ASSESSMENT OF THE QUALITY OF DRINKING WATER SUPPLY, DEMAND AND SANITATION CONDITION IN RURAL AREAS OF SHEBEDINO WOREDA SIDAMA ZONE, SNNPR.

MSc THESIS

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DEDICATION

This work is dedicated to Meseret Mulugeta for her altruistically unlimited encouragement to the educational betterment and for every success in my life.

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STATEMENT OF THE AUTHOR

This thesis is my original work and all sources of materials used for this thesis have been duly acknowledged. I declare that this thesis has not been submitted to any other university for the award of any academic degree.

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ABBREVIATIONS AND ACRONYMS

ADF	African Development Fund
ANOVA	Analysis of Variance
APHA	American public health association
BoWME	Bureau of Water, Mine and Energy
CFU	Colony Forming Unit
CSA	Central Statistics Agency
DEDWS	Draft Ethiopian Drinking Water Standards
DWSS	Drinking water supply and sanitation
EC	Electrical Conductivity
EEA	Ethiopian Economics Association
FC	Fecal Coliform
FMOH	Federal Ministry of Health
FMoWR	Federal Ministry of Water Resources
GIS	Geographic Information System
GPS	Geographic Position Systems
HHs	House holds
LCD	Liter per capita per day
m.a.s.l	Meter above sea level
MDGs	Millennium Development Goals
MoFED	Ministry of Finance and Economic Development
MPN	Most portable number
NGOs	Non Governmental Organization

NTU	Nephlometric turbidity unit
OECD	Organization for Economic Cooperation and Development
pH	Power of Hydrogen
RHB	Regional Health Bureau
RWSSI	Rural water supply and sanitation initiatives
SZFEDS	Sidama Zone Finance and Economic Development Sector
SZWM&ES	Sidama Zone Water, Mine and Energy Sector
SW-WaSH	Shebedino Woreda Water Sanitation and Hygiene
SWAFRO	Shebedino Woreda Animal & Fish Resource Office
SWHO	Shebedino Woreda Health Office
SWWMEO	Woreda Water, Mine and Energy Office
TC	Total Coliform
TDS	Total Dissolved Solid
UN	United Nations
UNEP	United Nations Environmental Programme
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USEPA	United State Environmental Protection Authority
WHO	World Health Organization
WSS	Water Supply and Sanitation

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ABSTRACT

Water is a natural resource of fundamental importance. Ethiopia is one of the developing countries with problems of water supply and sanitation. This study was conducted in Shebedino Woreda, Sidama Zone, Southern Nations Nationalities and Peoples State. The aims of this study was to assess the quality, accessibility of drinking water supply and sanitary condition and forecast the future demand by 2026. For this study 4 rural Kebeles and 11 Water points were selected by using systematic sampling method. For household survey, 120 respondents were selected from which 70 were male house headed and 50 were women who were primary responsible in fetching water. Questionnaires were used to assess sanitary and access of drinking water to the community and personal observation was used to identify a water point and to assess sanitary condition of the water source. Also Key informant' interviews were carried out to collect background information on hygienic behavior, accessibility of water supply and causes of water associated communicable diseases. Totally 33 samples (3 samples from each water point) were collected and tested in the laboratory to assess physico chemical and bacteriological quality of the drinking water. Data was analyzed using descriptive statistics and the result presented in frequencies, mean, standard deviation and percentages. The physico chemical and bacteriological parameters were analyzed using ANOVAs and the result was presented using tables and graphs. Based on the findings, the major problems regarding drinking water and sanitation were: low coverage (30.50%),low quantity (7.1 liters of average per capita consumption and also more than 96.67% *of the people take less than 20 liters of potable water), and long water fetching time (in average 47 minutes). Likewise, sanitation situation was not so healthy and encouraging. Many factors were responsible for poor sanitation. Some of them were lack of proper disposal of garbage and toilet waste and lack of knowledge of rural people about personal hygiene and health. The survey result showed that about 51.5% of the households were disposing baby faeces and solid wastes in the open field, majorities of them (70.36%) who constructed a latrine used it now and then and also more than 50% of respondents in the study area don't use water at all for hand washing after defecating. Physicochemical quality test showed that the concentration of Turbidity is very high in Sedeka Kebele at Lamala and Shemeta sites, in Howolso Kebele at Kitawo site and in Gonowagabalo Kebele at Burama and Handisa sites. Level of Manganese also higher in Remeda Kebele at Tado site, which is much greater than WHO guideline values and not suitable for drinking purpose. According to the result of Bacteriological quality test water supply in the studied area had mean number of total coliform and fecal coliform is 8.37and 4.87respectively,which is much greater than WHO guideline values and not suitable for drinking purpose. Therefore, the major copping strategies for the challenges are water points should be protected and water disinfection techniques should be used, evaluating the existing performance, adjusting periodically revised population growth, preventive and regular maintenance program, focusing on the construction of communal latrines and integrating water supply and sanitation sectors.*

***Key words**: Water accessibility, Sanitation, Water quality, Woreda, Household survey.*

1. INTRODUCTION

1.1. Background

No other single intervention is more likely to have a significant impact on global poverty than the provision of safe water. Water is a central theme, which can be used to achieve millennium development goals (MDGs) (Schuster Wallace et al., 2008). Water is a natural resource of fundamental importance. It supports all forms of life and creates jobs and wealth in the water sector, tourism, and recreation. As global slogan, “Water is Life” implies that water is one of the critical life need for a human being. Without water, life as it exists on our planet is impossible (Asthana and Asthana, 2001).

Water supply and sanitation are two of the most important sectors of development. Development of community water supply and sanitation results in improved social and economic conditions and improved health (Davis et al., 1993). The benefits of improved water supply and sanitation are many. Including prevention of disease, improved basic health care, better nutrition, increased access to institutions such as health centers and schools, improved water quality, increased quantity of and access to water, reduction in time and effort required for water collection, promotion of economic activity, strengthening of community organization, improvements in housing and ultimately improved quality of life (Okun, 1988).

As the world urban and rural population suffering from water, access to basic sanitation is also a challenge to these groups of world population. Africa has the lowest water supply coverage of the global regions and is second to Asia in terms of lowest sanitation coverage in which 62% of the population has access to improved water supply and 60% have access to improved sanitation (UNICEF, 2006).

In Africa, 602 million people had access to improved drinking water sources in 2006. This shows coverage increased from 56% in 1990 to 64%. The rate at which Africans gained access to improved drinking water sources, 245 million people since 1990, falls short of that required to meet the 2015 MDG drinking water target (Haysom, 2006). The key to increase human productivity and long life is good quality of water. The provision of good quality drinking water is often regarded as an important means of improving health. Although, some parts of the worldare making encouraging progress in meeting this Millennium Development Goals, serious disparities remain. Lack of access to improved drinking water is still a serious problem in large portions of Asia and Sub-Saharan Africa (WHO and UNICEF, 2004).

Even though, Ethiopia is a country with high ground water potential that has twelve major river basins, including the Blue Nile and eleven major lakes, which makes the country the "Water Tower" of East Africa. Yet, access to safe drinking water supplies and sanitation services in many parts of the country is among the lowest in Sub-Saharan Africa. While governmental and non-governmental organizations have been implementing water supply and sanitation projects in recent years, many lack sustainability due to improper management. This fact attributed to the service delivery modalities adopted by financers and implementing agencies (Yewondwossen, 2012).

Shebedino Woreda is characterized by potential surface water source having a number of rivers and springs. There is a huge ground and surface water potential in the Woreda. Despite the ground water supply potential of the Woreda, it is not possible to construct enough water schemes in all Kebeles. Even in Kebeles where there are improved water schemes, the water supply is not adequate for all and the functioning schemes themselves are not providing reliable and adequate services for different reasons to respect communities (SWWMEO, 2016).

This study was conducted in Shebedino Woreda, Sidama zone, SNNP Regional State, the water supply and sanitation challenges are still untouched and unsolved problems. The investigator considered from his observation and experience that the problem of water in the Woreda is growing from time to time. Improving the drinking water accessibility, quality and supply has a number of advantages for the society of the Woreda as well as for the government socially and economically.

1.2. Statement of the problem

Ethiopia ranks among the lowest countries in the world in levels of safe water and sanitation coverage 66% of Ethiopia's 83 million citizens do not have access to an improved water supply and 79% lack access to basic sanitation. The majority of Ethiopia's citizens live in rural areas where rates of coverage are even worse. Among rural Ethiopians, only 34% have access to an improved water supply (Water access in Ethiopia, 2013).

Shebedino is one of the Woreda found in rural Ethiopia, where the community does not have access to potable water and basic sanitation. Thus, the communities are forced to use water from unprotected water sources, which they may share with their animals. Access and quality of potable water supply and sanitation services are supposedly very sounding problem in study area. During field assessment it has been observed long distances (30-60) minute walking) to the water point that are unprotected water sources lead the community to poor hygiene practices. The current water supply sources are river, unprotected springs, open wells and shallow boreholes fitted with hand pump. Diarrhea and typhoid are the most prevalent water associated communicable diseases in the study area. The major problems related to water, sanitation and hygiene in the study area are lack of awareness of people and microbiological pollution. (SWWMEO, 2012).

The other major problems related to water, sanitation and hygiene in the study area are lack of awareness of people and microbiological pollution. Moreover, pesticides used in agricultural fields impose additional burden in the study area. Diarrhea, gastroenteritis, malaria, typhoid, and hepatitis are the most prevalent water associated communicable diseases in the study area (SWHO, 2016).

This research work therefore, specifically assessing the accessibility and quality of drinking water supply and sanitation the gap associated with water scarcity to initiate intervention measures in order to address the aforementioned problems in Shebedino Woreda.

1.3. Objectives

1.3.1. General objectives

The main objective of the study is to assess the accessibility and quality of drinking water supply, demand and sanitation condition in the study area.

1.3.2. Specific objectives

1. To assess accessibility of drinking water supply
2. To assess the quality of drinking water
3. To predict the future demand of supply
4. To assess sanitary and socio-economic condition of respondents related to water use

1.4 . Research questions

In order to address the above issues, the study attempted to answer the following four research questions:

a. How does the poor accessibility to potable water and basic sanitation affect the environment of the area?

b. Why demand for water exceeds the supply of water?

c. Does the water quality in the study area fulfill the established standards?

d. How do users evaluate the existing water supply and sanitation against their satisfaction?

1.5. Significance of the study

This study was found to be very important to reveal the problems of drinking water supply and sanitary condition of the studied area in terms of accessibility, quality, demand of the service provided by the sector. It has importance of providing information regarding water supply and sanitary condition in the study area that could be used as a base for further investigation in the sector. Moreover, this study has provided possible suggestions and recommendations on existing investigated water supply and sanitary challenges in order to improve the current condition of the sector and find a way to solve the problems and make the system sustain for coming generation.

2. LITERATURE REVIEW

2.1 Global issue in water supply and sanitation

Since 1970‟ s, there was a consensus that governments and donors should alleviate poverty in rural areas through providing basic needs such as drinking water, which was largely free at least in capital costs. This approach is now labeled as supply driven. The survival and wellbeing of a nation depends upon sustainable development and for this, water supply and sanitation which are ingredients of a healthy and productive life are essential requirements. For the poor people residing in urban slums and rural areas, to achieve a better economic growth rate and higher productivity, priority has to be given to the health of these people, for which provision of public utilities like water supply and sanitation is necessary (Pathak et al., 2002).

Water has always been a very important issue on the United Nations (UN) agenda. When defining the Millennium Development Goals (MDGs), water was also taken into account as one of the aspects for ensuring environmental sustainability. The aim of the UN is to reduce by half the proportion of people without sustainable access to safe drinking water by 2015 (UNICEF, 2006). The UN says guaranteeing a proper water supply is vital to eradicating poverty. It says the absolute daily minimum amount of water a person needs is 50 liters, which include 5 liters for drinking, 20 for sanitation and hygiene, 15 for bathing and 10 for preparing food. However, because of scarcity, millions of people try to exist on 10 liters a day. Achieving these goals requires sustainable economic and social development in developing countries. However, also notes that most of the constraints to development increasingly tied to water (WHO, 2003).

The consumption of unsafe water contributes to about 2.2 million deaths annually. The amount of disease and lost person-hours due to unclean water is vastly greater than the cost of improving water systems (WHO and UNICEF, 2008). Although only one of the MDGs directly relates to water, improved water management can make significant contributions to achieving most of the other goals. Inadequate supply of water has therefore been identified as one of the central causes of poverty in developing countries as it affects their basic needs, health, food security and basic livelihoods. Much of sustainable development therefore focuses on getting people out of poverty, while improved access to adequate and safe water has been shown to make a major contribution towards poverty alleviation (Katte et al., 2003).

Inaccessibility of safe water and adequate sanitation facility strengthens the cycle of disease, poverty and weakness; therefore, water and sanitation programs are instrumental in efforts to rescue people from poverty. In other word, provision of water and sanitation should be indispensable parts of the poverty reduction strategies applied by developing countries. In the developing world today, poor access to safe water and adequate sanitation continues to be a threat to human health. Expanding access to basic water supply and sanitation, integrated with hygiene education can reduce the burden of water-related diseases significantly by improving the lives of a large part of the world's population. Since provision of sanitation breaks the vicious cycle of poverty and initiates a virtuous cycle of economic well-being, it should be a vital ingredient in the poverty alleviation programs (Pathak et al., 2002).

According to the JMP (2010), Africa has the lowest total water supply coverage of any region, with only 62 percent of the population having access to improved water supply. The situation is worst in rural areas, where coverage is only 47 percent. Around 2.6 billion people do not have access to basic sanitation; and because of poor access to basic sanitation 1.5 million peoples die each year. Many of these people live in south East Asia and sub-Saharan Africa. Sanitation coverage in Africa also is poor, only 60 percent of the total population in Africa has sanitation coverage, with coverage varying from 84 percent in urban areas to 45 percent in rural areas.

2.2 Water Supply and Sanitation in Ethiopia

Provision of safe and sufficient water supply and adequate sanitation services are indispensable components in the sustainable development of Ethiopia's urban and rural socioeconomic wellbeing. At present, most of the population does not have adequate and safe access to water supply and sanitation (WSS) facilities. As a result, over 70% of the contagious diseases in the country are water borne/based diseases. Source of most of these diseases could be traced back to inadequate WSS facilities (MoWR, 2001).

Ethiopia has been trying to supply potable water to its population, without great success, for more than a century. While water for agricultural use has attracted high levels of investment, water resource management for domestic supply has been relatively neglected, especially before the post imperial period. Even today, rural water supply programs, which affect the majority of the country's population, have not been given sufficient attention (Rahmato, 1999).

The water distribution systems in the country are generally inadequate. The problem is associated partly with unfavorable topography, seasonal fluctuation of the water reservoirs, low capital investment and lack of efficient water governance among concerned authorities (Getachew, 2002; Tesfaye, 1985). Quite frequently Ethiopian planners emphasize the agronomic, engineering or technical aspects of water projects, while giving less attention to governance and participation of stakeholders. Rahmato (1999) observed that among the main reasons given for the slow progress in water supply services in the 1980s (but still relevant today) are: the lack of comprehensive water legislation; inadequate investment resources and the lack of a national water tariff policy. In order to address the low coverage, Ethiopia has committed itself to achieve the Millennium Development Goals (MDGs), including target 10, on halving the share of people without access to water and sanitation by 2015. To reach and surpass the MDGs, the Ministry of Water Resources introduced a Universal Access Plan (UAP) in 2005 with the aim to reach full coverage in water supply services for urban communities access is 20 liter per day per capita within 0.5 Km distance by the year 2012 (MoWR, 2006).

However the Ministry of Water Resources (MoWR) estimates that 33% of water supply schemes in Ethiopia are non-functional at any time, with negative impacts on coverage and universal access due to lack of funds for operation and maintenance, inadequate community mobilization and commitment and a lack of spare parts (Moriarty et al., 2009). However the paradox is Ethiopia has 12 major river basins, the total annual runoff from these basins is estimated at about 122 billion cubic meters (MoWR, 2000). Although a comprehensive national ground water resources study has not been conducted, some surveys suggest that the ground water potential in many parts of the country is high (UNDP, 2005).

2.3 Sanitation and hygiene promotion

Adequate sanitation and good hygiene knowledge and practice are more important for protecting water supplies than any other factor. Removing faeces safely from the environment eliminates the main source of water pollution. The proper use and maintenance of water facilities and the hygienic transport and storage of water protects the water supply chain from faecal contamination. But the importance of sanitation and hygiene goes far beyond protecting water quality because water is not the only transmission route in the faecal oral cycle. Improving the quality of water in sources, systems and homes can result in significant health benefits. However, one of the most important lessons learned from water supply programmes worldwide is that maximum health benefits are achieved if water interventions are accompanied by sanitation and hygiene promotion. (UNICEF, 2008).

In addition to this, the safe handling of drinking water at the household level can make a significant difference in terms of its bacteriological quality. As Kumie and Ali (2005) stated the latrine coverage of Ethiopia, the increase rate in proportion of population coverage in latrine use was less than 0.2 percent per year over the last 30 years at the national level since 1970. According to a study in 2005 treating water at the point of use can result in a 35% reduction in diarrhoeal disease (Clasen, 2005). The WHO have been actively promoting household water treatment (HWT) in combating waterborne disease, and advocate that it should be integrated into any water supply project as part of a holistic approach to improving health. A study conducted in squatter camps of Karachi, Pakistan revealed that washing hands with soap reduces diarrhoeal diseases by 53 %, pneumonia by 50 % and impetigo by 34 % (Luby et al., 2004).

Improving access to safe water and sanitation facilities leads to improved health in families and communities. However, when people are also motivated to practice good hygiene practices, health benefits are significantly increased. Hand-washing with soap can result in major health improvements: one review of studies worldwide documented a 45- percent reduction in diarrheal morbidity from improved hand-washing (Curtis and Cairncross, 2003) and another documented over 50 percent reductions in the incidence of both diarrhea and pneumonia when children washed their hands with soap (Luby et al, 2004). Hygiene is especially important for the survival and development of young children.

Good hygiene practices among mothers and other caregivers (especially hand-washing with soap after defecating and before preparing food, and the safe disposal of children's faeces) prevent diarrhea. Children's faeces are often not disposed of safely even though they are more likely to contain diarrheal pathogens than adult faeces. The UNICEF Multiple Indicator Cluster Surveys (MICS) carried out in 2000 in 17 African countries found that in more than half of households surveyed in rural areas the faeces of children less than three years old were not disposed of safely. There is a need to educate the people to dispose off the waste in proper places (Sethi, 1996; Ayres, 1998).

