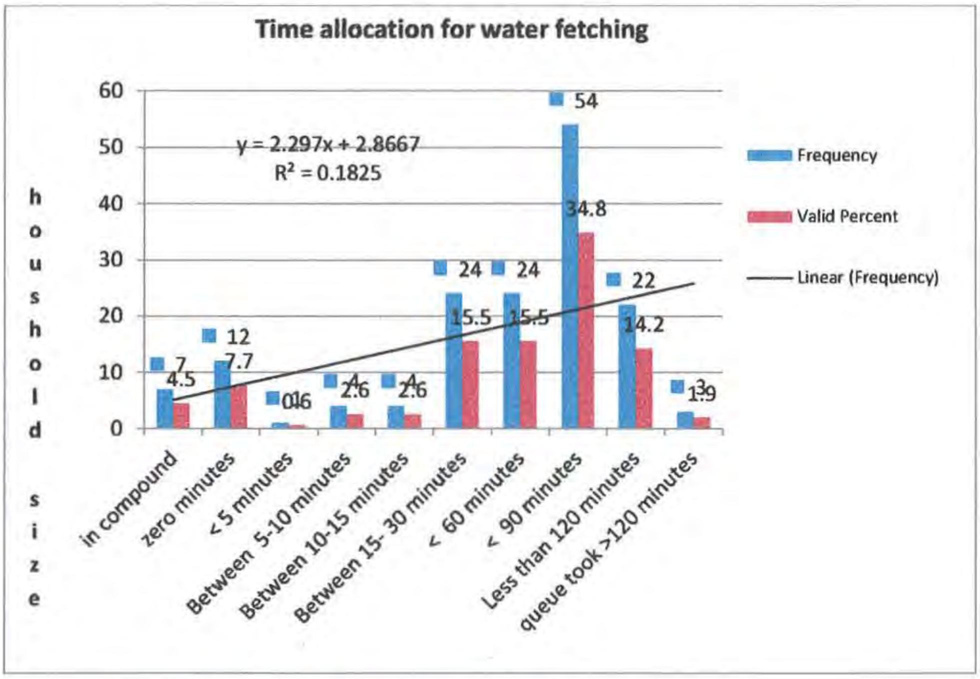


Figure 4. 3 Time Allocation for Water Fetching

According to WHO and other agencies, a minimum quantity of water supplies per person per day together with a maximum tolerable distance/time to a source (e.g. 20 liters, and within 1 km/30 minutes, respectively, for basic access) Guidelines for Drinking-Water Quality, WHO 4th edition 2011).

The assessment showed that 80% of the respondent's allocated time was beyond the WHO recommendation in the areas. Accessibility to water was critical in the study areas burdening households to fetched water from a distance and consuming time. What worried the respondents was not only accessibility but also queue that shifts normal household activities to water fetching. Schedule of routine household activities were affected by limited water accessibility.

Access to safe drinking water was essential to health, a basic human right, and a component of effective policy for health protection (WHO, 2011). "Access to water means access to other resources" a women respondent expressed. One respondent said, "Compared to our previous life, these days; Water is no more a commodity accessed by the poor. The haves can have it". Thus, limited access to water affected time allocation for other household activities and household labor for other works. That means productivity at household level decreased.

4.1.2 On Water Storage

Water storage in the households was affected by many factors. Building and or colon and or shaft to uphold storage containers on top of their house, bigger and or wider veranda and or corridor, wider houses or rooms, bigger and or many containers that can store water until the empty tap yields. Water storage practiced in the areas was to secure water in case the tap was empty for longer time.

Consumers understood that safe water was not on their table. This means the tap did not harvest water. In general, it was the question of availability and quality as well. The container was empty or had insufficient and or a little dirty water. The first action was to beg a glass of water from neighborhood. The intermediate action was to fetched water from other places. The long-term wish was to harvest fresh water from their tap every time. Thus, to secure water access, households' first option was to store water, the second was to fetch from nearby or far protected sources and the last option was fetching from unprotected sources.

As indicated in Table 4.3, 90(58%) of households (HHs) store water for fear that the tap was empty suddenly, 19(12.24%) of HHs store water because they own tap but no water in it, 15(9.6%) of HHs store water but believed that long time stored water was un clean, 9(5.7%) of HHs did not need to store water because their tap yield water always, 9(5.7%) of HHs store water to access on time for their homesteads, medications and other purposes.

Still others did not store because of lack of space and containers. As a result, there was a problem to collect water for sampling. During the survey time, it was challenging to collect water sample from the tap then from the household containers for cross checking point of pollution.

Table 4. 3 **Water storage practices**

I usually store/did not store water…	Frequency	Valid Percent
I have two pipes when one line gone the other will come	1	0.6
But no water for your sampling for now	3	1.9
But I lack spaces in my home/	3	1.9
But I lack big water containers	3	1.9
With my storage containers	7	4.5
To access on time for my homesteads/medications/others	9	5.7
No need to store water my pipe yield water always	9	5.7
But long time stored water was un clean	15	9.6
Because we have the pipe line but no water	19	12.24
For fear that the tap will be empty	90	58

4.2 Knowledge, Attitude and Practice of Households on Water Sanitation, Hygiene, Quality and Treatment

4.2.1 On Water Sanitation

Water sanitation was affected by point (e.g. Cotton bleaching, etc.) and non-point (e.g. open defecation) sources

Open defecation, urination and unmanaged soiled wastes were a threat to water sanitation. As the number of HHs, sharing the sanitation facility increases open defecation practices increases. The study showed household size greater than three members were 86(55.5%). As household size increase, sanitation facilities need increases. This was beyond Millennium Development Goals (MDG, 2008) indicator for poverty line monitoring.