As Hutton et al., (2007) explain the occurrence of diarrheal diseases caused by unsafe drinking water and improper sanitation would be reduced if improvements were made in water and sanitation. Since diarrheal diseases are highly associated with unsafe drinking water and sanitation and poor hygiene, the improvements in water and sanitation would have a significant outcome.

The improvements in water supplies and sanitation also have an impact on poverty and economy, as it is logical that only healthy people are strong enough to work and fulfill their needs. As Hutton et al., (2007) stated the improvement to water and sanitation will have economic benefits of three types: direct economic benefits of avoiding diarrheal diseases, indirect economic benefits related to health improvements and non-health benefits related to improvements in water and sanitation. The direct economic benefits of avoiding diarrheal diseases include cost savings due to the reduced incidence of diarrheal disease, full health care costs, and non-health sector direct costs. The indirect economic benefits include productivity effects of improved health and the non-health benefits.

2.4 Water sources and sanitation classifications

Water for drinking purpose can be found from natural sources like surface water, ground water, and rainwater. Water from all these sources to use for household activities need treatment based up on their impurities. However, the treatment and the degree of cleanness of the water make the water safe or unsafe to drink. WHO and UNICEF classified water sources as improved and unimproved based on their purity to drink (JMP, 2006).

2.1 Elaborates the improved and unimproved water sources (Source: JMP, 2006).

Water Supply		Sanitation	
Improved	Unimproved	Improved	Unimproved
-Household connection -Public standpipe -Borehole -Protected dug well -Protected spring water -Rainwater collection	-Unprotected well -Unprotected Spring -Vendor-provided water -Bottled water -Tanker-truck provided	-Connection to a public Sewer -Connection to a septic System -Pour-flush latrine -Simple pit latrine -Ventilated improved pit Latrine	-Service or bucket Latrines -Public latrine -Latrines with an open pit

2.5 Existing estimates of per capita water requirements

A range of estimates of per capita water requirements have been developed. The WHO and UNICEF in their global assessment of water supply adopted the figure of 20 l/c/d for domestic hygiene purposes from a source located within one kilometer of a person's dwelling and coming from one of a range of technologies generally considered capable of supplying safe water. No clarification was given, however, about how their estimate of 20 l/c/d was derived. (Gleick, 1996), argues that at least 50 l/c/d are required to meet human and ecological needs, namely 5 l/c/d for drinking in tropical climates, 20 l/c/d for sanitation, 15 l/c/d for bathing and 10 l/c/d for food preparation (Gleick, 1996).

(Howard and Bartram, 2003), argue that 7.5 l/c/d can be calculated as the basic minimum water requirement to meet direct human consumptive needs, of which 2 l/c/d is required for food preparation. When water required for maintaining human hygiene is considered also, calculating a minimum water requirement becomes less precise as the effective use of water for hygiene purposes is more important than the quantity used, with only a very small quantity of water required to prevent water acting as an absolute constraint on hygiene). With basic access of approximately 20 l/c/d (7.3 m^3/c/y) it is unlikely that all water requirements for hygiene will be met; at 50 l/c/d (18.3 m^3/c/y) (intermediate access) most requirements can be met, and at 100 l/c/d (36.5 m^3/c/y) (optimum access) all requirements can be met (Howard and Bartram, 2003).Table 2.1: shows maximum per capita water requirements estimates.

Table 2.2 Minimum per capita water requirements estimates (Chenoweth, 2007)

Source	**Estimate (l/c/d)**	**Basis of estimate**
WHO/UNCEF (2000)	20	Basic domestic health and hygiene needs
Gleick(1996)	50	Basic domestic health and hygiene needs
Howard and Bartram(2003)	100	All domestic health and hygiene needs

2.6 Water demand analysis

Evaluation of the amount of water available and the amount of water demanded by the public are primary tasks in designing any water supply system. Demand of water is the amount of water required to meet all the needs of the people, which the system serves. It is expressed as per capital per day (l/c/d). Water resource planning requires reliable forecasts of population and water demand. Increasing populations translate into increased water demand for municipal, residential and commercial uses. Community growth, the growth of local commerce and industry and the development of new industries all increase demand for water. In planning the water system it is necessary to find out not only the total yearly water requirement but also to access the required average rate of flow and the variation in these rates (Kaika, 2003).

2.6.1 Population growth

The design of the water supply projects is done on the basis of projected population since it is the main factor which affects the water supply project. Future population growth can be influenced by affecting birth, death, or migration rates due to social, economic, political, technological, and scientific developments (Lee and Tuljapurkar, 1994; O'Neill et al., 2001).The two approaches commonly used for characterizing uncertainty in demographic forecasting are scenario and probabilistic. Scenario uses to describe its projections in consistent story in which fertility, mortality, and migration assumptions are embedded to provide a comprehensive picture of what the future might be. Probability distribution explicitly accounts for uncertainty in projected trends of fertility, mortality, and migration; and derives the resulting probability distributions for projected population size and age structure (Khatri and Vairavamoorthy, 2007). The knowledge of population forecasting is very important for the design of any water supply scheme. The design is done on the basis of projected population at the end of the design period. Otherwise a present scheme will be inadequate in the near future (Chatterjee, 2005).

2.6.2 Socio-economic changes

There is a strong correlation between water consumption and socio-economic changes. Examples are changing life style, changing housing type and household size, acceptability, and market penetration of water efficient appliances alternative sources of water, economic development, employment opportunities, education level, and water pricing (Bradley, 2004; Clarke et al., 1997; Scheider 1991). Forecasting and describing these parameters are subjected to uncertainties.

2.6.3 Climate change

Climate variability and change affect the availability of demand and quality of water, and runoff or temperature extremes. Different sources of uncertainties stemming from the climate change; such as future temperature, precipitation, sunshine duration, wind speed, relative humidity, evaporation rate, transpiration rate, soil moisture content will have significant impact on future water consumption. The extreme events (drought or frequent flood) will have also considerable impact on future demand. Therefore, how these climatic parameters changes in future will govern to water demand forecasting (IPCC, 2007)

2.7. Accessibility of Water

According to WHO (2008), access to safe water is the share of the population with reasonable access to an adequate amount of safe water. Safe water includes treated surface water and untreated but uncontaminated water such as from springs, medium/shallow wells and boreholes. In rural areas the water source a shallow well, hand dug and protected on-spot spring not more than 1.5km away from households. An adequate amount of water is that which is needed to satisfy metabolic, hygienic and domestic requirements usually about 15 liters of safe water per person per day. This minimum quantity, however, vary depending on whether it is an urban location or rural and whether warm or hot climate. Perhaps this is why the WHO (2008) described basic human water need to be 20 to 50 liters of uncontaminated water daily.

2.8. Water quality

To provide safe water there is a need to ensure that the quality of drinking water is assessed and monitored (UNEP, 2008). Quality is defined by certain physical, chemical and biological characteristics. Even a personal preference such as taste is a simple evaluation of acceptability. Drinking water quality is assessed by comparisons of water samples to drinking water quality Guidelines or standards (WHO, 2004).

2.8.1 Physicochemical drinking water quality aspects

Physical and Chemical testing of drinking water is necessary to assure that treated water is safe and palatable and to monitor the various water treatments for safe drinking water supply. Physicochemical testing of raw water is also helpful to determine treatment techniques and chemical dosage (Avcievala,1991; Eaton,1998).

Turbidity is a measure of the cloudiness of water and is used to indicate water quality and filtration effectiveness. Turbidity of natural water is caused by the presence of compounds such as clay, mud, organic matter, bacteria, and algae (WHO, 2003b). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria (APHA, 1998). These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches. Drinking water should have low turbidity since suspended particulates matter provides suitable sites for the growth of bacteria and other microorganisms which have health risk (Cairncross, 1990; Hutton 1996).

PH is one important water quality parameter, the pH of water, affects the biochemical process in water (Chapman, 1996). Most drinking water have a pH from 4 to 9 and the majority are slightly alkaline due to carbonates and bicarbonates of calcium and magnesium dissolved in water with variable pH are most likely contaminated and indicating the introduction of industrial wastes (Hutton, 1996).

Total dissolved solids (TDS) in waters constitute mainly carbonates, bicarbonates, chlorides, sulfates, calcium, magnesium, potassium, dissolved metals, dissolved organics and other substance account for a small portion of the dissolved residues in water. Dissolved solids and residues in drinking water tend to change the waters physical and chemical nature of drinking water (Zenaw, 1997). The WHO recommended limit of TDS concentration of drinking water should be 1000mg/l (Hutton, 1996).

Electrical Conductivity is the ability of aqueous solution to carry an electric current, this ability depends on the Electrical conductivity presence of ion and waters with high inorganic compounds are relatively good conductors indicates water quality. Electrical conductivity of the water is related to total concentration of ions in the water, their valence charge and mobility (AWWA, 2000).

Hardness is measure of concentration of calcium and magnesium salt in water, is important variable for drinking water quality. They are generally present as carbonate and bicarbonate salts. Scaling problem in pipes and utensil makes hard water objected by consumers in addition to its health and taste discomfort. Magnesium is the major contributor to hardness and like calcium, concentration of magnesium above 150mg/l especially if present with sulfate can cause gastrointestinal irritation and diarrhea; some salts of magnesium in water are toxic by ingestion or inhalation, concentration of magnesium greater than 125mg/l also can have a cathartic and diuretic effect (Clesceri et al., 1998).

Fluoride is found naturally in much water, it is also added in many water systems to reduce tooth decay. Excessive fluoride concentration can cause stained or mottled teeth (Sandra, 1996). This is true where the natural fluoride content is above 2.4mg/l the concentration of fluoride in drinking water is critical when considering the strength of growing teeth and bones.

Chlorine as the chloride ion is the major constituent in water and waste water with a wide range of concentration from few mg/l in clean rain to 10 of mg/l in supersaturated, hot saline ground water. Chloride may be increased in surface water since it is concentrated in human and animal urine reaching water courses. Human urine may contain 1-1.5% of NaCl. A related health problem of chlorine contamination in drinking water includes Eye/nose irritation; Anemia; Infants and young children: nervous system effects (Sandra, 1996).

Nitrate is an end product of the decay of nitrogenous material such as nitrate fertilizers or animal and human excreta (Hutton, 1996). Its presence in a water supply usually denotes bacterial activity as a result of recent or on-going pollution, often from sewerage. Nitrogen fertilizers are causing high level of nitrates in water supplies (Andreoli, 1993). Health hazards of high nitrate level in drinking water include shortness of breath and blue-baby syndrome and other disorders (Sandra, 1996; WHO, 2004).

Total chlorine or residual chlorine

In areas where there is little risk of a waterborne outbreak, residual free chlorine of 0.2 to 0.5 mg/l at all points in the supply is recommended General system failures, inefficiency in disinfection, poor maintenance are some of factors that affect the quality of water in Ethiopia (Dagnew et al., 2007). Therefore, when water leaves the treatment plant residual free chlorine of about 1 mg/l is needed for health reasons and it is recommended that such level is maintained at points of consumption (Momba et al., 2006).

2.8.2 Bacteriological drinking water quality aspects

The most common bacteriological water quality indicators include TC, FC and E.coli. An indicator organism may not necessarily pose a health risk but it can be easily isolated and enumerated, is present in large numbers, is more resistant to disinfection than pathogens, and does not multiply in water and distribution systems (WHO, 2008). Indicator bacteria are used to evaluate the potability of drinking water because it would be impossible to accurately enumerate all pathogenic organisms that are transmitted by water. Coliforms are a group of bacteria with common characteristics used to indicate unacceptable water quality. The presence of any coliform organism in drinking water is used as an indicator of faecal contamination since they are the most sensitive indicator bacteria for demonstrating excretal contamination. Within the total coliforms group, E.Coli bacteria specifically used to indicate faecal contamination Escherichia coli (E.coli), a thermo tolerant coliform, is found to be the most numerous in animal or human faeces of the total coliform group, rarely grows in the environment and is considered the most specific indicator of faecal contamination in drinking water. The presence of E.coli provides strong evidence of recent faecal contamination (Erah et al., 2002).

2.8.3 Water quality guidelines and standards

The World Health Organization (WHO) drinking water quality guidelines provide international norms on water quality and human health that are used as the basis for regulation and standard setting, in developing and developed countries worldwide. These guidelines are adopted by many countries as national guidelines to follow. These countries including Ethiopia set drinking water quality guidelines based on the WHO guidelines but may modify these based on what is achievable in the country.

Table 2.3 Maximum allowable concentrations of selected water quality variables for drinking uses (WHO, 2008; ES, 2002)

Parameters		**Unit**	**WHO guideline**	**Ethiopian Standard**
Physical Parameters	Temperature	°C	<15	-
	Turbidity	NTU	5	7
	EC	µs/cm	1000	1500
	pH	pH	6.5 - 8.5	6.5 - 8.5
Chemical parameters	TDS(mg/l)	mg/l	1000	1000
	Nitrate	mg/l	50	50
	Chloride	mg/l	250	250
	Fluoride	mg/l	1.5	3
	Total Hardness (CaCO3)	mg/l	300	300
	Iron	mg/l	0.3	0.4
	Magnesium	mg/l	50	50
	Phosphate	mg/l	0.005	0.02
Bacteriological parameters	E. Coli/thermo tolerant coliform bacteria	CFU	0/100ml	0/100ml

2.8.4 The effects of poor water quality

In spite of concerted efforts to improve access to safe drinking water (notably the International Drinking Water and Sanitation Decade, from 1981 to 1990), an estimated 1.1 billion people lack access to an improved water source. Over three million people, mostly children, die annually from water-related diseases. Almost two million of these deaths are the result of diarrheal diseases, which are caused by the ingestion of water contaminated by faecal matter, as well as by inadequate sanitation and hygiene. Contaminated water resources can also contribute to the spread of diseases caused by skin contact or by vectors (UNICEF, 2008).

Diseases caused by contaminated water consumption and poor hygiene practices are the leading causes of death among children worldwide. Water may be contaminated with pathogens at the source but contamination may also occur during distribution, transportation, or handling in households or other working places (WHO, 2004). Inadequate protection of water collection and storage containers and unhygienic conditions contribute to contamination at home (Nath et al., 2006).

The consequences of poor water quality go beyond health. Chronic bouts of water-related diseases impose significant social and economic burdens both on victims themselves and society as a whole. Poverty alleviation and the other Millennium Development Goals will be difficult to achieve without improvements in water quality (UNICEF, 2008). While microbiological contamination is the largest public health threat, chemical contamination can be a major health concern in some cases. Water can be chemically contaminated through natural causes (arsenic, fluoride) or through human activity (nitrate, heavy metals, and pesticides). The physical quality of water (e.g., color, taste) must also be considered. Water of poor physical quality does not directly cause disease, but it may be aesthetically unacceptable to consumers, and may force them to use less safe sources. Finally, drinking water can be contaminated with radioactivity, either from natural or man-made nuclear (UNICEF, 2008).

3. MATERIALS AND METHODS

3.1. Description of the study area

Shebedino Woreda is one of 19 Woredas in Sidama zone and covers a total area of 245.15km²,which is located at about 298 km south of Addis Ababa. The Woreda is subdivided in to 32 peasant associations . The capital town of Shebedino Woreda is Leku and it is bordered on the south by the Dale Woreda, on the west by the Boricha Woreda, on the north by Awasa zuriya Woreda and Hawassa town administration and on the east by Gorche Woreda, between Latitude: 6° 50' (6.8333°) north and Longitude: 38° 30' (38.5°) east (CSA 2007).

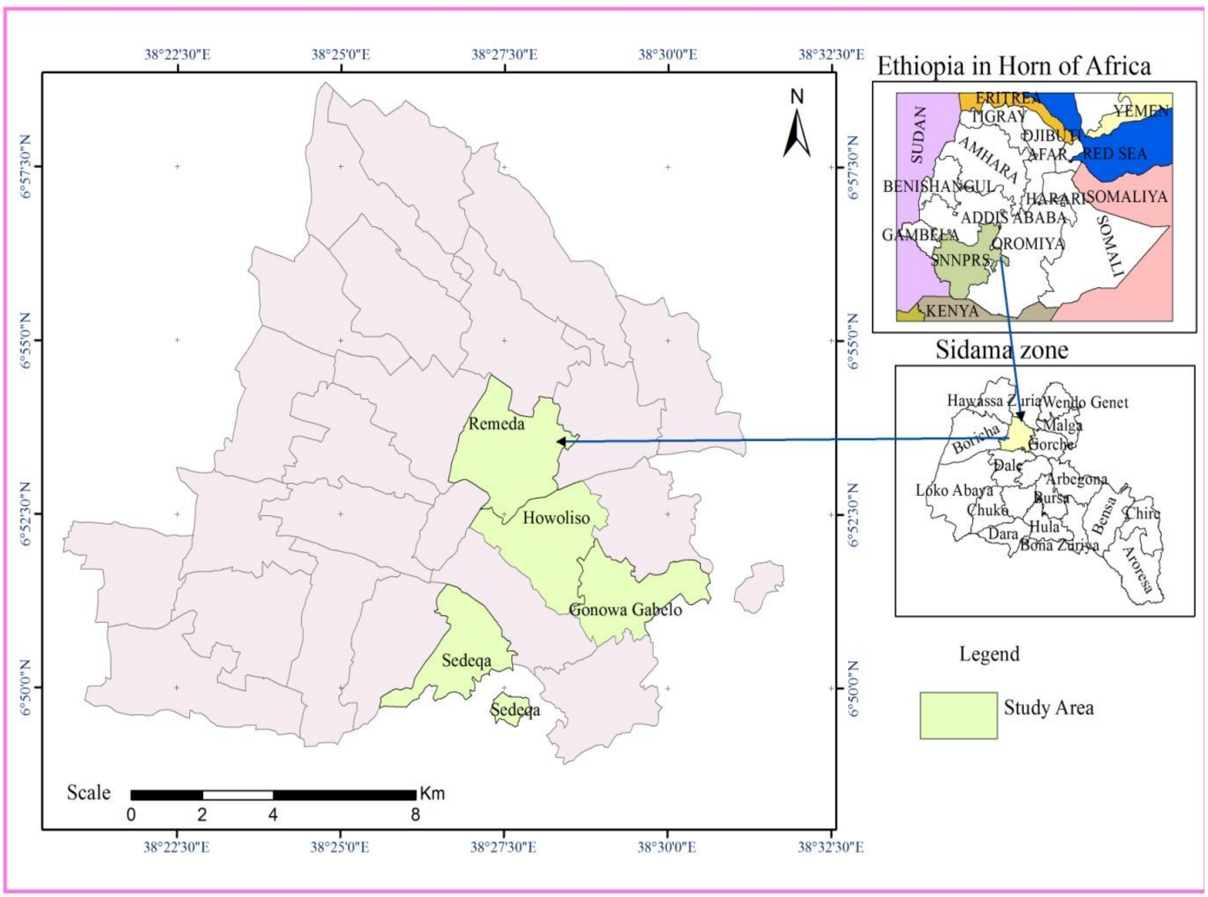

Figure 3.1. Location of the Study area (Source: SRFEDB, 2016).

3.1.1. Climate

The Woreda possesses the two sub climatic division zones of Woina dega and Dega. The majority of the area of the woreda is Woina dega. Wet and dry season is Jun- Sep and Oct-May, respectively. The Woreda is characterized by rugged terrain covered by green vegetation consisting of inset coffee and different types of mature indigenous trees & increasingly expanding eucalyptus trees. The average annual rain fall is 1000-1300mm. And the elevation ranges from 1760-2800 m.a.s.l (SW-WaSH,2005).

3.1.2. Population size and density

According to national population and housing census of the Ethiopian Federal Democratic Republic (EFDR), Central Statistical Authority (CSA, 2007), the projected total rural population of the study Woreda currently estimated to be 294,213 with the total area of 245.15km^2 and the average density of 1200 persons/ km^2. It is the second most densely populated Woreda in Ethiopia. From the total population 148,514 are female and 145,699 are male. Regarding the ethnic composition of the Woreda 97% of the population predominantly is Sidama, 1.6% Amhara 0.6% Oromo and the rest 0.8% is from different ethnic groups (CSA, 2007).

3.1.3 Economy

According to Shebedino Woreda water sanitation & hygiene (SW-WaSH) 5 years strategic program, the major source of the income in the Woreda is crop production, livestock rearing, petty trade, labor & carpenter. The major crop grown are inset, coffee, maize & chat. Coffee and chat are major cash crops. The live stocks raised in the area are cattle, sheep, goat, donkey & poultry & has significant contribution for income. Inset followed by maize and potato constitute the staple food production in the area (SW-WaSH, 2005). The total population of livestock in the Shebedino Woreda is 300,252 indicated as (Appendix 5).

3.1.4 Existing potable water supply condition in the woreda

According to the Shebedino Woreda Water, Sanitation & Hygiene (SW-WaSH, 2005) some development activities is done by zonal, Woreda Water Mine and Energy Office (WWMEO) and other NGOs to alleviate problem of potable water in the Woreda. The potable water supply sources of the Woreda are spot springs, hand dug wells with hand pumps and boreholes

(SW-WaSH, 2005). Table3.2 Summarizes type and number of existing water supply schemes in Shebedino Woreda.

Table 3.1:The operational status of water schemes constructed in Shebedino Woreda and their condition (SWWMEO, 2017).

Ser. No	**Type of water schemes**	**Present condition**		**Total No of schemes**
		Functional	**Non-functional**	
1	Hand dug well fitted with hand pump	29	26	55
2	Deep wells with distribution	18	4	22
3	Spot springs	78	0	78
	Total No schemes	125	30	155

Shebedino Woreda is situated in two topographically distinct areas. i.e. the Eastern Escarpment and the floor of the Ethiopian Rift valley system. As a result of this, the areas which are situated on the eastern escarpment are characterized by locally undulating topography with the general topography descending towards west. As a result, surface water and ground water follow from east to west, towards Hawassa Lake and Gidabo River. The areas, which are situated on the floor of the rift system, are characterized by plain topography associated with ridges (SW-WaSH, 2005).

One of the objectives of the development plan of the regional state is to provide the society with the pure drinking water to rural areas. Accordingly, some development activities have been done by zonal, Woreda Water Resources Office (WWRO) and other NGOs to alleviate problem of potable water in the Woreda. The potable water supply sources of the Woreda are protected springs, hand dug wells with pumps and boreholes (SW-WaSH, 2005). Among these water supply sources, most of the time, hand dug wells with pumps and borehole become non-functional rather than spot springs, because of drying of sources and damage of hand pump deep well spare parts. According to SW WaSH, (2005), operation and maintenances of water schemes are categorized under small and large. Small maintenance is carried by the local trained water committee, especially hand pump maintenance. Large maintenance is maintained and operated by the Woreda Water office and Regional Water Bureau (SW-WaSH, 2005).

3.2. Data collection

In this study, both primary and secondary data were used. Primary water quality data was collected by conducting laboratory test of water samples taken from 11 different water schemes selected from four studied Kebeles. From all of the 11 selected schemes, sample was taken by the replication of three times to take mean result of the values. Accordingly, 33 samples of water were taken. Geographical Positioning System (GPS) reading was used for mapping.

For Physico-chemical quality data, some parameters like pH, Turbidity, EC and Temperature was tested at the site and the rest were collected by using polyethylene plastic bottles. The bottles were washed by distilled water before they were used for sample collection. Hence, 33 bottle of sample water was taken to laboratory of Inistitute of Technology at Hawassa University. At the time of testing one parameter (Cl), then the sample was taken to Southern Region Bureau of Water and tested. For bacteriological quality data, water sample was taken from the sources immediately to reduce contamination while transporting the sample to the laboratory and tested following instructions in manual with the help of laboratory technician. In this way, data of 33 observations were collected for all parameters of quality test.

Primary data for socioeconomic condition of respondents, water accessibility, water supply and sanitary condition of the study area was collected by interviewing respondent households. From each household, individual who is the head of household whether male or female was selected as respondent.

The Questionnaires of the interview were structured and unstructured. Discussions with the communities, water use committees, Health extension workers, Kebele administrators and experts of the Woreda also helped a lot to develop qualitative data to discuss on the objectives of this study. Secondary data was also collected to study all the stated objectives more. Secondary data have been collected from existing documents, books, journals, reports, and other sources from sectorial offices and concerned bureaus inside and outside the Woreda.

3.3. Determination of sample size and sampling procedure

3.3.1. Determination of sample size

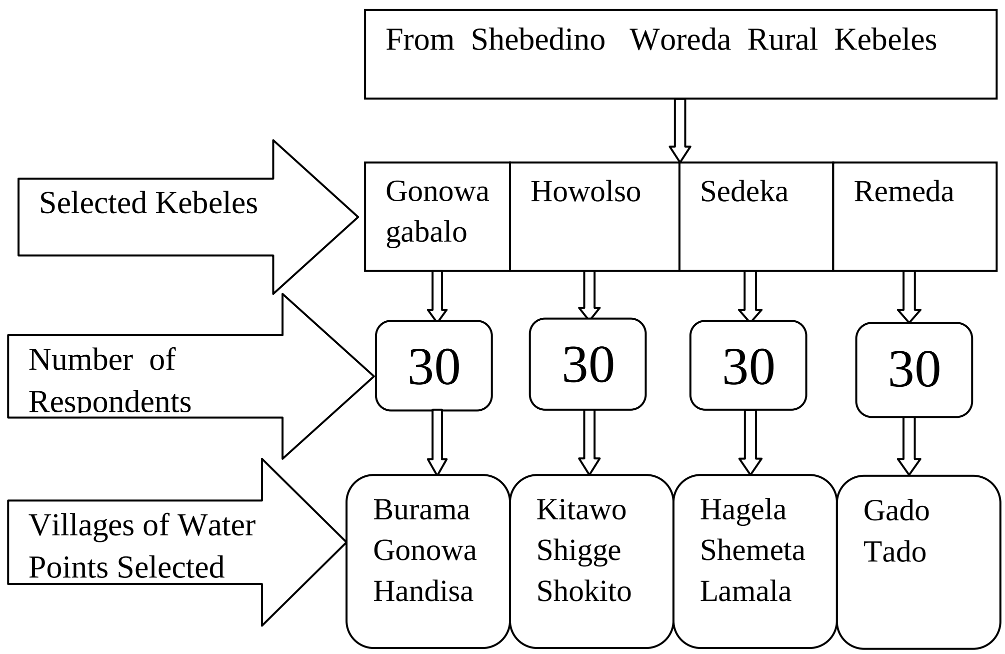

Figure 3.2 Diagram indicating size of respondent households and water sampling Points (Villages).

3.3.2. Selection of sample Kebeles and sampling schemes in the Kebeles

For this study, four Kebeles were selected systematically that it was appropriate to include all types of existing water schemes used for drinking purpose in the area. Kebeles with seasonal water scarcity, shortage of water availability and poor accessibility of water supply were given priority to be selected as sample Kebeles. For this systematic selection, most of the relevant information was obtained from Woreda Water Resource Office. Accordingly, four Kebeles selected were Gonowa gabalo, Howolso, Sedeka, and Remeda Kebeles.

After selection of Kebeles, 11 different water schemes were selected for water sampling, three schemes from Gonowa gabalo, Howolso and Sedeka Kebeles and two schemes from Remeda Kebele. Selection of schemes was made based on types of water schemes available in the Kebele and administrative structure of Kebeles into sub-communities called "Villages". Each of the Kebeles in the Woreda has three administrative Villages. One water scheme from each village and three schemes from each three Kebeles and two scheme from Remeda Kebele were selected.

In Gonowa gabalo, Howolso, and Sedeka Kebeles, more proportion of people living in all villages commonly get drinking water service from natural springs (protected and non protected). From those springs two schemes were unprotected which is found in Gonowa gabalo Kebele at Burama village and in Sedeka Kebele at Hagela village. In these three Kebeles bore holes and hand pump schemes are available but non-functional due to technical problems. In Remeda Kebele the two villages people getting drinking water from the source of Leku town bore holes installed in these two villages (Gado and Tado), and the third village which is (Galuko village) adjacent from Galuko haro Kebele all of people from the village fetches water from there.

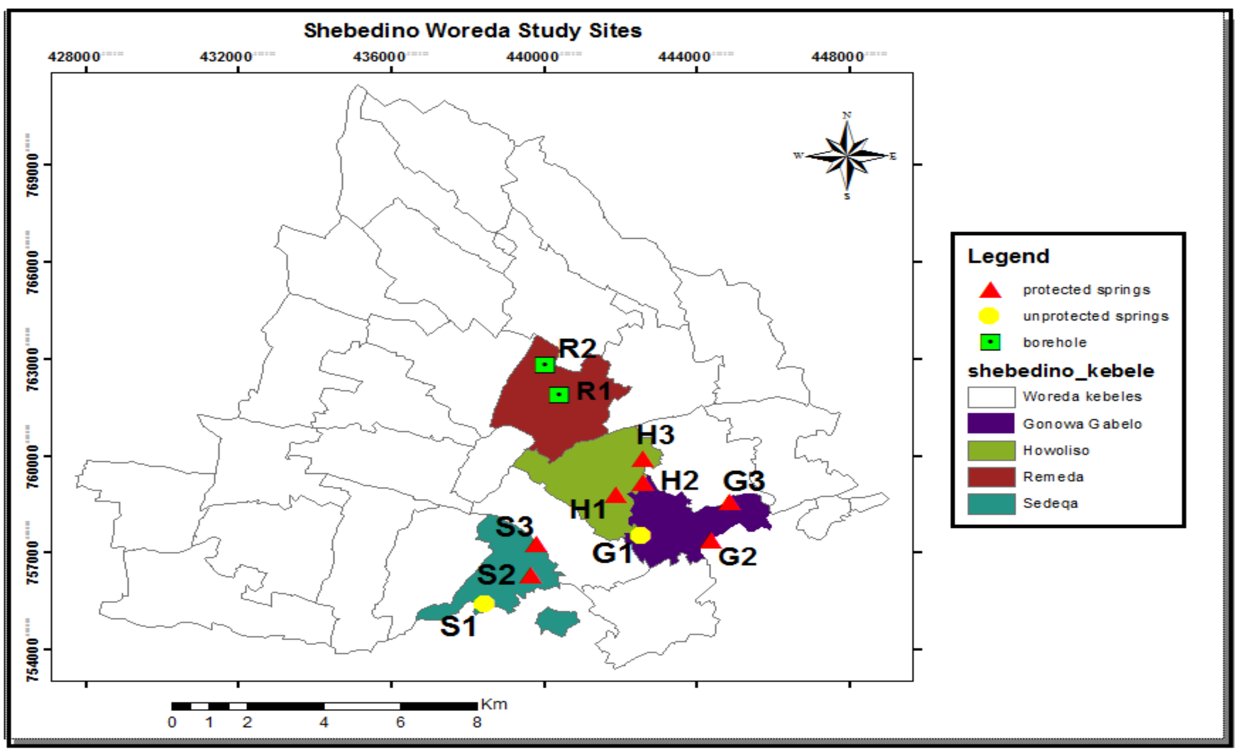

Figure 3.3 Map of Shebedino Woreda indicating water schemes used for water sample

In Figure 3.3 , four Kebeles from where water samples collected were identified by respective color and names in the legend. R1 and R2 are borehole water points used for water sampling in Remeda Kebele. G1 and S1 is unprotected spring water points used for water sampling in Gonowa gabalo and Sedeka Kebeles. G2, G3, H1, H2, H3, S2 and S3 are protected spring water sources in Gonowa gabalo, Howolso and Sedeka Kebeles used for sample collection.

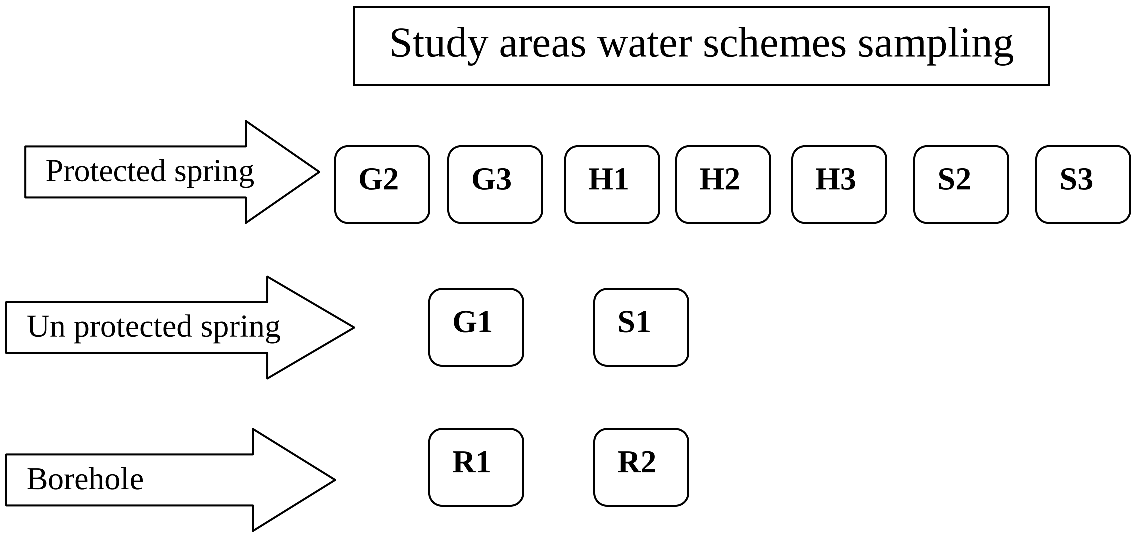

Figure 3.4 Selected water schemes sampling on the study areas.

Beneficiaries are the main primary data sources in this study. In order to ensure the generalization of the findings to larger population, the study considered adequate sample respondents for selection through appropriate techniques. The numbers of sample households for interview were determined using the formula developed by Cochran (1977).

$$n' = \frac{z^2 pq}{d^2} \quad \ldots\ldots\ldots\ldots\ldots(3.1) \text{ and } \quad n = \frac{n'}{1 + \frac{n' - 1}{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Where, n' = desired sample size when the population is greater than 10,000

n= No of samples size when population is less than 10,000

Z= 95% confidence limit (z-value at 0.05 is 1.96)

P= 0.05 (proportion of the population to be included in the sample i.e. 5%)

q= 1-0.05 i.e.(0.95), N= total No of population (6087) and

d= margin of error or degree of accuracy (0.05).

Since the population (HHs) of the Kebele involved in the study area are less than 10,000; in number both equations (1&2) are used to determine sample size required for this study as shown below: $n' = \frac{z^2pq}{d^2}$ = $(1.95)^2$x(0.05)x(0.95)/$(0.05)^2$=72.24 then,

$$n = \frac{n'}{1 + \frac{n'-1}{N}}$$ =72.24/(1+(71.24/6087=71

The investigator found that the calculated sample size was only 1.16 % of total average households in four selected Kebeles for the study. Therefore, the researcher decided to use 2% of the total households for better representation. Finally, number of sample households used for interview in the study was determined by taking 2% of 6,040 households, which was average total household number in the selected Kebeles. This was calculated as 0.02*6,040=120.8. So, 120 households, 30 from each Kebele were used for interview in this study.

3.3.4 Present and future population projection

The Central Statistical Authority (CSA) is the recognized Ethiopian organization to determine the official population figures and growth rates that should be taken for any development activity throughout the country. Population data of Shebedino Woreda were collected from central static authority with two purposes. Firstly to know the present population that is served by the existing water supply system, Secondly to forecast the future population of the Woreda to be served from water supply system.

Several models are used but it should be pointed out that the judgment was made based on the trend of population growth and to minimize uncertainties that may occur due to improper estimation of the population. Therefore, the constant population growth rate of 2.8 (%) was used and method used by Ethiopia Statistic Authority was adopted for this scenario for the purpose of future population forecast of the rural areas of the Woreda. The baseline population figure of rural areas of the Woreda as per CSA was 286,200 for the year 2016.

Method used by Ethiopian statistic Authority (CSA, 2007) can be written as:

$$P_n = P_o e^{rn} \ldots\ldots\ldots\ldots\ldots\ldots..(3.3)$$

Where, P_n = Population at n decade or years   **n** = decade or year

r = growth rate in % P_o = present population

3.3.5 Present and future water demand forecasting

To determine the total quantity of water utilized by various purposes the water demand need to be known. After considering some factors which affect all types of water demands, the water demand forecast were made.