Open defecations practices were potential sources of water pollution. For example, in the study areas, it was common to observe faeces in the village corners. Children play in the areas. Feet, fingers, flies and fluids (water) may take faeces home. On top of that, personal hygiene was low and proper hand washing practiced and iterate the problem end in poor health. Proper hand washing practices include before meals, after toilet, after child cleaning (USAID, 2011)

Sanitation problem was unpleasant in the study areas. This was because more than five households (25 to 130 persons) use one Ventilated Improved Pit latrine (VIP). Sooner the VIP was full it was not suctioned for the next use. Hence, every one tends to practiced open defecation. Poor sanitation (feces and urination) practice polluted the environment. Polluted environment polluted water. Polluted water caused health hazard to water consumers. When the health condition was endangered, household expenditure increases by incurring cost for medical services and medication. This had shifted household income from the regular pattern by affecting other needs/demands negatively.

As indicated in Table 4.4, 113(72.9%) of the HHs accessed pit latrines, 97(62.6%) shared sanitation facilities with more than five HHs, 16(10.3%) accessed toilet facilities 11(7.1%) didn't have the facility to share, 10(6.5%) shared the facility with four HHs, 8(5.2%) shared the facility with five HHs, 6(3.9%) didn't share sanitation facilities and 3(1.9%) shared the facility with less than 3 households. Thus open defecation was practiced if no facilities, the facilities were full and bad management by individual households that affect the group interest.

Table 4. 4 **Access and sharing Sanitation** Facilities and Services

Did you access and share sanitation facilities?	Frequency	Valid Percent
Two HHs share	1	.6
Three HHs share	2	1.3
Did not share sanitation facilities	6	3.9
Five HHs share	8	5.2
Four HHs share	10	6.5
No facility to share	11	7.1
Access Toilet	16	10.3
sharing Sanitation Facilities More than five HHs	97	62.6
Access pit latrine	113	72.9

The same to open defecation, waste disposal practices were low in the areas. Though liquid wastes disposal ditch was intended to receive liquid wastes, the respondents indicated they also damped solid wastes in the same place. This practice was likely to obstruct liquid waste flow to its destination.

An effluent from cotton bleaching was one of the concerns that the study assessed. Cotton-bleaching chemicals were disposed to ditches and dug wells. Sulfur, sodium carbonate, hydrogen per oxide, detergents, other chemicals, water, firewood, barrel and other material were used to bleach cottons. The bleaching helped HHs to meet the market demand of customers by whitening the traditional clothes.

Poor sanitation was the cause for water pollution. Polluted water affected water quality. This had caused poor health. To recover from the illness HHs incurred cost to medical services and medications. This decreased indemnity cash, income and livelihoods.

Table 4. 5 Waste disposal practices

Liquid and solid waste disposals	Frequency	Valid Percent
1. Practiced Burning solid wastes	2	1.3
2. Practiced Disposal in the sewerage canal	2	1.3
3. Practiced disposal(liquid and solid) wastes to open field	6	3.9
4. Practiced dispose to river	7	4.5
5. Cow dung may affect water supply	8	5.2
6. Sanitation facilities may affect water supply	8	5.2
7. Cotton bleaching chemicals may affect water supply	24	15.5
8. Practiced disposc into ditches	36	23.2
9. Practiced liquid/solid wastes to dug hole	54	34.8
10. Households who shared VIP (who travel less than 10 minutes)	132	85.2
11. Disposed solid wastes into the sack and store...	143	92.3

As indicated in Table 4.6, 143(92.3%) of the HHs disposed solid store into the sack and dispose in to waste disposing truck, 132 (85.2%) were households who shared VIP and who travelled less than 10 minutes to use the facility, 54(34.8%) practiced to dispose liquid/solid wastes to dug hole, 24(15.5%) fear that cotton bleaching chemicals may affect water supply, 8(5.2%) believed sanitation facilities may affect water supply, 8(5.2%) believed cow dung may affect water supply, 7(4.5%) practiced waste disposal to rivers, 6(3.9%) practiced waste disposal(liquid and solid) to open fields, 2(1.3%) practiced waste disposal into sewerage canal, and 2 (1.3%) of them practiced burning solid wastes.

Table 4. 6 Respondents opinion on water pollution Points

Where does water pollution occur?	Response
1 Catchment areas economic and non-economic practices;	2(1.3%)
2 Presumably untreated and released spore forming microorganisms from the treatment plant;	1(0.6%)
3 Any waste intrusion into the transmission canal and reservoirs;	6(3.9%)
4 Waste intrusion to public taps.	30(19.4%)
5 Waste intrusion into public taps and HHs connections;	3(1.9%)
6 In addition, the last was poor hygiene water handling during fetching, consumption and use from public taps, HHs connections, HHs storage containers and water glasses	66(43%)

However, respondents reiterated about the importance of prioritizing household income rather than water quality, sanitation, hygiene and teachings about water sanitation in general.

It was assessed that water sanitation was a problem that occurred outside houses while hygiene was inside house practices. Water was polluted from catchment sources to pipeline connection meter by sanitation problem while, after the AAWSA water meter connections reading to each households it was affected by poor hygiene. There were cases where both sanitation and hygiene overlaps. This was at water fetching places.

According to the assessment, water sanitation was by bacteriological and physico- chemical pollutions while hygiene was bacteriological. Poor liquid and solid waste disposals, open defecation, cotton bleaching chemicals, cow dungs, garage effluents, households wastes were major potential sources of water pollution problems in the study areas.

Water from the sources was open to pollutions. Treatment plant was used to disinfect pollutants. Reservoir was used as recipient/water tank from the plant. This water was distributed to households by household connections, public taps and group household taps.