3.3.5.1 Domestic water demand (DWD)

Water is utilized in the houses for different uses. The residential or domestic use includes water requirements for drinking, cooking, bathing, washing of clothes, utensils and house, and flushing of water closets. The quantity required for domestic demand mainly depends on climatic conditions, the social and customs of the people. Therefore, the daily domestic water demand (DWD) is projected by adopting the per capita water consumption recommended for rural communities by Ministry of Water Resource of Ethiopia. The Ministry of Water Resource has adopted the general design standards of 30 to 50 liters per capita daily (lpcd) for urban centers and 15–25 lpcd for rural areas. For rural water supply, the daily DWD is projected as being: 15 lpcd for short term (2002-2006), 20 lpcd for medium term (2007-2011) and 25 lpcd for long term (2012-2016) (MoWR, 2002).

Therefore, there is a rational ground to adopt the per capita consumption of 25 liters to make the demand forecast for the coming ten years.

$$DWD = PnAWD \ldots\ldots\ldots\ldots\ldots\ldots..(3.4)$$

Where, DWD =Domestic water demand   Pn = Population at the target year

AWD = Average per capital domestic water demand

3.3.5.2 Livestock water demand (LWD)

The custody of livestock is an integral part of rural community life, and water is an essential commodity for animals just as it is for humans. However, the use of improved domestic water sources for livestock is not encouraged. It is assumed that most of the animals will be watered from such natural sources as rivers, streams, lakes, ponds, and springs in the vicinity. If no such sources are available nearby for the livestock, the animals should be watered from cattle troughs sited below water sources for human consumption. In case potable water supply schemes are to be used for livestock watering, an allowance of 3 lpcd is made (MoWR, 2002).

Since in some part of the Woreda households use the cattle troughs at water sources to water their livestock as acquired during personal observations and site visit. Moreover, 67.5 % of respondents indicated their using the same water sources for animal watering. Livestock water demand is therefore incorporated in this Woreda water supply demand analysis. Hence, water sources designed considering the needs for the rural livelihood in addition to the domestic water demands by the households.

While estimating Livestock water demand, relationship with size of population was captured as follows: (a) 60 per cent of the population in rural communities; (b) 30 per cent of the population of towns with fewer than 10,000 inhabitants; (c) 9 per cent of the population of towns with 10,000 –50,000 inhabitants; and (d) 1 per cent of the population of towns exceeding 50,000 inhabitants (MoWR, 2002). By adopting 60% of the population in the rural communities population projection for livestock water demand was estimated (Table 3.2).

Table 3.2 Population projection for human and livestock water demand of Shebedino Woreda rural area (2016-2026

Year	**Projected Human population**	**Projected Livestock population**
2016	286,200	171,720
2017	294,213	176,528
2018	302,451	181,471
2019	310,920	186,552
2020	319,626	191,776
2021	328,576	197,146
2022	337,776	202,666
2023	347,234	208,340
2024	356,957	241,174
2025	366,952	220,171
2026	377,227	226,336

3.3.5.3 Commercial and institutional water demand (CIWD)

In addition to those of household consumers, the water requirements of public utilities include the needs of such commercial and institutional consumers as public schools, clinics, hospitals, offices, shops, bars, restaurants, and hotels. For small- and medium-sized towns, it was estimated at 5 per cent of the DWD. For larger towns, the CIWD estimate was 10 percent of DWD but no allowances were made for CIWD for rural communities (MOWR, 2002).

3.3.5.4 Industrial water demand (IWD)

For planning purposes, a reliable IWD indicator was assumed to be the following percentages of DWD: 30 per cent of DWD in large and medium towns; and 10 per cent of DWD in small towns. As far as possible, large- and medium-sized industries are assumed to provide water supply from own sources. No IWD allowance was made for rural communities.

3.3.5.5 System losses (SL)

It is obvious that all the water which goes in distribution pipes does not reach the consumers. Some portion of this is wasted in the pipe lines due to defective pipe-joints, cracked and broken pipes, loose valves and fittings. Sometimes consumers keep open their taps even when they are not using the water and allow continuous wastage of water. The water loss in the distribution system was considered to be a function of the ages of the distribution system.

But due to unavailability of sufficient data associated with unreliable metering, the volume of water loss could not be assessed in rural areas. While estimating the total requirement of water of the Woreda, allowance of 10% of the total water demand for the losses is adopted (MOWR, 2002).

Therefore, SL = 10% (DWD + LWD)…………..(3.5)

Where:

SL = System losses

DWD = Domestic water demand

LWD = Live stock water demand

3.3.5.6 Total average daily demand (ADD)

Rural TADD for water supply is the combined total of domestic demand, livestock demand and system losses.

TADD= DWD + LWD +SL………………(3.6)

3.4. Water sample collection and quality analysis

To assess the physico-chemical and bacteriological quality of water in the sample Kebele, 3 samples were taken from the 3 Kebeles (Gonowa gabalo, Howolso and Sedeka) and 2 samples also from the one Kebele which is Remeda this was because no other sources were in the Kebele.

To assess the physico-chemical and bacteriological quality of water, 33 samples were collected from 11 sample points of 4 Kebeles and tested in the laboratory of Hawassa University Institute of Technology. That means, from one sample site, 3 samples were taken for precession. Samples were collected in polyethylene plastic bottles and sterilized bottle for different physico-chemical parameters and bacteriological parameter.

Water sampling and preservation techniques followed the standard methods of water sampling and preservation techniques (APHA, 1998). For physico-chemical parameters before collection bottles were washed with concentrated nitric acid and distilled water to avoid contamination. Also for bacteriological parameters bottles were sterilized using ethanol alcohol.

Physico-chemical and bacteriological parameters were selected based on information given by the laboratory technicians. For each sample, a code was assigned with respective Kebeles such as Gonowa gabalo (G1, G2 and G3), Howolso (H1, H2 and H3), Sedeka (S1, S2 and S3), and Remeda (R1 and R2) as represented in Figure 3.2.The Figure shows selected water sampling sites from the GPS reading (using GIS arc view).

After the samples were taken, different Physico-chemical and Bacteriological qualities of sample water were analyzed in the laboratory. Physico-chemical water quality parameters of water supply that were analyzed include turbidity, electro-conductivity, chloride, fluoride, nitrate, nitrite, pH, Iron, manganese, total hardness, and total dissolved solid.

Physico- chemical and bacteriological parameters were measured and analyzed on the site and in the laboratory. pH of the sample water was measured by using PH meter of (model 211, HANNA, Portugal). Electrical Conductivity and total dissolved solids were measured by Conductivity meter (model 4200, Jenway, England). Nitrate, nitrite, Fluoride and iron were analyzed calorimetrically using HACH spectrophotometer (DR/2010, USA) according to HACH procedural manual (HACH, 1999). Palintest fluoride No 1 and Palintest fluoride No 2 tablets were reagents used to test fluoride. Palintest Nitratest powder, Palintest Nitratest Tablets and Palintest Nitricol Tablets were reagents used in testing nitrate. Palintest Nitricol Tablets were used in testing nitrite. Total hardness and chloride were analyzed calorimetrically by using titration method. Turbidity was measured metrically by using HACH spectrometer.

All of the considered parameters were tested according to procedures in the manual. Water samples were also analyzed to test total coliform and fecal coliform. Bacteriological analysis was made by conducting test at the site of water schemes following instructions in the manual in order to reduce contamination while transporting the sample water. This was made to identify total and fecal coliform in the sample water. All the instruments were sterilized with ethanol before testing the sample. According to American Public Health Authority (APHA, 1998), filter membrane technique was used and the membrane was incubated on a growth promoting medium for 24 hrs at 37°c to identify total coliform and at 44°c to identify fecal coliform.

3.5. Data analysis

Data of Physico-chemical and bacteriological water quality was analyzed by computing overall mean value for each parameter. Mean values of each parameter for selected Kebeles was also computed. To understand the variation of concentrations of studied water quality parameters from one sampling site to the other, ANOVA was used. The mean values of quality data was presented by table along with Ethiopia and WHO guideline value for drinking water quality of each parameter for comparison. Graphical presentation was also used to show findings of quality data with respective WHO guideline.

Qualitative data collected from respondents, discussion with community, water committee and other key informants was entered and analyzed by descriptive statistics for the study of socioeconomic characteristics, water accessibility, water supply and sanitary condition. Percentages, proportions, standard deviations and means were descriptive statistics used to analyze the data for the objectives in this study.

Water accessibility data analyzed by descriptive statistics was about drinking water sources, time spent on accessing water, per capita water consumption, consumers' satisfaction and water supply coverage. Data of sanitary condition include type and latrine availability, coverage, habit of using pit latrine, disposing baby faeces and solid wastes and materials used for hand washing after defecation . Socioeconomic data include age, sex and size of respondent households. Tables and graphs were used for presenting and discussing findings of all objectives as necessary.

Water supply coverage was calculated based on secondary data of population and water schemes. The formula depends on population of Kebeles and type and number of water schemes existing in the Kebeles.

Coverage in % = $(Ps \div Pk)$x100;…………………..(3.7)

Where, Ps= Expected number of people to have service by total available schemes

Pk= Total population of the Kebele.

Table 3.3 Basic information needed to calculate water supply coverage (SZWM&ES)

Ser.No	**Scheme type**	**Number of people to be served**
1	Improved household well without HP	6
2	Improved community well without HP	75
3	Hand dug well with HP	275
4	On spot spring	300
5	Spring distributed to villages	5000
6	Shallow well	500
7	Motorized deep well	3500
8	Borehole	362

4. RESULTS AND DISCUSSION

4.1 Socioeconomic characteristics of the respondents

4.1.1 Age and sex of respondents

The general overview of this section was describes the respondents' background and how it affects water use, collection, allocation and gender relations in rural households in the study area. The key issues identified are; education, occupation and household size. These highly determine the water use and demand in the households and the extent to which the households get involved in sanitation and hygienic issues. An understanding of these can help the researcher to see which areas are critical for enhancing water supply and sanitation schemes.

Table 4.1 Age and sex distribution of respondents

Age of respondents by sex							
Age	**Male**	**Female**	**Total**	**Percent**	**Average Household size**	**Mean**	**Standard deviation**
20-29	14	11	25	20.83			
30-39	21	20	41	34.16	5.68	38.84	11.27
40-49	21	14	35	29.16			
50-59	5	4	9	7.5			
60-69	7	1	8	6.66			
70+	2	0	2	1.66			
Total	70	50	120	100			

About 98% of respondents were in the economical productive age group (25-64 age group). That means data was gathered from the productive age group and indeed people of this age group are those expected to take actions in the development processes of rural water supply and sanitation. The average age of respondents was about 38.84 with a standard deviation of 11.27 having significant age difference among the respondents (Table 4.1). The mean household size is about 6 persons which is greater than the average Ethiopian family size of 4.7 persons (CSA, 2007).

4.1.2 Educational background and occupation of the respondents

Table 4.2 describes that 36.7 % of the respondents did not have access to formal education and their understanding on water and sanitary issues was known to be poor. The primary school is divided into two as the first cycle (1-4th grade) and second cycle (5-8th grade). Proportion of respondents those accessed first and second cycle primary education level was 58.3 %. Their understanding on water and sanitation was good. Proportion of respondents with secondary education access of grades 9-12 and college level was 3.3%. Understanding of these groups on water use and sanitary importance was proved to be very good and excellent respectively. During house-to house survey, it was understood that households headed by such an educated individuals had better outlook about water quality and sanitation issues. The availability and management condition of household latrine in such households was also observed to be better. On the other hand, in the households headed by person with low-level education, poor sanitation condition was observed. From this, it is clear that education level of the community affects improvement of water supply and sanitation system.

Table 4.2 Education level and occupation of respondents responsible to fetch water

Educational level	**(N=120)**	**Percentages**
Non-formal education	0	0
Primary	70	58.3
Secondary	4	3.3
Tertiary	2	1.7
Not educated	44	36.7
Occupation	**(N=120)**	**Percentages**
Farming	112	93.3
Small scale business	2	1.7
Government employee	6	5
Private work	0	0

Table 4.2 also describes that the households have different occupations in the study area. These include farmers, small scale business, government employees and private work. Out of the total of 120 sample households only 1.7 % are government employees, since farmers constitute 93.3 % of sample households they are the dominant section of the population. Nearly all of the households make a living out of subsistence agriculture and animal farming. Small scale business men constitute 5 %.

4.2 Accessibility of water of the study area

4.2.1 Drinking water sources in the study area

The major sources of drinking water in the study Kebeles were ground water. As a result, almost all of the community members obtain their drinking water from the ground water. From the total respondents it was found that about 58.33% and 16.66 % of the households in the study Kebeles use protected and unprotected springs respectively. About 25% of the households in the Remeda Kebele use borehole. From the total respondents about 16.6% and 16.66% from Gonowa gabalo and Sedeka Kebeles respectively obtain their drinking water from protected spring. Also about 8.33% and 8.33% from Gonowa gabalo and Sedeka Kebeles respectively obtain their drinking water from unprotected spring (Appendix 3) .

4.2.2 Access to water sources in relation to time spent

ADF (2005) indicated that women in rural areas often travel long distances to collect water, accounting for two to six hours per day. The respondents in the study area were asked to give information on the time it took them to fetch water from water supply schemes. Although the values obtained were not based on accurate measurement it is roughly used to estimate the time taken from rural water supply services. The maximum time to fetch water from the supplied services including waiting time varies from 90 to 105 minutes, with a mean duration of 47 minutes and standard deviation of 21 minutes. The time taken to fetch water from protected facilities in this study exceeded the guide line value recommended by WHO (World Bank, 1999),which is set at 15 minutes of walking distance, equivalent to a distance of about one kilometer. Also of concern was result indicating that most people are travelling considerably more than the maximum of 1.5km targeted by Universal Access Plan (UAP). The results of this study were higher than that of the findings in Lesotho, in Zambia, and elsewhere in Ethiopia (Burgi, 1999). The mean duration to fetch water from the supplied services includes the time required for round trip from beneficiaries and waiting time. The standard deviation indicates there is significance difference among the households.

Table 4.3 The average time in fetching water by using water supply services

Comparison Parameters	**Time taken in minutes to fetch water**				**Total**
	Gon.gabalo N=30	**Howolso N=30**	**Sedeka N=30**	**Remeda N=30**	**N=120**
Average for scheme	49.33	42.5	46	51.66	47
Maximum of the scheme	100	95	90	105	97.5
Minimum for the scheme	20	20	25	15	20
Standard deviation	17.2	18.83	17.14	28.86	21

Most of the respondents stated that lack of timely access for domestic water in the community is associated with the problem of location of hand-dug wells and other existing sources, and inadequate schemes in relation to user households.

4.2.3 Household water use and water collection

According to respondents the amount of water used in study area varies between households based on the family size, water availability, economic status and season of the year. The availability of the water is low during a dry season from sources, Domestic water use patterns are generally similar in the study area regardless of the type of the water supply schemes and the distances covered to reach it. When there is an increase in household size, the probability of collecting more water for larger household size than individual household. However, the per capita water consumption decreased with an increase in household size because there is a problem of access and adequacy when considering the supply necessary to meet the needs of a large family like water for drinking, cooking, washing and etc. The main uses of water in the households in the study area are drinking, cooking, and washing clothes and other activities like watering animals among others. All respondent (100 %) households were using the water supply for drinking and cooking and 79.16 % for washing. However, the water in the study area is not used for irrigation or vegetables production. As Fontein (2007) notes multiple use water supply services are intended to meet the domestic and productive demands of the poor in more comprehensive manner. If appropriately planned, designed and managed, they have a much greater potential to reduce poverty, to lesson health hazards and to circumvent livelihood vulnerability of rural households. They can also facilitate gender equity, cost recovery, and hence sustainability of the water facilities.

While the fundamental priority of water use from the improved water sources is for human consumption. At many of the protected springs the taps are used not only for domestic water needs but also used for animal watering as pointed out by 67.5 % of respondents. The results of this study were almost similar to that of the findings which was found by Semaria (2012), in Humbo Woreda.

Table 4.4 Different purposes for which potable water and household member responsible to fetch water

Potable water is used for	**Frequency**	
	No	**Percentage**
Drinking and cooking	120	100
Washing	95	79.16
Livestock/animal watering	81	67.5
Irrigation/vegetable production	0	0
Household members responsible to fetch	**Frequency**	
Water	**No**	**Percentage**
Mother	106	88.33
Daughter	13	10.83
Father	0	0
Son	1	0.83

The result in Table 4.4 showed that women and daughters are responsible to fetch water in most of the households, as indicated by 88.33 % and 10.83 % respectively. Only 0.83 % of the sons are responsible for collecting water. Households' reported that the individuals who were responsible for fetching water, mostly women, travel on average two times in a day to the water sources/ points on normal condition. Most of the responsibility to fetch water from distant sources for household use lies on females (women and girls). Women and girls were the bearers of responsibilities with regard to water collection and other domestic works and hence there is a big workload and a long walk in search of water for household use. The considerable labor involved in ensuring the availability of water for about 6 people in a household is almost exclusively done by women and daughters. This clearly shows that gender plays a significant role in domestic water management. The results of this study were almost similar to that of the findings which was found by Semaria (2012), in Humbo Woreda.

Therefore it can be concluded that most of the responsibility to collect water for household use lies in females than males. As the amount of time spent on water collection increases, women's involvement in other economically beneficial activities significantly decreases. Thus daughters and mothers, who are the common water entourages, spend much time on water collection in the rural settings. The impact of spending of a lot of time for collecting water and carrying other household activities on her education can be judged. As WHO (1992) pointed out this believed to affect spare times required for other household affairs that may impact the health of the family as a whole.

Table 4.4 shows the maximum amount of water used per household per day is 80 liters/day and the average household water use per day in study area is 40.25 liters/day and the standard deviation was 14. However, this varied per household depending on the household size, the distance to the water point and the waiting time at the water sources/points. The average household water use in Gonowa gabalo is 44.83 liters/day, in Howolso is 36.33 liters/day, in Sedeka is 37.16 liters/day and in Remeda is 42.66 liters/day. The difficulty in collecting sufficient amount of water due to few water supply facilities, anomalies of the schemes and long distance between the water points and beneficiaries made the water use to be inadequate.

Table 4.5 The average water consumption of respondents per household per day

Statistical parameters	Amount in liters per household per day (in liters)				
	Gon.gabalo N=30	**Howolso N=30**	**Sedeka N=30**	**Remeda N=30**	**Total N=120**
Average	44.83	36.33	37.16	42.66	40.25
Maximum	70	60	60	80	67.5
Minimum	20	20	10	20	17.5
Stand.dev	15.91	11.88	13.87	12.84	14

4.2.4 Per capita water consumption (liter per day)

All the households use jerry cans to collect water; these jerry cans typically hold 20 liters. Children also use smaller jerry cans, up to 10 liters. The respondents were asked to tell the average number of liters in terms of "jerry can" that their family used per day due to unfamiliarity of measuring in liters besides their inability to tell the amount in liters. The per capita consumption of water in a respondent's household was then calculated by multiplying the number of "jerry can" used per day with the amount of liters it contains and then dividing the result by the household's family size.

According to Table 4.6, the average volume of water used by a person per day per household ranged from 2.43 liters to 11.93 liters and the average per capita water consumption is 7.1 liters and less used by the majority, was significantly different from WHO guide line value set at least 20 liters per capita per day (Webster et al., 1999). Assefa (2006) quoting FAO suggested that if a country has less than a thousand (1,000) cubic meters (m^3) per capita per year, it is adjudged to be a water scarce country. If water availability is below 1, 000 m^3/c/yr chronic water related problems impeding development and human health. Shebedino Woreda has been so designated, as its available water resources are currently rated at 2578.66 m^3 per person per year.

Table 4.6 Per capita water consumption liter per day

Statistical parameters	**Amount in liters per person per day per household(in l/c/d)**				
	Gon/gabalo N=30	**Howolso N=30**	**Sedeka N=30**	**Remeda N=30**	**Total N=120**
Average	7.31	6.98	7.61	6.53	7.1
Maximum	11.66	8.57	7.5	20	11.93
Minimum	2.85	2.85	2	2	2.43
Stan.dev	4.4	2.95	3.2	9.36	4.75
% above 20 liters	0	0	0.83	2.5	3.33
% below 20 liters	100	100	99.17	97.5	96.67

Inadequate drinking water adversely affects personal hygiene, clean food preparation, and housing sanitation, hence favoring the transmission of water borne and water washed communicable diseases. Around 96.67% of people consume less than 20 liters of water in a day, as indicated in the same table. The standard deviation was found to be 4.75 liters implying there is variation in the pattern of water consumption per person per day among different households in the study area. Highest average value was recorded in Sedeka and the lowest average value was recorded in Remeda Kebeles.

4.2.5 In house hygiene

Water treatment is essential to improving water quality which reduces risks of water borne diseases (WHO, 2003b). According to the consumers' responses 62 (51.6%) collect water which is in contact with their hands and 68 (56.7 %) have no separate water containers in their home to store it from the water used for other purposes. Most of them 85 (70.8 %) did not use any particular treatment at home before use. Although some people use water treatment (boiling) in their home 35 (29.2 %), general water treatment for all household basic needs is still limited in study area. Poor sanitation and poor hygiene were the main effects of the contaminated water during transportation and after storage in household. This finding was in agreement to the studies conducted elsewhere in Ethiopia (Dagnew et al., 2007 and Mengesha et al., 2004). The results of sanitation and hygiene practices of the consumers at the households are shown in Table 4.7.

Table 4.7 Responses of respondents related to sanitation and hygiene practices of the consumers at the households

Questions asked to the consumers	**Frequency**			
	Yes		**No**	
	No	**%**	**No**	**%**
Separate container for storage of drinking water	52	43.3	68	56.7
Have no contact with your hand.	58	48.4	62	51.6
Particular treatment for your drinking water (boiling)	35	29.2	85	70.8

4.2.6 Rural water supply and consumers' satisfaction

Consumer satisfaction can be assessed from service takers in different ways using different indicators. Satisfaction with the quality of water namely: color of water, taste of water, smell, hardness of water, amount of the water, time given for water service a day, general services of water points, whether they stand in line for long period of time to collect water could be the main one's to mention.

The four principal dimensions on domestic water supply and availability are: Quantity, quality, spatial variability and temporal variability (Lenton et al., 2008). Good water quality is important to human; however, most of the improved sources are seasonally unreliable. As UNDP (2005) noted control of water variability is important because poverty stricken and vulnerable households can have devastating effects in case of water related events like droughts and floods. With this regard, the survey found that almost all 99.2% of respondents are not satisfied with the provided amount of water, 26.4% are satisfied with the quality of water namely taste, color and smell (Appendix 5); and about 61.8% of them indicated the average working hours per day of the water supply scheme is 1-3 hours time in a day for water collection in water points (Appendix 4). This community satisfaction is a tool for the overall water supply services and projects. When the respondents were asked to tell the period through which the quantity of water supplied was not adequate to fulfill their demand, they specified the period through which low quantity of water was obtained. This somehow affected the satisfaction of community due to the fact that the sources/points get unpredictable during dry season (Jan – March) in a year as indicated by 43.1% of the respondents complained the inconvenience of the water quality. The former problem is most pronounced in two Kebeles of the study area namely Howolso and Remeda (Appendix 5)

4.2.7 Assessment of drinking water supply current status and coverage.

There are two types of rural water supply schemes in the study area. The micro schemes are defined as those rural water schemes comprising point source supplies such as hand dug well equipped with hand-pumps, collection tanks, stand posts, and protected springs whilst macro schemes are those schemes with a powered system such as submersible pumps, gravity schemes or point sources with collection tanks supplying more than four communal standpipes (GOS, 2003). Springs and boreholes were the main source of water for household use in the study area where the schemes are functional. Observation and field visit result showed that most of the water points are not neat at all as Demonstrated by poor drainage and water stagnation, bad smell and in some of the sources by the presence of livestock waste. Catchments rehabilitation with the aim of increasing ground water recharge is done around the surroundings of one-third of the water points.

As far as water supply services are concerned some development activities have been done by Zonal, Woreda water resources office and NGO's to alleviate the problem of potable water in the woreda. However, the problem of potable water supply is still very sounding in the woreda. In addition to this the existing water supply schemes are characterized by very low service coverage, limited service over the day from public distribution points, poor operation and maintenance as specified by key personnel.

In relation to this, the following adverse conditions were identified as problems related to operation and maintenance functions of Woreda water resource development office. Lack of awareness of beneficiaries, lack of spare parts, design problem, poor financial management and scantiness, inadequate planning, lack of preventive maintenance and lack of trained personnel who fully understand how to operate the systems and low capacity of the schemes to satisfy the demand are the main ones.

Table 4.8 Water supply coverage of studied Kebeles

Kebeles	**Water supply Coverage %**
Gonowa gabalo	27.1 %
Howolso	23 %
Sedeka	23.76 %
Remeda	20.63 %
Average of the four Kebeles	23.62 %

According to Table 4.8, the coverage of water supply in the study areas Gonowa gabalo Kebele the total coverage is 27.1 %, more coverage in this Kebele at source of G3 (Handisa village), in Howolso Kebele the total coverage is 23 %, more coverage in this Kebele at source of H2 (Shigge village), in Sedeka Kebele the total coverage is 23.76 %, more coverage in this Kebele at source of S2 (Shemeta village) and finally in Remeda Kebele the total coverage is 20.63 %, more coverage in this Kebele at source of R1 (Gado village). The coverage in the studied areas was low because of boreholes and hand dug wells were non functional in Gonowagabalo, Howolso and Sedeka Kebeles. Average water supply coverage of four studied Kebeles was found to be 23.62 %.

As per the official data of Woreda water resource development office recently there are 78 spot springs available all of them are functional , totally 218 boreholes were available from which 57 were non functional and 161 are functional. Finally 55 hand dug well with hand pumps were available from which 26 is nonfunctional and 29 are functional. Therefore 78 spot springs are estimated to serve 23,400 people, 161 boreholes are estimated to serve 58282 people and 29 hand dug wells with hand pump are estimated to serve 7975 people. Since the populations served by the schemes in the Woreda are 89657 out of the total population of 294,213, hence; the total coverage is 30.50 %. Current the coverage of Woreda is low, because of many boreholes and hand dug wells are non functional. The remaining 69.50 % is not covered with the reasonable population load per a single water source/point. This finding was lower than the studies conducted elsewhere in Ethiopia (Birhanu, 1999; World Bank 2005).

To improve the coverage and problems associated with non functional schemes the community elected a water user committee (WUC) which has the delegation to maintain the source on behalf of the community. The community elected a water user committee has the responsibility of protecting the scheme and charging a water user for further scheme maintenance and development of another water source. Though communities are involved in the scheme construction and maintenance, there is a problem in protecting the water point and maintenance of the schemes.

4.3 Water quality analysis

4.3.1 Physico-chemical quality of drinking water

Physico-chemical quality of drinking water from ground water sources was analyzed and the results of different parameters were presented in Table 4.9. According to the average value of each water quality parameters, comparison was made using WHO drinking water guideline and Ethiopia standard as shown in Table 4.10. As it was also presented in the (appendix 9) , the values of $Pr > F$ for all of the considered parameters was < 0.0001. According to the results of analysis the sample was significant indicating that there was variation of the sample of different water points and the model is significant through out analysis of each parameter.

According to one way Analyses Of Variance (ANOVA) from 11 levels and 33 total sample size, water quality parameters were varied between and with in Kebeles. Based on GLM (general linear model), t grouping was assigned by using letters such as A, B, C and D for each Kebele. Accordingly “A” and “D” represent the highest and the lowest average value of water quality parameters of study Kebeles respectively. For instance turbidity, Fluoride, total dissolved solid, Electro conductivity, total and fecal coliform were highly different between and with in Kebeles as shown in Table 4.9 and 4.10.

Table: 4.9 Variations of mean of each of the parameters between Kebeles

Parameters	**Gonowa gabalo**		**Howolso**		**Sedeka**		**Remeda**	
	Mean	**tGroup**	**Mean**	**tGroup**	**Mean**	**tGroup**	**Mean**	**tGroup**
pH	7.20	B	7.19	B	7.68	A	7.81	A
Turbidity(NTU)	13.42	A	12.76	B	10.10	C	2.06	D
Cl (mg/l)	1.33	C	1.83	B	2.97	A	1.3	C
F (mg/l)	0.25	D	0.37	C	0.53	A	0.47	B
Fe (mg/l)	0.0167	B	0.017	B	0	C	0.6	A
Mn (mg/l)	0.0282	B	0.0313	B	0.0128	C	1.25	A
TH (mg/l)	33.33	A	24.66	B	27.33	B	19	C
TDS (mg/l)	59.55	D	79.66	B	71.83	C	168.17	A
EC (μs/cm)	88.88	D	118.88	B	107.21	C	251	A
$\mathbf{N0_3}$ (mg/l)	2.3	A	2.39	A	1.28	C	1.67	B
$\mathbf{No_2}$ (mg/l)	0.0176	A	0.0187	A	0.0022	B	0.0132	A

Note: Means with the same letter are not significantly different.

From the group of study Kebeles the level of Turbidity in Gonowagabalo, Howolso & Sedeka, Manganese & Iron in Remeda and total and feacal coliform in all study Kebeles were higher compared with WHO guideline. According to the result, water points in all studied Kebeles were contaminated.

Table: 4.10 Mean, Standard deviation, Range, Ethiopia standard and WHO guideline of Physico-chemical parameters

Parameter	Unit	Mean ±SD	Range	Ethiopia standard	WHO guideline
pH	pH Scale	7.470 ± 0.32197	6.24 – 8.44	6.5 – 8.5	6.5 – 8.5
Turbidity	NTU	9.5850 ± 5.21788	1.53 – 30.83	7	5
Cl	mg/l	1.8575 ± 0.78049	1.3 – 3.80	533	250
F	mg/l	0.4050 ± 0.12261	0.05 – 0.70	3	1.5
Fe	mg/l	0.1600 ± 0.29348	0 – 1.20	0.4	0.3
Mn	mg/l	0.3300 ± 0.61341	0.0068 - 2.50	0.8	0.1
TH	$CaCo_3$ mg/l	26.080 ± 5.95169	0 - 56	300	300
TDS	mg/l	94.8025 ± 49.60699	52.48- 169.51	1776	1000
EC	µs/cm at 20c°	158.9925±75.17941	78.33 - 253	-	1500
$\mathbf{N0_3}$	mg/l	1.9100 ± 0.52820	0 – 4.40	50	50
$\mathbf{No_2}$	mg/l	0.01250 ± 0.00957	0 – 0.0396	-	3

4.3.1.1 pH and Turbidity

According to the results of analysis the value of pH ranges 6.24 – 8.44 with average 7.47 ± 0.32197 (mean ± st.dv) indicating that there was variation of the sample of different water points. The pH value ranges from 6.24 in the Gonowa gabalo Kebele from protected spring at Handisa village up to 8.44 in the same Kebele from unprotected spring at Burama village as shown in Table 4.9. From the group of study Kebeles, highest average value of pH was obtained in Remeda Kebele (i.e. 7.81) following Sedeka, Gonowa gabalo and Howolso Kebeles with pH value 7.68, 7.20 and 7.19 respectively as shown in Table 4.9. According to the average value of pH (i.e.7.47) which is found between the range of recommended value of

(WHO, 2008). However, mean pH values of studied sample water were known to be the normal water that could have no health impact. All values found between six and eight pH scales. Therefore, water supply studied in Shebedino Woreda did reflect almost no problem in relation to pH.

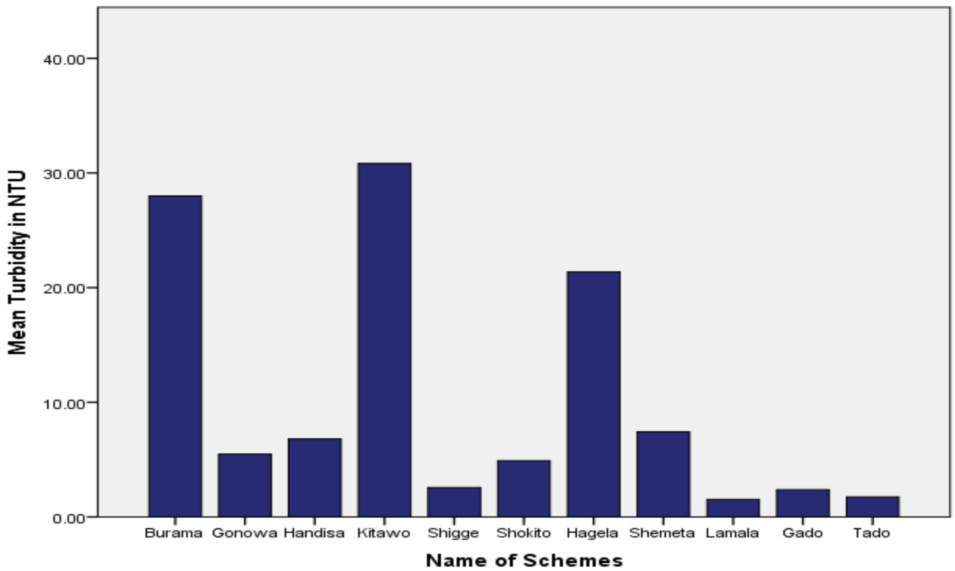

Figure 4.1 Level of turbidity in the sample water

According to the analysis of turbidity ranges from 1.53 – 30.83 NTU with its average value 9.5850 ± 5.2178 NTU as it was found that there was a significant difference between sample Kebele and with in Kebele of different water sources as shown in the Table 4.10. The physical parameter turbidity was above the recommended limits in Gonowagabalo Kebele from unprotected spring, in the Howolso Kebele from protected spring at Kitawo village and in the Sedeka Kebele from unprotected spring at Hagela village in their written order as shown in Table 4.10.The average value of turbidity in the study area was found 9.585 NTU which was above the recommended value of Ethiopia and WHO water quality guideline. The increase of turbidity value in the study area indicate that many of the drinking water sources were not properly protected from the entering of soil particles and organic material. For instances protected spring in the Howolso kebele, unprotected spring in the Gonowa gabalo and Sedeka Kebeles were liable for entering of silts, fine soil particles, plant residuals and other organic material. According to OECD/WHO (2003), turbidity peaks in ground water may originate from soil material, but also from the rapid ingress of surface water runoff or surface percolate.

Turbidity may result from insufficient filtration during water treatment or mobilization of sediments, mineral precipitates or biomass within the distribution system. High levels of turbidity can shield pathogens from disinfectants, so effective disinfection requires that turbidity is less than 1NTU nephelometric turbidity unit (UNICEF, 2008). In contrast low turbidity minimizes both the amount of chlorine required for disinfection of water and the potential for transmitting infectious diseases (Dagnew *et al.*, 2010).

4.3.1.2 Total hardness ,Total dissolved solid and Conductivity

The concentration of total hardness of different drinking water sample ranges from 0 – 56 mg/l with the average value 26.08 ± 5.95 mg/l, which indicate that there was a significant variation in the Kebeles. Also it indicates as it was found different value of total hardness between and with in Kebele. The highest value of total hardness was found in the Gonowa gabalo Kebele (i.e.56 mg/l) from unprotected spring at Burama village and zero value of the total hardness was found in the Remeda Kebele from on borehole at Gado village. From the group of sample kebele, average concentration of total hardness was 33.33 mg/l, 27.33 mg/l, 24.66 mg/l and 19.00 mg/l from Gonowa gabalo, Sedeka, Howolso, and Remeda Kebeles respectively as shown in Table 4.9. According to the result of the analysis, average concentration of the total hardness was 26.08 mg/l indicating that as it was below the recommended value of the WHO water quality guide line set as it to be 300mg/l for a safe drinking water. This number of total hardness is grouped under the class of soft water class. Hard water requires more soap to produce a lather, and can form scale deposits on pipes, basins, pots and hot water heaters (scale formation increases at higher temperatures) (UNICEF, 2008). There is epidemiological evidence to suggest a lower incidence of heart disease in communities with hard water (high calcium and magnesium content) (Lucie, 2004). The high concentration of total hardness is water samples may be due to dissolution of polyvalent metallic ions from sedimentary rocks, seepage and run off from soil (Gupta, 2009).

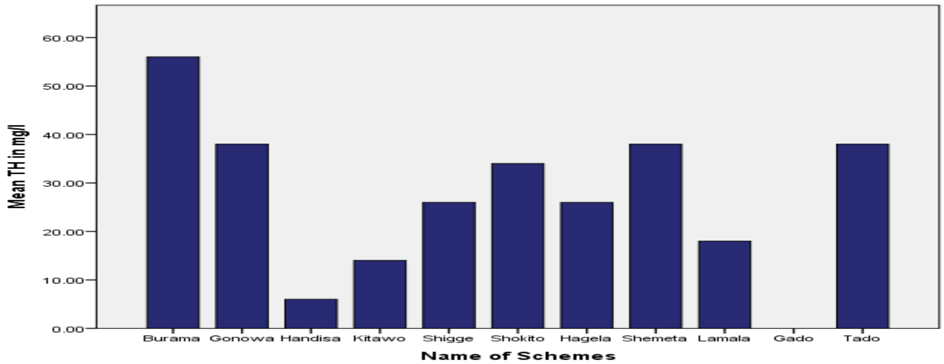

Figure 4.2 Amount of total hardness in the sample water

The concentration of the total dissolved solid range from 52.48 – 169.51 mg/l with average value of the 94.80 ± 49.60 mg/l respectively which indicate there was a much variation with in and between the study Kebeles as shown in Table 4.10. From the village the highest value was about 169.51 mg/l and 166.8 mg/l that found in the Remeda Kebele from borehole at Gado and Tado villages respectively as shown in Figure 4.3.