Hypothetically, water can be polluted any time and any places. However, the study showed that water was polluted at household containers and taps. Other routs of water distribution (treatment plant and reservoir) were confirmed clean under laboratory test in during this study. In addition, the HHs believed that water contamination was low at treatment plant and reservoir/tanker.

4.2.2 On Water Hygiene

Water hygiene was affected in the households. These were while fetching, transporting, storage, consumption, uses and customs. As indicated in Table 4.7, 42(27%) the tap was contaminated while fetching water, 15(10.3%) while transporting, 100(48%) during storage, 10(7.1%) while consumptions, 21(13.5%) while uses, 5(3%) in customs, 30(19.4%) in poor hand washing.

Table 4. 7 Responses on water hygiene

Was the water clean while fetching from the tap?	Frequency	Valid Percent
1. The tap was contaminated while fetching water	42	27
2. The water was contaminated while transporting	15	10.3
3. The water was contaminated during storage	100	48
4. The water was contaminated while consumptions	10	7.1
5. The water was contaminated while uses	21	13.5
6. The water was contaminated in customs	5	3
7. poor hand washing affect water quality	30	19.4

4.2.3 On Water Quality

It had been shown from the assessment that the color, taste, odor of the households tap water harvested was changed. The colors were reddish, blackish, yellowish, faeces like, urine like turbid, colloidal, viscoid, metallic residue like, etc. The tastes were strong taste, unable to be swallowed, bitter, muddy, dusty etc. The odor was like rotten eggs, pungent smell, faeces, urine and any odd odor.

As indicated in Table 4.8, 115(74.2%) of HHs reported that the tap water was turbid/muddy/dusty-colloid/rusty/metallic residue/etc., 17(11%) bad taste, strong odor 7(4.4%), bad smell (2.6%), Reddish/ blackish 3(1.9%) metallic /rusty metal, Urine like 2(1.3%), and faeces like 2(1.3%).

Reasons for poor Quality: When empty or old tap dried and aerated with oxygen- oxidation changes the color of water. This had caused to wash the iron pipe corrosion and other wastes and damp into the household containers. After harvesting few buckets, the color becomes reduced and usual colorless water observed. This was an event every time water was harvested from the empty tap. Rarely, the same problem was observed in household taps when the tap was not empty. The other reason for water pollution and color change was waste intrusion into the household pipeline.

The first intrusion was doubted to be from toilet, ditch, sewerage, and other sources like cotton bleaching, cow dung, solid and liquid household wastes. Water Pollution from Cotton bleaching chemicals (Sulfur, hydrogen per oxide, detergents, and soda) most likely affect surface and ground water.

The observation was that unprotected water sources could receive all wastes from the areas, household wastes, sanitation facilities wastes, garage wastes, animal dungs, open defecation , urination etc.

On the other hand, in the areas, it was explained by the respondents that abdominal bowl movement, diarrhea and vomiting occur. It could be from drinking water or other sources. It was confounding factor to examine the sources in this study. Public health assessment was needed to examine illness from water or from other sources.

Table 4. 8 **Households Water Quality Complaint**

Description of the water quality complaint by households	Frequency	Valid Percent
The tap water was faeces like	2	1.3
The tap water was Urine like	2	1.3
The tap water was metallic /rusty metal	3	1.9
The tap water was Reddish/ blackish	4	2.6
The tap water had bad Smell	5	3.2
The tap water had strong odor	7	4.4
The tap water bad taste	17	11
Turbid/muddy/dusty-colloid/rusty/metallic residue/etc.	115	74.2
Total	155	100

Survey result shown that there were a number of complaints on water quality. First, household respondents were complaining of tap water quality. Woreda officers and AAWSA used to say the majority of water pollution was at potentially at household level. These were two arguments that need to be clearly assessed. Where does pollution really occur? Was it at household level or at the distribution system? AAWSA was responsible until the household water meter reading. Beyond the water meter, it was the responsibility of household members to protect water quality.

Poor hygiene was responsible to pollute water at household level. Whereas sanitation problems affect water out there in the distribution system. Poor sanitation outside the houses can be cause of poor hygiene by contact, flies, fluids, foods, and feet. Be it poor hygiene or poor sanitation; it affects water quality introducing waterborne diseases (WHO, 2004).

The most critical place for pollution was public tap, household connection and household containers. This was because old water pipe broken and leakage intrude in to the water body. Households did not take care while building latrines and stretching water line. In addition, households were not washing storage containers regularly. At household container level, the reason was unclean utensils, not washing hand during critical times, negligence, low awareness and low health seeking behavior. Raw water was exposed to pollution in open field. Treatment plants and reservoirs were less likely to be sources of infection.

4.2.4 On Water Treatment

Two agents potentially practiced water treatment. The first was AAWSA at the treatment plant and the second was households at their containers. Water treatment at the treatment plant was at higher dose from (0.7mg/l to 1 mg/l). This was by the assumption that as the water flow from treatment plant to reservoir, public tap, pipeline connection and household container its concentration decreased. If water canals and storage were intact, waste intrusion and chlorine concentration decrease was very low. However, sunlight exposed pipeline-evaporated chlorine in the free water and decreased its concentrations increasing water pollutions.

Therefore, HHs who dwells near the treatment plant receiving water must not treat the water and those far from the treatment plant must treat the water. There could be probable breakage and leakage/seepages across the line and potential wastes intrusion into it.

In addition, there was augmentation of water from different sources like (springs and dug well) in the course to promote combined effect/synergy. Springs and dug wells were not chlorinated regularly, as treatment plant was (AAWSA, 2013). AAWSA believed was that water treatment was supposed to be conducted at every booster (springs, wells and tankers) water sources during synergy. However, this was not made possible because it costs technologies and funding (AAWSA, 2013).

Addis Ababa Water and Sewerage Authority water laboratory services collect samples regularly. One was for microbiological analysis and the other was physico chemical analysis. The microbiological analysis was made every day- 7 days a week. Presence of free chlorine was checked at every sampling. For example, tap water chlorine level must be 0.2mg/l to 0.5 mg/l (AAWSA, 2013). If it was low/trace or nil. This could detect presence of bacteria showing contamination. The Physicho chemical analysis was conducted every 3 months and when events were reported or new water source was produced.

AAWSA had two approaches in treating the water supply, one was proactive and the other was reactive. The proactive approach was collecting samples regularly to investigate any potential pollution. The reactive was an approach identifying the sources of pollution, collecting samples and prompt treatment within 24 hours.

As indicated in Table 4.9, 71(45.8%) of HHs tracing locations where to obtain household water treatment product(s), 41(26.5%) practiced water tableting technologies rarely, 40(24%) did not need to treat tap water-it was clean/treated and supplied by AAWSA, 31(20%) practiced safe water storage/wash/clean/cover hands and utensils, 20 (12.9%) practiced water boiling technologies rarely, 3(1.9%) practiced water filtering technologies, 10(6%) believed that tap water can be contaminated and need treatment, 10(6%) complained that swelling in the neck of many children in the areas near menber kibir spring, a spring developed during Italian aggression, 10(6%) do not bother if the water was clean or not they used it what matters is to access it, 10(6%) knew that treated water had chlorine odor, 20(12.9%) practiced sustained use of water treatment technologies, 20(12%) do not knew if the tap water was treated or not or chlorinated and 22(14.2%) practiced treating drinking water at home.

Table 4. 9 **Household Water Treatment Technologies and practices**

Water Treatments Practices and technologies	Frequency	Valid Percent
1. They practiced water filtering technologies/rarely	3	1.9
2. They believed that tap water can be contaminated and need treatment	10	6
3. They complained that swelling in the neck of many children in the areas near menber kibir spring, a spring developed during Italian aggression	10	6
4. They do not bother if the water was clean or not they used it what matters is to access it	10	6
5. They knew that treated water had chlorine odor	10	6
6. Practiced sustained use of water treatment technologies	20	12.9
7. They do not knew if the tap water was treated or not or chlorinated	20	12
8. They practiced water Boiling technologies/rarely	20	12.9
9. Practiced treating drinking water at home	22	14.2
10. Practiced safe water storage/wash/clean/cover hands and utensils	31	20
11. They did not need to treat tap water-it was clean supplied by GoE	40	24
12. They practiced water tableting technologies rarely	41	26.5
13. Tracing locations where to obtain household water treatment product(s)	71	45.8

Therefore, the study areas respondents were advised to treat water at their home. The perception of the community was that AAWSA treated water '' so no need to treat at home''. This perception is so dangerous and it will be a continuing concern that every stakeholder should plan on how best this malicious perception was addressed. It has to be part of the common practice that HHs treat water at HHs level. This is because the large-scale water treatment was a very big investment.

4.3 Biological and Pysico Chemical Tests

4.3.1 Biological-Bacteriological test

In the same study area, water samples collected and tested from HHs containers, 1(5%) was detected for E.coli and five (25%) was detected for total coli form. Tap water was sampled, tested, and detected five (25%) total coliforms. Raw water was not believed to be tested for bacteriological analysis. Reservoirs and treatment plants were free for bacteriological analysis. The result showed fecal contamination of household water containers and others.

A Table 4.10 shows the summary of bacteriological laboratory test result. Eshershia coli/fecal coliforms/ thermo tolerant coliforms and total coliforms were detected from household water containers and taps.

Table 4. 10 Shows the summary of bacteriological laboratory result

S/n	Sources of water sample	Possible sources of contamination	Possible causes	Results
1	Household container	fecal origin	Hygiene/sanitation	Fecal coliforms
2	Tap and container	non fecal origin	sanitation/hygiene	Total coliforms

Eshershia coli (E.Coli) Detected in Household water container

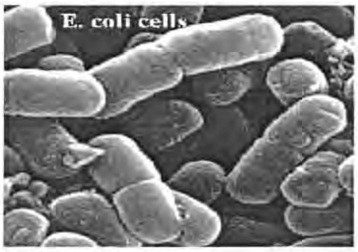
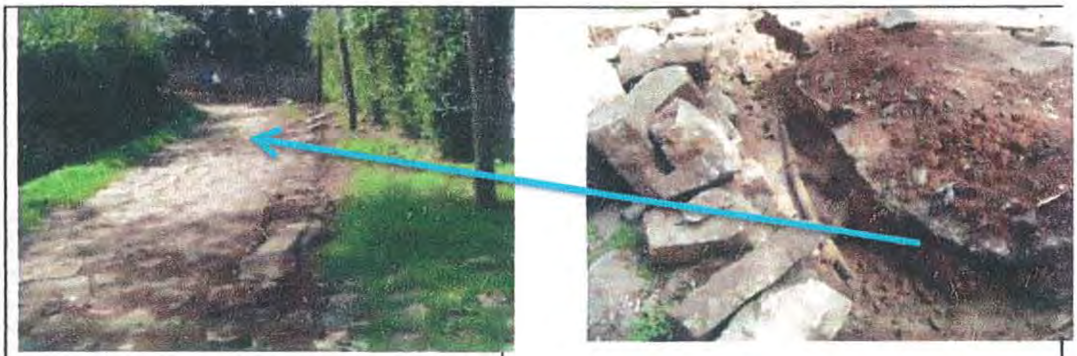


Figure 4. 4 E. coli indicated in household water

The above is shape of E.Coli under laboratory test. Lactose, BGB and Ec media were used for laboratory analysis. In Most Probable Number method (MPN) – probability. It is about counting number of positive test tubes for cloudy gas bubble.