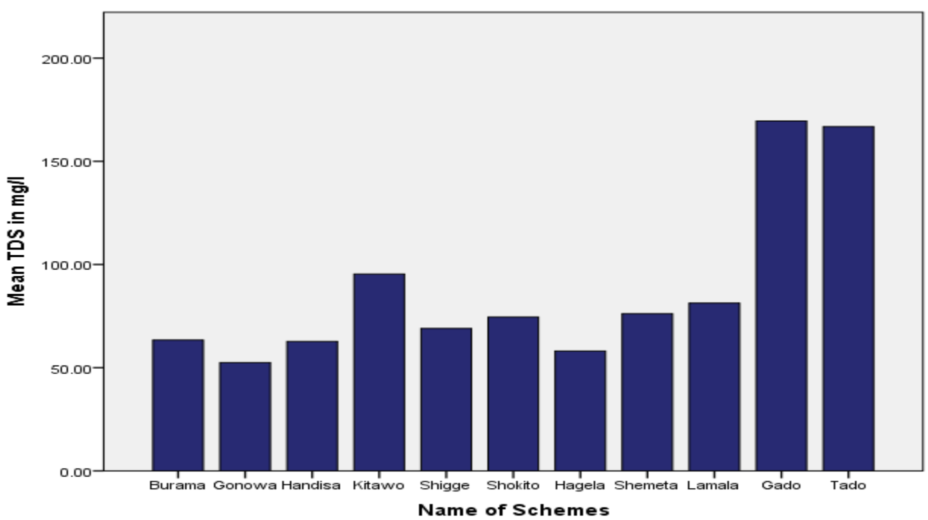

Figure 4.3 Level of total dissolved solid in the sample water

The average value of total dissolved solid in the study area was found to be 94.80 which indicate the result was below the recommended values of WHO in 2008. According to the average value of the total dissolved solid varies greatly at different drinking water sources, indicating that lack of proper sanitation and proper maintenances of the water sources.

It was found that Conductivity of sample ranges from 78.33 - 253 μs/cm with average value of 158.99 ± 75.18 of the drinking water in the study area indicating that there was a variation of the value of the conductivity from the average value of the water point as shown in Table 4.10. Conductivity of sample ranges from 78.33 - 253 μs/cm in the Gonowa gabalo Kebele from protected spring at Gonowa village and in the Remeda Kebele from borehole at Gado village according to their written order. From the group of sample Kebeles their average value of conductivity was 251μs/cm, 118.88μs/cm, 107.21μs/cm and 88.88μs/cm from Remeda, Howolso, Sedeka and Gonowa gabalo Kebeles respectively as shown in Table 4.9. The total average value of the conductivity in the study area was found 158.99μs/cm that was below to the WHO water quality guidelines. The average value of the conductivity (i.e 158.99μs/cm) was relatively similar to the 142.09μs/cm which was found by Belayneh (2012), in Dale Woreda.

Conductivity assays can be used to reflect total dissolved solids concentrations and can be applied on line although conductivity mainly reflects the mineral content (OECD/WHO, 2003). There is little direct health risk associated with conductivity, but high values are associated with poor taste, customer dissatisfaction and complaints (Howard et al., 2003; WHO, 2004).

4.3.1.3 Chloride and Fluoride

The concentration of the chloride range 1.3 – 3.8 mg/l with average value of the 1.86 ± 0.78 mg/l as shown in Table 4. 10. In this study about 3.8 mg/l of chloride which was the highest value that found in the Sedeka Kebele from protected spring at Lamala village and about 1.3 mg/l of the chloride, the smallest value that was found in the Gonowa gabalo Kebele from protected springs at Gonowa and Handisa village and Remeda Kebele from borehole at Gado and Tado villages respectively as shown in Figure 4.6. The average value of the chloride in study area was 1.86 mg/l indicating that the value was below the recommended standards by WHO. Chloride in surface and groundwater from both natural and anthropogenic sources, such as the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas (WHO, 2003).

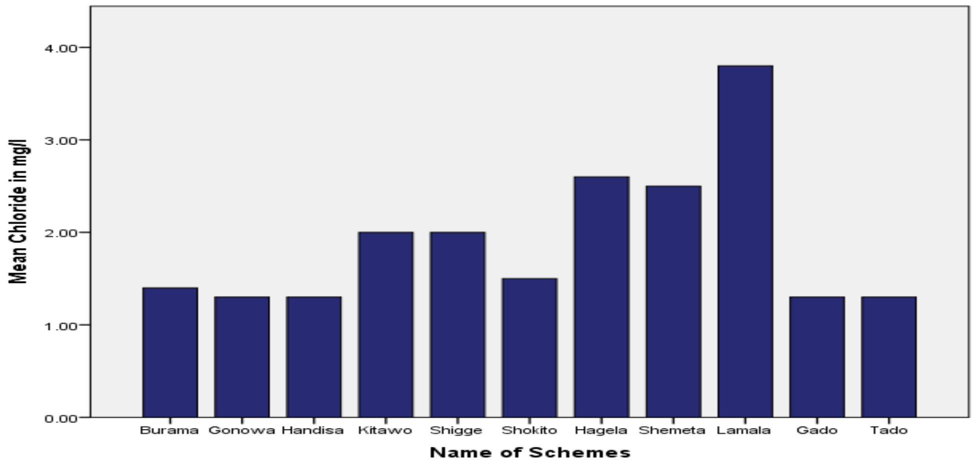

Figure 4.4: Chloride concentration of the sample water

According to analysis, the concentration of fluoride range from 0.05 – 0.70 with the average value of 0.41 ± 0.12 mg/l as shown in Table 4.10. The average fluoride content of the entire sample points range between 0.05 mg/l and 0.70 mg/l in the Gonowa gabalo Kebele from unprotected spring at Burama village and Sedeka Kebele from protected spring at Lamala village respectively. The average value of the fluoride was found about 0.41 mg/l because all sample water has got fluoride content below WHO and DEDWS (1.5mg/l and 3 mg/l respectively). In Gonowa gabalo Kebele from unprotected spring at Burama village has very low fluoride contents (0.05 mg/l) as shown in Figure 4.7; due to the nature of rocks and soil types located around the well do not have enough fluoride ions. The fluoride content of Sedeka, Remeda, Howolso and Gonowa gabalo Kebeles were 0.53 mg/l, 0.47 mg/l, 0.37 mg/l and 0.25mg/l respectively as shown in Table 4.7. The average value of the fluoride (i.e. 0.41 mg/l) was relatively similar to the 0.50 mg/l which was found by Belayneh (2012), in Dale Woreda. High intakes of fluoride can give rise to dental fluorosis, an unsightly brown mottling of teeth (Fawel *et al.*, 2001). At higher concentrations skeletal fluorosis may occur, involving stiffness and pain in joints (UNICEF, 2008).

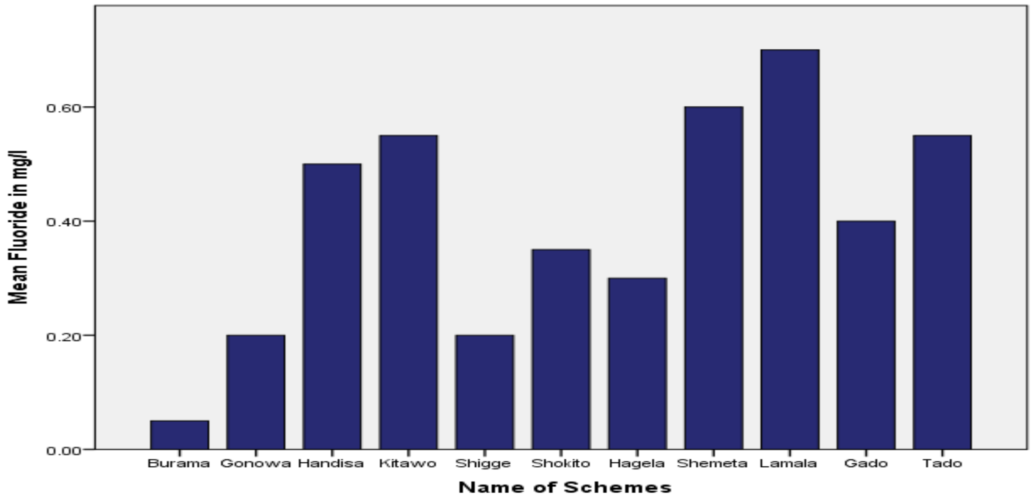

Figure 4.5: Fluoride concentration of the sample water

4.3.1.4 Iron and Manganese

Table 4.10 indicates that overall mean and standard deviation of Iron of studied area is 0.16±0.2935 mg/l. Its mean ranges from 0 to 1.20 mg/l. According to (Alan C. *etal*., 2000), the concentration of Iron usually found in drinking water is not harmful, but Iron can impart a bitter taste when present above 1mg/l. At lower concentrations, it may cause “dirty” water problems, with consumers rejecting the water on the grounds of appearance. It can also cause brown stains on laundry and plumbing fixtures. The WHO guideline value is 0.3mg/l to avoid discoloration and staining (Alan C. *etal*., 2000).

From Table 4.10, we could understand that drinking water supply of all the studied Kebeles had average Iron concentration below the WHO guideline value for drinking water, which is 0.3mg/l. From the group of sample Kebeles, the average value of iron was 0.60 mg/l, 0.0170 mg/l, 0.0167 mg/l and 0 mg/l from Remeda, Howolso, Gonowa gabalo and Sedeka respectively. When considering only mean concentration of each Kebeles, only Remeda Kebele was higher value compared to WHO guideline, which is unacceptable quality and the rest of three Kebeles the value known to be below WHO guideline and the water supply was concluded to be that of good quality in terms of Iron concentration.

Figure 4.6 shortly indicates individual water points with their respective Iron concentration. The Figure clearly indicates that each sample from the two Kebeles Gonowa gabalo and Howolso had minimum level of Iron concentration. On the contrary Samples were taken from

Remeda Kebele at Tado village indicates the higher Iron concentration, which was greater than WHO guideline, and the water was not suitable for drinking purpose.

The researcher put the reason for existence of high Iron level in water supply of Remeda Kebele to be the nature of soil geology in the area soil in source Kebele was known to have red color. According to the idea reflected from water and soil experts in the Woreda, red color of the soil is mostly associated with existence of high Iron constituent in that soil. The researcher could associate increased level of Iron concentration in water supply of Remeda Kebele with the previous idea of water and soil experts.

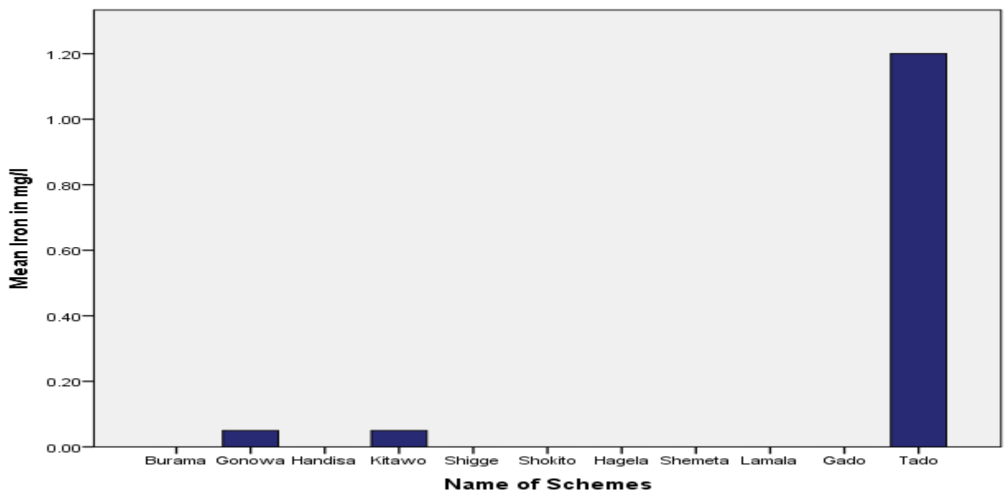

Figure 4.6: Iron concentration of the sample water

The concentration of the Manganese ranges 0.0068 ± 2.4833 mg/l with average value of the 0.3300 ± 0.61341 mg/l as shown in Table 4.8. We can understand that most of samples were found to have manganese concentration of below Ethiopia standards (0.8), but above WHO guideline value, which is 0.1mg/l. However, samples from Remeda Kebele indicated higher manganese concentrations that greatly vary from WHO guideline. Other nine samples from the rest three Kebeles showed best quality of drinking water regarding manganese concentration. According to (Wasserman *et al*, 2006), Manganese is an essential element for humans, but a growing body of research suggests that exposure to high levels in drinking water can lead to adverse neurological effects. As it can be observed from the Figure 4.7, the level of manganese concentration of water supply in Remeda Kebele might lead to such problems since its value is much higher than WHO guideline as indicated by the graph in Figure 4.7.

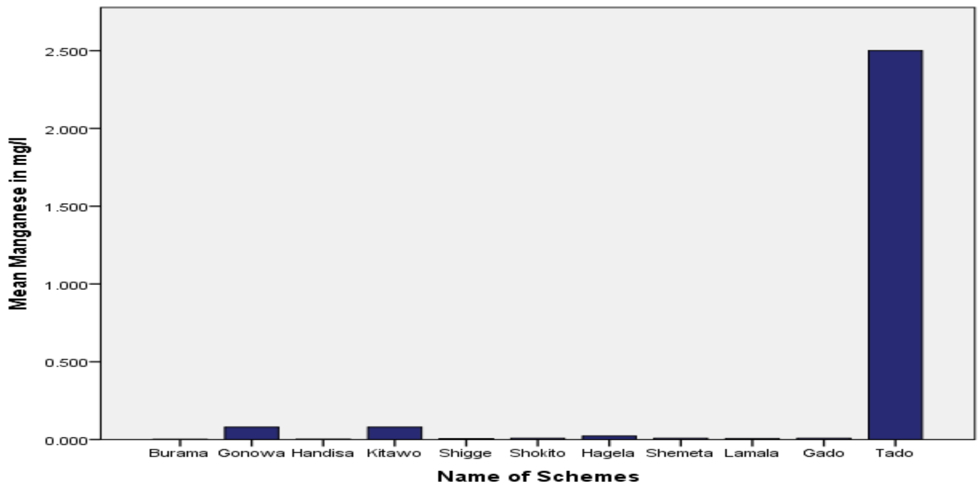

Figure 4.7: Manganese concentration of the sample water

4.3.1.5 Nitrate and Nitrites

The concentration of Nitrate ranges from 0 to 4.40 mg/l with the overall mean and standard deviation of the study area was presented as 1.9100 ± 0.5282mg/l. Figure 4.10 indicates how mean Nitrate value for each studied Kebele was compared to WHO guideline value for the same parameter. Nitrate ($N0_3$) is a plant nutrient that often occurs naturally in the environment. Nitrate often arises with excessive agricultural fertilization and leaching of wastewater or other organic compounds into water bodies. In comparison to surface water, groundwater usually shows slow concentration changes (WHO, 2008). From the graph in Figure 4.10, it can be observed that all water samples show concentration of nitrate very much lower than WHO guideline value of 50 mg/l. From this result, the researcher concluded that water supply in studied area did not have problems associated with nitrate concentration.

In Table 4.10, overall mean and its standard deviation of Nitrite concentration is presented as 0.0125 ± 0.00957mg/l. Its range differs from 0 to 0.0396 mg/l. Nitrite (No_2) is significantly present just in reduction processes, as nitrate is the most stable oxidation state. Nitrate and nitrite are among the chemicals that are considered to have the greatest health impacts in natural waters (WHO, 2008). In similar manner with the case for nitrate, all studied Kebeles had lower nitrite levels when compared with WHO guideline for nitrite. Then, it was generally proved that there was no water quality problem associated with nitrate or nitrite concentration in Shebedino Woreda, particularly in the studied Kebeles.

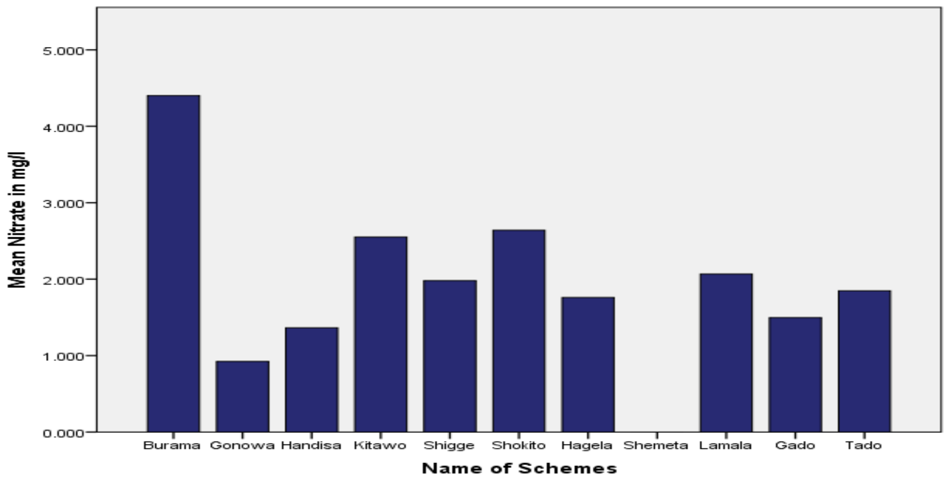

Figure 4.8: Amount of Nitrate in the sample water

4.3.2 Bacteriological quality of drinking water

Microbiological quality of drinking water has been implicated in the spread of infectious and parasitic diseases such as cholera, typhoid, dysentery, hepatitis, giardiasis, guinea worm, and schistosomiasis (Alan C. *etal*., 2000).

Table: 4.11 Mean, Standard deviation, Range and WHO guideline of Bacteriological parameters.