Total Coliforms



Assessment of compliants on water quality gets prompt action. Though the purose of the thesis was not fixing problems on the spot. Problems were fixed at the prompt. Nearly more than 500 meter new pipes streched. This was at Shiromeda, near St. Peter Hospital infront of Shiromeda police station, Woreda 01.

According to laboratory test result, total coliforms were positive. Sanitary survey was made by AAWSA. It was found out that waste ditch lines and water pipeline were in adjacent locations. All household liqud wastes flow in the same line with water line. It was intrusion of wastes that affected water quality. Laboratory result had shown that, total coliforms were positiive. Nearly 20 households were suffering from unpleasant water.

Figure 4. 5 Sewerage line and pipeline placed on one, caused water unpleasant water taste

4.3.2 Physico-Chemical Test

The water sample collected and tested from Shiromeda area had shown Iron (Fe), Manganese (Mn), Ammonia (NH3-N), Total Dissolved Solids (TDS), Electrolyte Conductivity (Ec) and turbidity. This result of laboratory test value was greater than Laga Daadhii Water data trends, especially for Total Dissolved Solids (TDS), Electrolyte Conductivity (Ec).

Shiromeda area was supplied by Laga-Dadhii and Diree water. The water was tested and the results were Electrolyte Conductivity (Ec) 1054 mg/l and TDS 500 mg/l. It was the first data record in the history of AAWSA to find Laga-Daadhii and Diree sources with this value. In kechene area, ammonia was found through laboratory test from households' water container. This also showed fecal contamination of household water (AAWSA, 2013).

Figure 4. 6 shows the summary of Physico- chemical laboratory analysis result

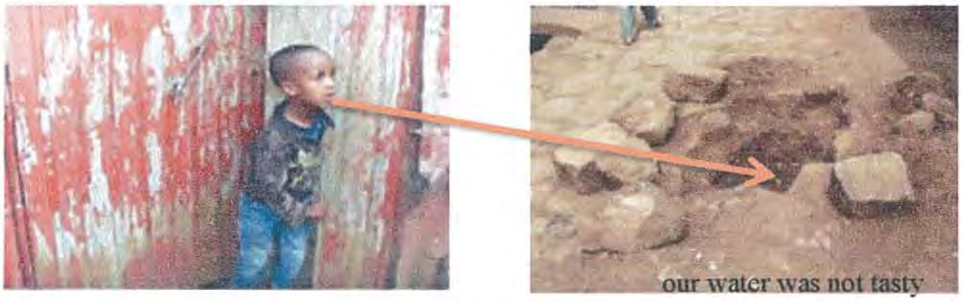
Sn	Parameters	Sources of water sample	Possible sources of contamination	Possible causes
3	Ammonia	Household container	fecal origin	Sanitation/hygiene
4	Electrolyte Conductivity	Tap and container	Anions and cations	Rust/corrosion/oxidation
5	TDS	Tap and container	Anions and cations	Rust/corrosion/oxidation
6	Iron	Tap and container	Pipe aeration	Empty tap
7	Manganese	Tap and container	Pipe aeration	Empty tap
8	Turbidity	Tap and container	Soil/mud	Breakage
9	PH	Tap and container	Alkalinity/acidity	Breakage

High value of physico- chemical parameter values

Villagers were saying they had springs that flow all the year round but it was a pipe broken and flow out through the outlet. Since then it was not reported ton AAWSA, and was not aware of the situations. AAWSA was driven to action after this findings.

Ex: Shiromeda, near youth center building, Woreda 01.

After having the information, AAWSA conduct sanitary survey. At the same time, a boy came out of house. He was asked about the water but he promptly said "our water was not tasty, it tasted metallic." A mother was asked, and she said the same. On spot action followed: Interviews, water supply line inspection and resampling was made. The result was the same.



water sample

Figure 4. 7 This little boy complains water taste

Water sample was taken from HHs containers and the tap. Electrical conductivity (EC) which was a measure of water's ability to conduct an electric current was related to the amount of dissolved minerals in water, but it does not give an indication of which element is present but higher value of Ec is a good indicator of the presence of contaminants such as sodium, potassium, chloride or sulphate (Orebiyi et al., 2010) in (Gebrekidan Mebrahtu and Samuel Zerabruk, 2010).

Table 4. 11 Result of water sample laboratory test

Sn	parameters	Lab result	WHO recommendation	Measurement Unit	Remark
1	*PH*	7.14	6.5-8.5	No unit	customer complaint
2	EC	1054	2000	µs/cm	AAWSA
3	TDS	510	1000	Mg/l	AAWSA
4	Chloride		250	Mg/l	customer complaint
5	NH_3-N	0.279	1.5	Mg/l	customer complaint
6	Iron	0.612	0.3	Mg/l	customer complaint
7	*Manganese*		0.4 and 0.1	Mg/l	Health and customer complaint
8	Turbidity	7.80	5	NTU	
9	Taste		Non objectionable		
10	Odor		Non objectionable		
11	color		Non objectionable		
12	Other Bacteria		Lactose media		
13	Total coliform	+ve	BGB media		
14	**E. coli**	**+ve**	**Ec media**		

Ammonia identifications

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">sewerage lines and pipelines were placed in one place. This has caused water contamination. Sample collected from households had shown organic waste pollution, ammonia, which could be an indication of contamination with fecal origin, in Kechene, Woreda 7. The yellow color shows presence of Ammonia in the water sample. Sampling from the tap was not possible though the researcher visited three times to collect water, the tap was empty.</td></tr>
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Figure 4. 8 Household water Ammonia Identification

4.4 Effects of Water Access and Pollutions on Household Income and Livelihoods

4.4.1 Socioeconomic Characteristics

Table 4.13 shows survey respondents by age structure. Older people were more vulnerable to access water than the adult and the younger ones. Walking a distance to fetch water, water purchase, carrying and incurring cost was tough task to them. As a result, these people were deprived from safe water supply, sanitation and hygiene.

Table 4. 12 Ages of the respondents

Age category	Frequency	Valid Percent
Age between 20 to 30 yes	4	2.6
Age between 31 to 45 yrs.	47	30.3
Age between 46 to 64 yrs.	58	37.4
Age greater than 65 yrs.	46	29.7
Total	155	100.0

The study showed there were 82(52.9%) males and 73(47.1%) females' survey households. The water supply was not sufficient to meet drinking and domestic needs of the households. It affected hygiene, income generating and food preparation demand of the households.

Limited access to water affected sanitation and hygiene practices. Women were worried on limited access to water than men counter parts. Old persons 46(29.7%) encroached to one place with no morning care. A child goes to school without morning care. Young siblings confront to access water in the morning.

Women, old people and children commonly practiced bathing at home. However, young and adult men went out to bath where the services were found. This had incurred cost, time wastage, lack of privacy and discouraging for better sanitation. Except bathing, all other water consumption, uses and norms were practiced at home.

In the study areas, disabilities suffer from water supply, sanitation and hygiene problems. Orphans and the sick were also affected. Schoolchildren, religious institutions, hospital patient attendants, and medical service procedures were also affected by limited water supply.

For instance, schoolchildren hate to use sanitation facilities at school. This was because it was not clean. This was potential causes of constipation that may potentially affect leaning. Churches were the place where many HHs members use water as a healer (holy water). Unless the water was clean, many of them had the potential to caught with waterborne diseases and transmit to family members. Medical procedures affected because of limited access to water. This had an imposition on quality of health services. Hospital patient attendants were assisting hospital admitted patients to recover from their illnesses. However, because of limited access to water they could not support patients. Rather travelled in villages to fetched, bought or beg water.

Thus, Limited access to water caused competing water demand in households. These demands were consumption, use and customs or norms. Water consumption was drinking and cooking. Water use was for hygiene purposes. Custom or norms were water for labor and delivery, childbirth, confinement care, burial care and water gift for guests.

For example, a family member goes out of house to shop bathing for money. For cost reason, regular pattern of hygiene practices were postponed. Quantity of water consumed decreased. Little water was used to do insufficient washing/cleaning. It also introduced the concept of water saving in the households. On the other hand, household hygiene was becoming worst resulting into poor health.

Order of priorities in water consumption ,use and customs were: drinking, cooking, morning and evening care, child care, dish/utensil washing, house cleaning, adult bathing/showering, laundry, child birth care, confinement care, burial care, serving guests who ask for cultural gift of water to drink and others.

Competing water demand forced to prioritize water consumption and then these had induced forced water saving. Water consumption, use and norms decreased when households found empty tap by imposing two things. One was learning household water saving because of unmet needs and competing demands and the other was by influencing negatively on health and income of the households.

The study had shown that, hygiene practices depend on water access. That means water supply and hygiene practices were correlated. As supply of water decreases household hygiene practices in household decreases. Furthermore, household members were not motivated for kitchen work; routine household activities were shifted forward until water was accessed. House cleaning, bathing, utensils cleaning were carried out when the tap yield water.

The study shows that access to water had two phases. These were quantity and quantity. However, people prefer to access poor quality water than suffering from shortage.

Water from the sources was open to pollutions. Treatment plant was used to disinfect pollutants. Reservoir was used as recipient/water tank from the plant. This water was distributed to households by household connections, public taps and group household taps.

4.5 Effects of Health Problems on Household Income and Livelihoods

4.5.1 Water Access and Livelihoods

As indicated in Table 4.14, 30(19.4%) of HHs reported that their personal private was kept clean only by water that makes them create fellowship with others. Thus, they travelled long distance, carry heavy water containers and fetch water in case of limited access to water. Bathing matters to made good relationship with friends and at work place. Thus, water was important to have it any time and any place. Other respondents remarked that two (1.3%) of HHs believed if no bathing, their body itched and they usually scratched.

Limited access to water forced 30(19.3%) of HHs to decrease their water consumption volume. They started to safe water affecting their hygiene negatively. They used one jug of water for washing different utensils; bath pattern reduced from weekly to biweekly.

Because of limited access to water 28(18.1%) of HHs prioritize household activities. That means limited access to water created competing need/demand in households. They tend to took one activity and left the other, though it was equally important for them, these were drinking, cooking, utensil washing, laundry, and childcare and waited for bathing until the pipe yield water.

It was described by 27 (17.4%) of the respondents, that lack of water decreased hygiene in households. They become negligent to take serious cleanness action in the households. Accordingly, 23(14.8%) of the respondents reported that lack of access to water increased regular time gap of bathing and 9(5.7%) explained that if no water, the house was not cleaned because it takes long time to fetch.

It was reported that eight (5.2%) of HHs went other places to bath, when they lack water access at home. Because it was incurring cost and increasing household expenditure. Incurring cost means decreasing household income from the regular indemnity budget. Those who hesitated to fetch water from other places in case of limited to access were three (1.9%). They never think of bathing fetching water from very long distance, carry heavy container and fetching. They took bath when the tap yielded water.

It was explained that HHs demand income and water access. If they had income and then water, no need to advise them on hygiene, they did it. Those who reported their living condition prevents them to keep their hygiene were one (0.6%).