Parameters	**Unit**	**Mean ±SD in the study areas**	**Range**	**WHO guideline**
TC	(cfu/100ml)	8.3725 ± 2.68076	4 – 15	3
FC	(cfu/100ml)	4.8725 ± 1.60515	2 - 8	0

Table: 4.12 Mean of Bacteriological parameters

Parameters	Unit	Gon.gabalo	Howolso	Sedeka	Remeda
TC	(cfu/100ml)	10	8.66	10.33	4.5
FC	(cfu/100ml)	5.33	5.66	6	2.5

4.3.2.1. Total coliform (TC)

Total coliform range from 4 to 15 cfu/100ml with overall mean and its standard deviation in drinking water supply of four-considered study area was 8.37 ± 2.68076 cfu/100ml of sample water. WHO guideline taken as standard in this study reflects that in drinking water, the number of total coliform in 100ml of sample water should not exceed three. When compared with this guideline, the obtained result is above the number of coliform. From Table 4.12, The highest level of total coliform number was found in the Sedeka Kebele (10.33 cfu/100ml) from unprotected spring at Hagela village. Also relatively high number of total coliform (10 cfu/100ml and 8.66 cfu/100ml) was found in the Gonowagabalo and Howolso Kebeles from unprotected spring at Burama village and protected spring at Kitawo village and in the last (4.5. cfu/100ml) was found in the Remeda Kebele. The average value of total coliform in the study area was found 8.37 cfu/100ml which was above the recommended value of WHO water quality guideline.

According to the finding of the study most of the water sources that were contaminated with total coliform was open water sources such as unprotected spring. The existence of increased total coliform associated with the human feaces and soil particles entering in to unprotected open water sources in the study Kebeles. Poor sanitation, low level of hygiene, and uncontrolled parameters were the causes of the problem. Diarrhea, cramps, nausea, vomiting, headaches; possibility of severe illness in children, the elderly, and people with immune deficiencies are the attributes of E. coli bacteria (WHO, 2004). According to WHO report re-growth of total coliform in the distribution system are unlikely unless sufficient bacterial nutrients are present or the water temperature is above 15°C, and there is no residual free chlorine (WHO, 2003). Groundwater sources are protected by sealing the sources against ingress of contaminated surface water, and by ensuring that the immediate surroundings are kept clean (UNICEF, 2008).

However, it was investigated that lack of chemicals and enough budget hindered water desk experts from disinfecting water after maintenance and other necessary times. Another possible factor of increase in coliform was found to be lack of clean environment around water sources and reservoirs. Dirty environment provides favorable condition for bacterial multiplication.

During investigation of the study area, it was observed that there was dirty and unclean condition near and around water sources.

4.3.2.2. Fecal coliform

Fecal coliform range from 2 to 8 cfu/100ml with overall mean and standard deviation of 4.8725 ± 1.60515 cfu/100ml in water samples analyzed in studied area as shown in Table 4.12. The highest number of feacal coliform (i.e.8 cfu/100ml) was found in the Sedeka Kebele from unprotected spring at Hagela village. From the group of sample Kebeles, the average value of feacal coliform was 6 cfu/100ml, 5.66 cfu/100ml, 5.33 cfu/100ml and 2.5 cfu/100ml from Sedeka, Howolso, Gonowagabalo and Remeda Kebeles respectively. The average value of feacal coliform in the study Kebeles was found 4.87 cfu/100ml which was above the permissible value of WHO water quality guideline. WHO put guideline of drinking water that states thermo tolerant or fecal coliform should not be present in 100ml samples of drinking water at any time, for any type of water supply, treated or untreated, piped or un piped (Alan C. *etal*., 2000).

Almost all of the water points have contaminated with feacal coliform in the study Kebeles. Unprotected water supplies can be heavily contaminated with feacal matter from humans and animals (UNICEF, 2008). Frequent examinations of feacal indicator organisms remain the most sensitive way of assessing the hygienic conditions of water (WHO, 2003). Disinfection (physical or chemical) is the most effective and reliable way to ensure that any pathogens present in drinking water are removed to acceptable levels (UNICEF, 2008). Depending on the nature of the catchment minimizing the level of contamination is possible, removing animal grazing, stop construction of pit latrine at vicinity of water source, diverting surface run off that caries different waste material to the water point especially during a period of heavy rain fall.

4.4 Population and water demand projections

The Woreda population has been increasing at the course of time. The population projection was developed from National Statistical Report of the Population and Housing Census of 2007 were utilizing year 2016 population data as a starting point (base year) with growth rate of 2.8%. Figure 4.1 below presents the 2016 to 2026 population projections of the rural areas of the Shebedino Woreda.

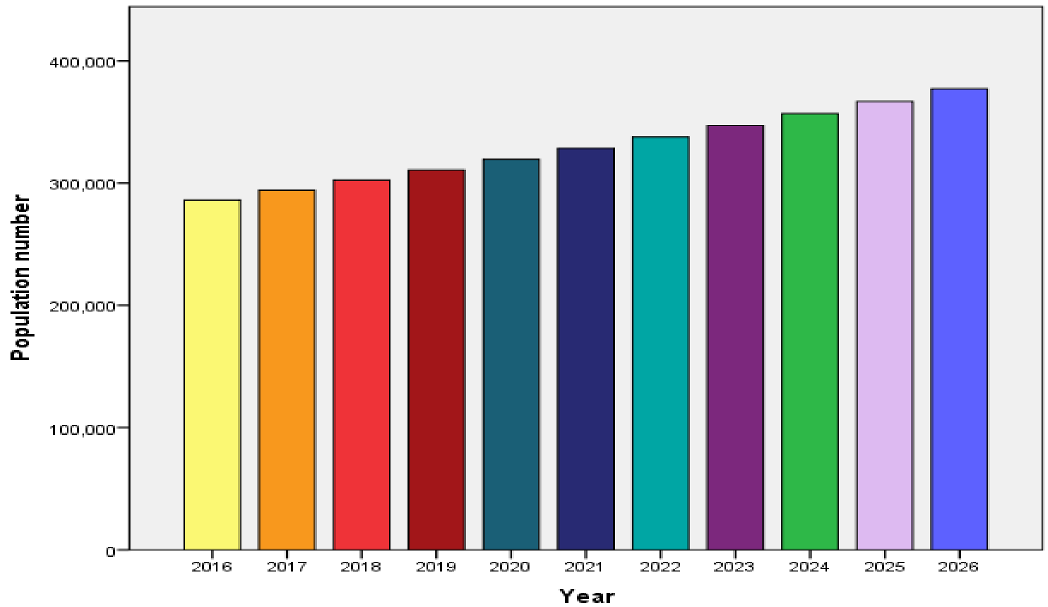

Figure 4.9 Population projection in rural Kebeles of Shebedino Woreda

Evaluation of the amount of water available and the amount of water demanded by the public are primary tasks in designing any water supply system. Water resource planning requires reliable forecasts of population and water demand. Increasing populations translate into increased water demand for different uses. The projected increase in population is the principal force triggering the projected increase in total water demand. Water demand increases with time due mainly to population growth and economic development. Figure 4.2 shows water demand projections by category for the year 2016-2026.

The projected total water demand for the Woreda will increase by nearly 2,447.25 m³/day over 10 years period. Since the current total domestic consumption is 2,650.86 m³/day as indicated in the survey result, it shows the amount of water that reaches the inhabitants is not adequate, as the government hoped in it universal access program (UAP) for water supply and sanitation services. Since the existing water coverage is estimated about 30.50 % and should be raised by four times (2,650.86 m³/day to 11,120.64 m³/day) for the coming 10 years period (Appendix6). Therefore exploration of new water sources and increasing the water supply efficiency seem to be inevitable activities of the stakeholders of the sector.

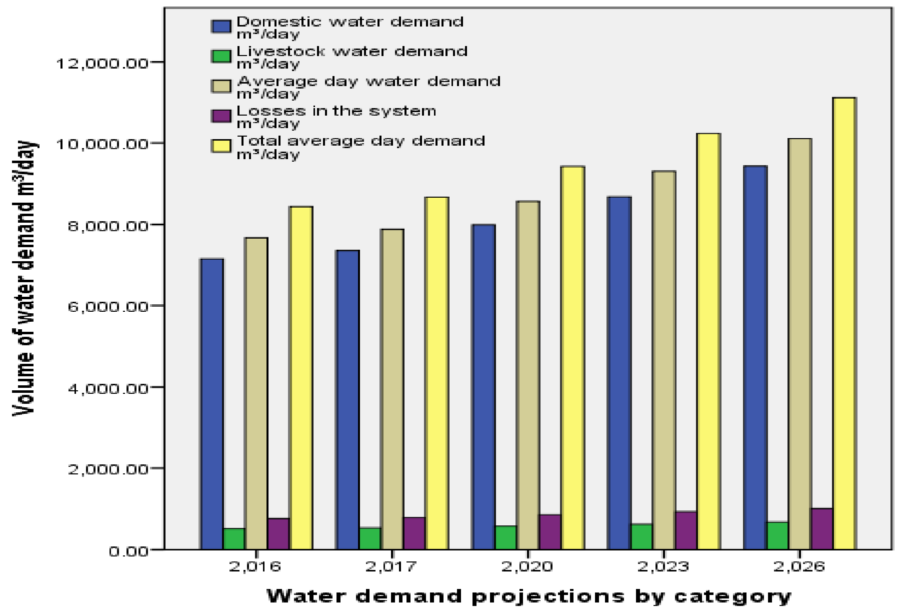

Figure 4.10 Water demand projections by category for the year 2016-2026

4.5. Assessment of sanitation and hygiene condition

4.5.1. Availability and types of latrine

According to the HDR of UNDP (2006),'sanitation is safe disposal of human excreta' and it is also one of the basic human needs. Types of latrines constructed in the study area: 36.66% of the respondents have constructed open pit latrine/without house, and 45% of them were constructed pit latrine without closed wall but with roof. The maximum number of this type was found in Howolso, Sedeka and Remeda Kebeles. On average over the study areas 7.49% of the latrines have a wall and roof. This latrine has no container to store water for washing hands after defecating (Table 4.13). The latrine construction coverage was 89.15% in the study area.

According to the result shows (Table 4.13), the latrine coverage in the study area seems encouraging as traditional latrines, which do not meet official standards, are taken in to consideration in the arithmetic. The sanitation technologies said to be improved if those sanitation facilities prevent humans, animals and insects from coming in contact with human excreta (UNICEF, 2008). However, such improved technologies have never been observed in the study area, therefore; the condition is not so healthy and enjoyable as the toilets are simply made of local materials without any facilities. As it is applied to water sources, people in the community can also be classified as people with improved/unimproved sanitation. Accordingly people in the study area can be categorized under unimproved sanitation. Therefore, lack of proper sanitation is the major cause of spreading diseases which are harmful to human life in the study area as they do not have access to improved sanitation.

Table 4.13 Coverage and types of latrines used in the study area

Parameters	Study Kebeles				
	Gon. gabalo N=30	**Howolso N=30**	**Sedeka N=30**	**Remeda N=30**	**Total N=120**
Open pit latrine/without house	63.33 %	16.66 %	23.33 %	43.33 %	36.66 %
Pit latrine without closed wall but with roof	16.66 %	56.66 %	53.33 %	53.33 %	45 %
Pit latrine with closed wall and roof	6.66 %	16.66 %	3.33 %	3.33 %	7.49 %

4.5.2 The habit of using pit latrines

Although latrines are available, in most cases, they are not being used. The survey result showed that only 43.51 % or less of those who constructed a latrine used it regularly and 26.85% of them used it now and then. On average, about 22.4 % of the respondents who had constructed a latrine used it very rarely or not at all. The basis for not using the latrine regularly were in order of importance: bad smell around the compound, feeling uncomfortable in using the latrine and farther distance between farming place and home rendering the latrine uncomfortable for the regular use (Appendix 11) . Among the reasons given by respondents for the occasional use of the latrine they had constructed in their home was farther distance between farming place and home. Additionally respondents pointed out considerable amount of time it would take to come to the latrine from farming places and get back. Therefore, to fight against this problem a need to construct communal latrines around farming and grazing places is mandatory. Organizations involved in sanitation works in rural areas should focus not only on the household latrine construction but also focus on the construction of communal latrines around farming and grazing places as well.

4.5.3 Disposing baby faeces and solid wastes

As the researcher observed in the study area children are not expected to go far or to use toilet to defecate, rather they are expected to defecate in a place near to their houses and may be in a place where they play. This habit of children is not only limited to those who do not have toilets but also it works for those that have toilets as well as it is not safe for children to use. About 89.2 % of the respondents disposed of baby faeces in to the latrines while only 9.2 % of them threw in the field outside their compound (Table 4.14). Good hygiene practices (especially hand-washing with soap after defecating and before preparing food, and safe disposal of children's faeces) prevent diarrhea (UNICEF, 2008). It has been reported that baby feces that is not properly disposed might put household members at risk of diarrhea (Tumwine et al., 2003). This finding was in agreement to the studies conducted by UNICEF Multiple Indicator Cluster Surveys (MICS) carried out in 2000 in 17 African countries found that in more than half of households surveyed in rural areas the faeces of children under three years old were not disposed of safely.

About 51.5 % of the households were disposing solid wastes in the open field (dispose everywhere), 37.5 % used communal land fill and 11 % of them used private sanitary pit (Appendix 10). The main source of solid waste is domestic refuse. Because of lack of awareness how to handle the refuse the household vicinities were found to be full of solid wastes (garbage's) scattered all over. Considerable number respondents (51%) did not use the proper way of disposing the waste which is unhygienic and responsible for spreading diseases. The condition is, therefore, likely to present a high risk for the continued transmission of communicable diseases despite the efforts made by the Woreda health office to alleviate the existing solid waste management problems. This was able to indicate the condition of environmental sanitation in Shebedino Woreda mainly in relation to water supply and sanitation. The situation in most cases was very poor. There is a need to educate the people to dispose off the waste in proper places.

Table: 4.14 Disposing places of the children faces

Places for disposing baby feces	Study Kebeles				
	Gon. gabalo N=30	**Howolso N=30**	**Sedeka N=30**	**Remeda N=30**	**Total N=120**
Throwing inside compound	6.66 %	0 %	0 %	0 %	1.6 %
Who put in to latrine	73.33 %	90 %	29.66 %	29 .66%	89.2 %
Throw in the field outside their compound	20 %	10 %	3.33 %	3.33 %	9.2 %

4.5.4 Pit latrines with bowls covered

Usually bowls and air vents are used to avoid bad smell around latrines. Moreover, covering might prevent bad smells from spreading beyond the latrine. However, bowls were not covered in most latrines observed in the study area. In more than 57.4% of the latrine, bowls were not covered (Appendix 10). This poses a risk as far as human health is concerned due to the fact that a high probability of water contamination resulted by flies from the latrines. Apart from water contamination, food and utensils used in households may also be contaminated by flies.

4.5.5 Hygienic condition

4.5.5.1 Materials used for washing hands after defecation

According to the result of the survey, about 49 % of respondents in all the study area don't use water at all for hand washing after defecating , 11.66 % of the respondents were using water and ash, 27.5 % using water and soap and the remaining 11.66% were using water only for hand washing after attending toilet .Use of soap was limited because soap was reportedly expensive and was only used for laundry purposes. There may be socio-economical, cultural, and related knowledge barriers inherent in the study area which strictly hampering this practice.

Table: 4.15 Washing materials used after defecating

Washing materials used after defecating	Study Kebeles				
	Gon. gabalo N=30	**Howolso N=30**	**Sedeka N=30**	**Remeda N=30**	**Total N=120**
Water only	23.33 %	13.33 %	10 %	16.66 %	11.66 %
Water and soap	6.66 %	10 %	16.66 %	13.50 %	27.5 %
Water and ash	20 %	23.33 %	23.33 %	26.30 %	11.66 %
Don't use water at all	50 %	53.33 %	50 %	43.33 %	49.16 %

Poor health awareness and poor level of personal hygiene might explain lesser amount of water consumption. Hand-washing with soap can result in major health improvements: one review of studies worldwide documented a 45% reduction in diarrheal morbidity from improved hand-washing (Curtis and Cairncross, 2003) and another documented over 50% reductions in the incidence of both diarrhea and pneumonia when children washed their hands with soap (Luby et al., 2004). This finding was higher than the studies conducted in Ghana, Peru and Kyrgyzstan (Scott et al., 2005).

5. SUMMARY AND RECOMMENDATIONS

5.1. Summary

According to the finding access to safe drinking water is low since the availability of drinking water is not adequate to meet the demand of the community. Water consumption is affected in the study area due to population growth, household size and distance to the water point. These problems imposed different challenge on inhabitants especially on women and daughters such as lose of time and exposure to water borne and related diseases which penalizes the poor. The study helped to understand the nature of rural water supply and sanitation issues such as water use practices, hygienic practices, sanitation practices, the technical quality of water from improved water schemes, the status of improved water facilities, coverage of water supply and sanitation.

As found out, Shebedino Woreda rural water supply service could not meet water demands of the population with existing capacity. At present the coverage of water supply is only 30.5 %. The existing water supply schemes are characterized by very low service coverage, poor operation and maintenance and some water supply services are non functional. Water use at the household level is significantly determined by household size and collection time. Inadequate drinking water adversely affects personal hygiene and clean food preparation hence favoring the transmission of water communicable diseases. The problems in rural areas of developing countries are of particular concern as still large sections of the community are living without safe water supply and basic sanitation services. To resolve this problem United Nations set the goal and target on its millennium development goal. However, it is still lacking far behind from its target. Findings included an estimated use of safe water of 7.1 l/p/d, well below the UAP target of 15l/p/d. Also of concern was data indicating that most people are travelling considerably more than the maximum of 1.5km targeted by UAP.

Most of the water supply schemes in the study area were constructed by NGOs, which were mainly focused on construction of new water supply systems. Little provision was made for operation and maintenance of the constructed water supplies schemes. This indicates that maintenance of the schemes was the most neglected aspect of rural water supply schemes. There is an urgent need for planned action to manage water supply schemes effectively.

As far as water quality is concerned, bacteriological water testing resulted in a presence of pathogens (disease causing bacteria) in all studied Kebeles. The mean number of total coliform and fecal coliform is 8.37 and 4.87 respectively. According to physicochemical water quality testing high Turbidity in Sedeka Kebele at Lamala and Shemeta sites, in Howolso Kebele at Kitawo site and in Gonowagabalo Kebele at Burama and Handisa sites. Manganese and Iron level also higher in Remeda Kebele at Tado site. The water points which were positive for *E. coli* show fecal contamination and the number of coliforms was above the recommended international and national limits.