Very few reported one (0.6%) they saved water for critical cases and reduced hygiene practice temporarily. Having a glass of water at home was necessary. A guest may come and ask for water, sickness, and other unusual events may happen at households. Apparently, one (0.6%) did not save water for tomorrow. They fetch right away and use it. Remarked, God knows for tomorrow. The concern here was unless the water was treated, it inflicted in to illness.

Table 4.14 showed that water supply and hygiene practices were correlated. Because hygiene practices depend on water access. For example, if water supply decreases household hygiene practices in household decreases. Furthermore, household members were not motivated for kitchen work 1(0.6%); routine household activities were shifted forward until water was accessed. House cleaning, bathing, utensils cleaning were carried out when the tap yield water.

Table 4. 13 Water access and hygiene practices

Households water access and hygiene practices	Frequency	Valid Percent
1. Personal private was cleaned only by water that makes them create fellowship with others with confidence. Thus, travel long distance, carry heavy containers and fetch water	30	19.4
2. They decreased their water consumption volume. They used one jug of water for washing different utensils; bath pattern reduced from weekly to biweekly	30	19.3
3. There was competing need in households. Drinking, cooking, childcare, bathing, washing clothes waited for bathing until the pipe yield water.	28	18.1
4. lack of water decreased hygiene in households	27	17.4
5. Lack of access to water increased regular time gap of bathing	23	14.8
6. If no water , the house was not cleaned because it take long time to fetch	9	5.7
7. They visited other places to bath, when they lack access at home, it was incurring cost and increasing household expenditure	8	5.2
8. They never think of bathing fetching water from very long distance, carry heavy container and fetch	3	1.9
9. If no bathing their body itched and they usually scratched	2	1.3
10. Their living condition prevents them to keep their hygiene	1	0.6
11. They save water for critical cases and reduced hygiene practice	1	0.6
12. They could not save water for tomorrow. They fetch water and used for the day live goes on like this	1	0.6

4.5.2 Water Induced Health Problems

Water induced diseases such as trachoma, scabies, skin itching diseases, and abdominal pain were most common illnesses diagnosed in nearby health center (Hidasse Health Center, 2013). These illnesses were believed to be the potential results of limited access to water poor sanitation and hygiene. HHs had no health seeking behavior to nearby health facilities.

For instance, a mother holding her child on her lap and flies hovering over her and her child hardly understands the health teachings. She rather requests food and water provision to listen to the social worker. In addition, respondents tend to build small room to rent than build latrine. Building small rooms and renting benefitted then than building sanitation facilities. It means, bread winning should precede sanitation and hygiene practices.

As indicated in Table 4.15, the respondents believed good health was the function of access to water and its quality. An illness with water-borne disease was reported as follows. These were 31 (20%) had been sick from waterborne illnesses in the last two weeks and 26 (16.8%) of HHs was sick in the last six months.

Table 4. 14 Sickness from waterborne

Sick from waterborne	Frequency	Valid Percent
1. Has … (each household member) been sick from waterborne diseases in the last two weeks?	31	20.0
2. Has … (any of the household members) had been sick from waterborne diseases in the last 6 months?	26	16.8

CHAPTER FIVE

5. Conclusions and Recommendations

5.1 CONCLUSIONS

Household water supply was affected by sources or/and point of distribution, fetching time, housing condition, distance travelled and household labor and cash at hand.

The study had shown that households were aware on water supply problems. They believed that limited access to water affected their water consumptions, uses and norms. It had two phases. These were limited quantity and quality. However, people preferred to access poor quality water than suffering from shortage/scarcity. They tend to use unprotected sources and inflicted with diseases that affected their health, income and livelihoods. HHs needed/demanded water timely, sufficiently and clean. Shortage was to mean when they could not access for their basic needs and demand means to mean when they could not produce something and sell to earn revenue.

The need to increased access to clean and adequate water, better sanitation facilities and services and hygiene calls for comprehensive intervention of different stakeholders for improvement of better life.

House renters, informal settlers/squatters, uphill dwellers and the homeless suffer from limited access to water more than house owners did. Yet, housing status was a precondition; People who suffered from limited access to water were house owners than renters, informal settlers, uphill dwellers and the homeless in size.

Access to water on time, good in quality and quantity was a problem in the study areas. When access to water decreased, time gap of empty tap in the household increased. Increased time gaps of empty tap increased water pollution in the households.

The study had shown that mothers and girls share the lion's share of water fetching responsibility. Time allocation for water fetching increased in case of empty taps. This had shifted time allocated for other homestead activities. Limited access to water shifted time allocated for other activities and increased time for water fetching.

Water storage practiced in the areas was to secure water in case the tap was empty for longer time.

Households receiving water with chlorine residue above WHO guideline must not treat with chlorine as this can increase concentration and can cause human harm. On the other hand, households who received water far away from the treated reservoir must treat the water. This was because chlorine concentration decreased and the water exposed to probable contaminants that can be pathogenic.

Open defecation, urination and unmanaged soiled wastes were a threat to water sanitation. As the number of HHs sharing the sanitation facility increases open defecation practices increases. Respondents reiterated about the importance of prioritizing household in-come rather than water quality, sanitation, hygiene and teachings about water sanitation in general.

It had been shown from the assessment that the color, taste, odor of the households tap water harvested was changed during bucketing into containers. The colors were reddish, blackish, yellowish, faeces like, urine like turbid, colloidal, viscoid, metallic residue like etc. The tastes were strong taste, unable to be swallowed, bitter, muddy, dusty etc. The odor was like rotten eggs, pungent smell, faeces, urine and any odd odor. The assessment in Kechene showed that 15.5% of the respondents indicated that cotton-bleaching chemicals were disposed into their village unsafely. These were water pollutants in the areas that could spoil water quality.

Limited access to water was the main problem in the study areas. It created competing demands in households. Water consumption, use and cultural norms were affected. It also caused HHs task and hygienic practices prioritization.

Hygienic and sanitation practices such as VIP and toilet washing were affected due to limited water access. It also created in house toilet facilities to be unhygienic. HHs income activities like cow bathing, cotton bleaching, pottery, lavajo and others were also affected.

HHs water consumptions like drinking and cooking and water uses of hygienic practices like utensil washing, bathing, childcare, sick and old care, morning and evening care, childbirth care were also affected.

Water rationing resulted in empty taps. Long stayed empty taps loaded waste into the pipe when it yielded water. Though water rationing principle seems advantageous to the less privileged communities, it has brought about two major problems one after the other. The first problem was empty tap and the subsequent was loading wastes into the tap.

Full pipes pump water without allowing external substances to enter into the system. However, in case of low volume flow of water or empty pipe and existence of breakage pipes, water seeps to the water distribution systems by negative pressure. Thus, when the system yields water from the sources; it pumps all wastes in the pipe and load into the HHs tap and containers.

Water sources and distribution points range from raw water, treatment plant, reservoirs, public taps, HHs connections, HHs storage containers, bottles, and glasses. Catchment areas water sources decreased in quantity because of economic and non-economic activities out there. Water sources decreased in quality for the same reasons. In addition, there was potential leakage and decrease of water in the course of transmission canal from treatment plant to chain recipient reservoir. Booster sources such as springs and wells were treated on adhoc basis. Most of the time, public taps and HHs containers were affected by contaminants by poor sanitation and poor hygiene respectively.

Sanitation was an outdoor problem while hygiene was an indoor one. Sanitation affected water quality in the AAWSA distribution systems while hygiene affected water quality during and after the water was fetched, in the storage containers and water glasses.

Limited access to water created poor sanitation. Wastewater was loaded to HHs pipe because of limited access to water. In contrast, poor sanitation affected water quality by loading wastes into the water systems. In addition, limited access to water created poor hygiene and poor hygiene affected water quality in turn.

Finally, pollutions could be transmitted to HHs containers from any sources in the distribution systems and affect water quality and hence consumption, use and norms. The only point to treat water and tackle quality problems were at treatment plant and HHs.

It was important to note that political leaders, catchment and all near and far residents' must be aware that any economic and non-economic activities affect present and future life of the water at their disposal

Water quality decreased from the treatment plant (clean water) to HHs containers whiles its sanitation problem decreases from HHs to treatment plant. This was because chlorination decreases as the watercourse in the canal and storage increases and waste intrusion into the water sources and distribution point increases. Thus, it created coincidence at household containers, taps and pipelines in the villages.

Laboratory result had shown that Ammonia, Ec, TDS, Fe, Mn, Turbidity, PH, E. coli and total coliforms were detected in the water sample.

5.2 RECOMMENDATIONS

AAWSA should provide clean, timely and sufficient water to the study areas residents. Kechene and shiromeda areas should be the attention of local government administration to access water by building public tap for those renters, dwellers, houses located at the uphills. Reservoir must be planted near the areas, other sources of water be searched. In general, the local government should work on public taps improvement as renters suffer from its lack. AAWSA has to supply water to house renters, squatters and uphill dwellers.

The community, AAWSA, local government, NGO's and Health Sectors must collaborate to educate the HHs on water supply, sanitation and hygiene;

AAWSA with the linkage it had already developed with catchment areas residents should strengthen the socio- economic department to continue awareness creation to catchment areas residents, community leaders, and local administration officers to reduce the treatment burden of cost that significantly increases monetary requirements.

Study Areas Rivers crossing the city with full of liquid and solid wastes must be in the attention of political actors and planners. Water pipelines and sewerage canals that are cased in one place needs to be lined separately. These potentially reduces water pollution from intrusion of wastes during the empty tap that loads wastes into household containers and cause water pollution and the subsequent diseases. This could be made up to the AAWSA operational standards.

AAWSA must coordinate, monitor and aware religious institutions, schools, prisons and bigger public gatherings for proper Water supply, sanitation and hygiene and quality of water. This can be done by integration of concerned bodies. The suggestions were considerations to be made in Woreda strategic Plans. Health, AAWSA and Municipal workers responsible for the study areas are expected to operate in coordination and collaboration in order to minimize redundancy of resources utilization and ensure efficiency of services.

AAWSA Water sampling must focus on households' pipeline complaint areas and down-hill places where liquids usually flow by gravity.

Like that of public tap, sanitation facilities and services were important to improve water supply, sanitation and hygiene coverage in the areas. Therefore, it was a necessary condition to build VIPs (Ventilated Improved Latrines) to reduce open defecation and hence reduce water pollution. VIPs must be water saving in its structure to flush faeces. It must flush VIP faeces from showering services.

AAWSA has to announce water-rationing schedule to households to ensure that they get prepared to fetch and store water before the yield stops.

Households are expected to clean water containers, committed to health teachings, and hand washing to reduce water contamination. Incentive systems to be adopted among model HHs until the practice is well adopted well. Livelihoods improvement interventions for the community must be in place or strengthened for the most needy community groups. Women focused livelihoods improvement interventions are likely to transform the poor family units.

Awareness creation must based on the community's context. Community educators should be aware and trained on socio-economic implications and goal of the education they deliver at community level. The training package of pre-service social and health community educators, to include adequate practical sessions on sociology of slum dweller communities.

The study areas respondents were advised to treat water at their home. It has to be part of the common practice that HHs treat water at HHs level.

Finally, it is important to share this thesis with Gulelle Sub city Woreda 01, Woreda 05 and Woreda 07 and come up with short term and long-term plans in relation to livelihood improvement goal and strategic objectives alongside rigorous stakeholders analysis.

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