Pathogenic contamination is the primary health concern in drinking-water supplies, requiring disinfection to inactivate the microbes. Poor hygiene and sanitation behaviors, as well as poor water storage practices are likely causes for the spread of diseases. Likewise, sanitation situation was not so healthy and encouraging. Many factors were responsible for poor sanitation. Some of them were lack of proper disposal of garbage and toilet waste. Poor health awareness and poor level of personal hygiene might explain lesser amount of water consumption. Because of reduced quality of water, lack of household water treatment and poor sanitation there was a greater probability of spread of diseases in the area. To reduce the incidence and prevalence of diarrheal diseases, improvements in the availability, quantity and quality of water, improved sanitation, and general personal and environmental hygiene is required. People can protect themselves from diarrheal diseases and other infections if they are provided with the appropriate information and if they are encouraged to change their behavior. It is therefore important to promote and enhance continuous hygiene education programmes in water and sanitation in order to change behaviors.

5.2 Recommendations

The following recommendations may be useful in achieving more effective and efficient provision of water supply and sanitation in the study area.

- The available quantity of water from all sources of supply schemes should be accessed to all the people on fair distribution basis.
- Both governmental and non-governmental organizations chiefly focus on construction of new water supply schemes currently but the operation and maintenance of rural

water supply are in the lowest performance margin. There should be preventive and regular maintenance program by local institutions and communities in order to keep a water supply system sustainable.

- Attempts are necessary to improve the safety of water from the sources. This can be made through the use of source disinfection mechanisms such as chlorination or point of-use disinfection mechanisms such as boiling to decrease the bacteriological health hazards.
- Using proper drainage and fencing will greatly improve water quality and reduce the risk of water borne diseases.
- Sedimentation method for removal of coarse and fine suspended materials by letting water to settle in sedimentation basins reduces the turbidity problems.
- Responsible bodies in sanitation of rural areas need focus not only on household latrine construction but also focuses on the ways of communal latrines are constructed at selected areas to improve accessibility and use.
- Training should be given to entire community about sanitary, personal hygiene and to protect water fetching material properly.
- More private sanitary pit and communal landfills have to be established to ensure proper waste collection.
- The Woreda WMEO, health office and other concerned bodies should work by integrating water supply and sanitation as they are interdependent on each other instead of treating them disjointedly.

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APPENDICES

Appendix: 1 Summary of livestock population

Ser.No	**Name of livestock**	**Livestock population**
1	Oxen and cows	208,097
2	Sheep and goats	85510
3	Horses, mules and donkeys	6645
Total		**300,252**

Appendix:2 Sample Kebeles and villages selected to collect water sample

Ser.No	**Name of Kebeles**	**Name of village**	**Types of water source**	**Codes assigned**
1	Gonowa gabalo	Burama	Unprotected spring	G1
		Gonowa	Protected spring	G2
		Handisa	Protected spring	G3
2	Howolso	Kitawo	Protected spring	H1
		Shigge	Protected spring	H2
		Shokito	Protected spring	H3
3	Sedeka	Hagela	Unprotected spring	S1
		Shemeta	Protected spring	S2
		Lamala	Protected spring	S3
4	Remeda	Gado	Borehole	R1
		Tado	Borehole	R2

Appendix: 3 Different sources of water used by the community in each Kebeles

Name of Kebele	Sources of water							
	Protected spring		Unprotected spring		Borehole		Total	
	No	%	No	%	No	%	No	%
Gon. gabalo	20	16.66	10	8.33	0	0	30	25
Howolso	30	25	0	0	0	0	30	25
Sedeka	20	16.66	10	8.33	0	0	30	25
Remeda	0	0	0	0	30	25	30	25
Total	70	58.33	20	16.66	30	25	120	100

Appendix: 4 Daily water collection frequency of respondents and average working hours of the scheme in the study areas.

Water collection frequency per day	Number of Respondents		Percentages	Mean	Standard Deviation
Once	7		4.9	2.47	0.607
Twice	50		34.7		
Three times	63		43.8		
What are the average working hours per day of the water supply scheme?	**Number of Respondents**		**Percentages**	**Mean**	**Standard Deviation**
	1-3	89	61.8	1.26	0.44
	3-6	31	21.5		

	6-9	0	0		

Appendix: 5 Respondents satisfaction on existing water supply

Parameters		**Frequency**		
			No	**Percentages**
Are you satisfied with this amount water available to your household daily for drinking, cooking and sanitation?		**No**	119	99.2
		Yes	1	0.8
Does the source get dry during some periods in a year?		**No**	102	93.33
		Yes	18	6.66
Are you satisfied with quality of water you get from scheme?		**No**	62	43.1
		Yes	38	26.4
Does the source get dry during bega (Tir – Megabit)?	**Gonowa gabalo**	**Howolso**	**Sedeka**	**Remeda**
Yes	0 %	4.16 %	0 %	10.83 %
No	100 %	95.83 %	100 %	89.16 %

Appendix: 6 Projected water demand (m3/day) for the year 2016 – 2026

Year	**2016**	**2017**	**2020**	**2023**	**2026**
Human population number	286,200	294,213	319,626	347,234	377,227
Average per-capita domestic water demand (L/c/d)	25	25	25	25	25
Domestic water demand (m^3/day)	7155	7355.32	7990.65	8680.85	9430.67
Livestock population number	171,720	176,528	191,776	208,340	226,336
Average per livestock demand (L/c/d)	3	3	3	3	3
Livestock water demand (m^3/day)	515.16	529.58	575.33	625.02	679.00
Average day water demand (m^3/day)	7670.16	7884.90	8565.98	9305.87	10,109.67
Losses in the system (% of average day demand)	10 %	10 %	10 %	10 %	10 %
Losses in the system (m^3/day)	767.02	788.49	856.60	930.59	1,010.97
Total average day demand (m^3/day)	8437.18	8673.39	9422.58	10,236.46	11,120.64

Appendix: 7 Physicochemical and bacteriological analysis in each study sites

Appendix: 7.1 Physicochemical and bacteriological analysis in Burama site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Gonowa gabalo/ Burama

Source of scheme Unprotected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 442577 Easting (UTM) 757537 Altitude (m) 1874

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	19	19	19	19
PH	8.97	7.92	8.45	8.44
Turbidity (NTU)	27.6	27.6	28.8	28
Conductivity (μs/cm)	96	94	94	94.66
Chloride (mg/l)	1.40	1.52	1.28	1.40
Flouride (mg/l)	0.06	0.04	0.05	0.05
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.002	0.001	0.002	0.0016
Magnesium (mg/l)	10	8	9	9
Total hardness (mg/l)	53	59	56	56
Total dissolved solid (mg/l)	63.42	61.85	67.98	63.42
Nitrate ($N0_3$) (mg/l)	4.20	4.40	4.60	4.40
Nitrites (No_2) (mg/l)	0.04	0.04	0.04	0.04

Bacteriological Analysis				
Total coliform (cfu/100ml)	12	14	13	13
Fecal coliform (cfu/100ml)	8	7	9	8

Appendix: 7.2 Physicochemical and bacteriological analysis in Gonowa site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Gonowa gabalo / Gonowa

Source of scheme Protected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 444373 Easting (UTM) 757377 Altitude (m) 1881

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	19	19	19	19
PH	7.75	6.56	6.47	6.92
Turbidity (NTU)	5.39	5.57	5.49	5.48
Conductivity (µs/cm)	68	84	83	78.33
Chloride (mg/l)	1.30	1.40	1.20	1.30
Flouride (mg/l)	0.20	0.15	0.25	0.20
Iron (mg/l)	0.05	0.06	0.04	0.05
Manganese (mg/l)	0.08	0.09	0.06	0.08
Magnesium (mg/l)	5	4	6	5
Total hardness (mg/l)	38	40	36	38
Total dissolved solid (mg/l)	52.48	50.45	54.51	52.48
Nitrate ($N0_3$) (mg/l)	0.92	0.73	1.11	0.92
Nitrites (No_2) (mg/l)	0.0099	0.0115	0.0083	0.0099

Bacteriological Analysis				
Total coliform (cfu/100ml)	7	6	8	7
Fecal coliform (cfu/100ml)	5	4	3	4

Appendix: 7.3 Physicochemical and bacteriological analysis in Handisa site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Gonowa gabalo / Handisa

Source of scheme Protected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 444860 Easting (UTM) 758572 Altitude (m) 1934

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	19	19	19	19
PH	5.27	6.97	6.48	6.24
Turbidity (NTU)	7.13	6.43	6.85	6.80
Conductivity (µs/cm)	92	94	95	93.66
Chloride (mg/l)	1.65	1.15	1.10	1.30
Flouride (mg/l)	0.45	0.48	0.57	0.50
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.003	0.002	0.003	0.003
Magnesium (mg/l)	0	0	0	0
Total hardness (mg/l)	5	7	6	6
Total dissolved solid (mg/l)	59.34	63.42	65.49	62.75
Nitrate ($N0_3$) (mg/l)	1.26	1.44	1.38	1.36

Nitrites (NO_2) (mg/l)	0.0028	0.0031	0.004	0.0033
Bacteriological Analysis				
Total coliform (cfu/100ml)	9	10	11	10
Fecal coliform (cfu/100ml)	4	3	5	4

Appendix: 7.4 Physicochemical and bacteriological analysis in Kitawo site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Howolso / Kitawo

Source of scheme Protected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 441907 Easting (UTM) 758793 Altitude (m) 1882

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	20	20	20	20
PH	6.78	6.92	6.57	6.75
Turbidity (NTU)	30.7	31.4	30.4	30.83
Conductivity (µs/cm)	141	142	144	142.33
Chloride (mg/l)	1.86	2.15	1.99	2.0
Flouride (mg/l)	0.49	0.58	0.58	0.55
Iron (mg/l)	0.04	0.05	0.06	0.05
Manganese (mg/l)	0.06	0.075	0.094	0.08
Magnesium (mg/l)	8	7	9	8
Total hardness (mg/l)	13	15	14	14
Total dissolved solid (mg/l)	96.08	95.33	94.66	95.36

Nitrate ($N0_3$) (mg/l)	2.89	2.43	2.34	2.55
Nitrites (No_2) (mg/l)	0.0138	0.0144	0.0114	0.0132
Bacteriological Analysis				
Total coliform (cfu/100ml)	11	10	12	11
Fecal coliform (cfu/100ml)	9	8	7	8

Appendix: 7.5 Physicochemical and bacteriological analysis in Shigge site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Howolso / shigge

Source of scheme Protected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 442590 Easting (UTM) 759159 Altitude (m) 1893

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	20	20	20	20
PH	8.2	7.78	7.92	7.96
Turbidity (NTU)	2.26	3.21	2.22	2.56
Conductivity (µs/cm)	102	103	104	103
Chloride (mg/l)	2.10	1.80	2.10	2.0
Flouride (mg/l)	0.19	0.22	0.19	0.20
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.004	0.006	0.0074	0.006
Magnesium (mg/l)	7	8	6	7
Total hardness (mg/l)	25	25	28	26

Total dissolved solid (mg/l)	68.84	69.55	68.64	69.01
Nitrate ($N0_3$) (mg/l)	2.1	1.88	1.96	1.98
Nitrites (No_2) (mg/l)	0.024	0.0198	0.0255	0.0231
Bacteriological Analysis				
Total coliform (cfu/100ml)	7	6	5	6
Fecal coliform (cfu/100ml)	3	4	2	3

Appendix: 7.6 Physicochemical and bacteriological analysis in Shokito site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Howolso / Shokito

Source of scheme Protected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 442592 Easting (UTM) 759902 Altitude (m) 1909

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	19	19	19	19
PH	7.2	6.95	6.45	6.68
Turbidity (NTU)	4.95	5.37	4.42	4.91
Conductivity (µs/cm)	111	112	111	111.33
Chloride (mg/l)	1.40	1.65	1.45	1.50
Flouride (mg/l)	0.37	0.35	0.33	0.35
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.009	0.008	0.0066	0.008
Magnesium (mg/l)	6.90	7.80	7.80	7.50

Total hardness (mg/l)	36	34	32	34
Total dissolved solid (mg/l)	75.16	73.33	75.28	74.59
Nitrate ($N0_3$) (mg/l)	2.48	2.54	2.9	2.64
Nitrites (No_2) (mg/l)	0.0188	0.0196	0.0210	0.0198
Bacteriological Analysis				
Total coliform (cfu/100ml)	9	10	8	9
Fecal coliform (cfu/100ml)	6	7	5	6

Appendix: 7.7 Physicochemical and bacteriological analysis in Hagela site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Sedeka / Hagela

Source of scheme Unprotected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 438462 Easting (UTM) 755411 Altitude (m) 1794

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	21	21	21	21
PH	8.42	7.86	7.97	8.08
Turbidity (NTU)	20.9	21.4	21.8	21.36
Conductivity (µs/cm)	78	83	99	86.66
Chloride (mg/l)	2.50	2.70	2.60	2.60
Flouride (mg/l)	0.29	0.30	0.31	0.30
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.0064	0.0082	0.0088	0.02
Magnesium (mg/l)	8.40	7.80	9.30	8.50

Total hardness (mg/l)	27	25	26	26
Total dissolved solid (mg/l)	57.94	58.54	57.70	58.06
Nitrate ($N0_3$) (mg/l)	1.82	1.68	1.78	1.76
Nitrites (No_2) (mg/l)	0.0029	0.0030	0.0040	0.0033
Bacteriological Analysis				
Total coliform (cfu/100ml)	16	14	15	15
Fecal coliform (cfu/100ml)	7	8	6	7

Appendix: 7.8 Physicochemical and bacteriological analysis in Shemeta site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Sedeka / Shemeta

Source of scheme Protected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 439676 Easting (UTM) 756304 Altitude (m) 1823

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	21	21	21	21
PH	7.72	6.78	7.45	7.31
Turbidity (NTU)	7.41	7.41	7.48	7.43
Conductivity (µs/cm)	112	114	115	113.66
Chloride (mg/l)	2.60	2.40	2.50	2.50
Flouride (mg/l)	0.50	0.65	0.65	0.60
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.0086	0.009	0.0068	0.08
Magnesium (mg/l)	9.80	9.30	9.40	9.50

Total hardness (mg/l)	40	38	36	38
Total dissolved solid (mg/l)	75.94	76.06	76.45	76.15
Nitrate ($N0_3$) (mg/l)	0	0	0	0
Nitrites (No_2) (mg/l)	0	0	0	0
Bacteriological Analysis				
Total coliform (cfu/100ml)	7	9	8	8
Fecal coliform (cfu/100ml)	5	6	7	6

Appendix: 7.9 Physicochemical and bacteriological analysis in Lamala site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Sedeka / Lamala

Source of scheme Protected spring Nature of sample Untreated

GPS Reading: Northing (UTM) 439803 Easting (UTM) 757261 Altitude (m) 1826

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	20	20	20	20
PH	7.45	8.08	7.49	7.67
Turbidity (NTU)	1.78	1.67	1.15	1.53
Conductivity (µs/cm)	120	121	123	121.33
Chloride (mg/l)	3.60	3.90	3.90	3.80
Flouride (mg/l)	0.65	0.75	0.70	0.70
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.005	0.0076	0.0086	0.007
Magnesium (mg/l)	5.5	5.5	4	5

Total hardness (mg/l)	19	17	18	18
Total dissolved solid (mg/l)	80.34	81.06	82.47	81.29
Nitrate ($N0_3$) (mg/l)	2.12	1.98	2.10	2.07
Nitrites (No_2) (mg/l)	0.0028	0.0036	0.0035	0.0033
Bacteriological Analysis				
Total coliform (cfu/100ml)	8	7	9	8
Fecal coliform (cfu/100ml)	6	5	4	5

Appendix: 7.10 Physicochemical and bacteriological analysis in Gado site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Remeda / Gado

Source of scheme Borehole Nature of sample Treated

GPS Reading: Northing (UTM) 440403 Easting (UTM) 761890 Altitude (m) 1922

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	25	25	25	25
PH	7.84	6.98	7.99	7.60
Turbidity (NTU)	2.25	3.64	1.26	2.38
Conductivity (µs/cm)	254	252	253	253
Chloride (mg/l)	1.10	1.40	1.40	1.30
Flouride (mg/l)	0.35	0.45	0.40	0.40
Iron (mg/l)	0	0	0	0
Manganese (mg/l)	0.0088	0.009	0.0072	0.008
Magnesium (mg/l)	8	9	7	8

Total hardness (mg/l)	0	0	0	0
Total dissolved solid (mg/l)	168.95	169.05	170.53	169.51
Nitrate ($N0_3$) (mg/l)	1.39	1.44	1.66	1.50
Nitrites (No_2) (mg/l)	0.0220	0.0240	0.0233	0.0231
Bacteriological Analysis				
Total coliform (cfu/100ml)	5	4	3	4
Fecal coliform (cfu/100ml)	1	3	2	2

Appendix: 7.11 Physicochemical and bacteriological analysis in Tado site

Date of sampling (E.C) 02/06/2009 Date of testing (E.C) 08/06/2009

Zone Sidama Woreda Shebedino Kebele/Village Remeda / Tado

Source of scheme Borehole Nature of sample Treated

GPS Reading: Northing (UTM) 440047 Easting (UTM) 762824 Altitude (m) 1906

Sample taken by Daniel Sokamo

Physicochemical Analysis				
Parameters	**1**	**2**	**3**	**Average**
Temperature (°C)	25	25	25	25
PH	8.45	7.79	7.86	8.03
Turbidity (NTU)	1.81	1.75	1.70	1.75
Conductivity (μs/cm)	248	250	249	249
Chloride (mg/l)	1.20	1.30	1.40	1.30
Flouride (mg/l)	0.50	0.52	0.63	0.55
Iron (mg/l)	1.10	1.30	1.20	1.20
Manganese (mg/l)	2.38	2.45	2.62	2.5
Magnesium (mg/l)	0	0	0	0

Total hardness (mg/l)	39	37	38	38
Total dissolved solid (mg/l)	165.32	167.54	167.63	166.83
Nitrate ($N0_3$) (mg/l)	1.78	1.86	1.90	1.85
Nitrites (No_2) (mg/l)	0.0026	0.0031	0.0042	0.0033
Bacteriological Analysis				
Total coliform (cfu/100ml)	4	5	6	5
Fecal coliform (cfu/100ml)	3	4	2	3

Appendix: 8 Mean values of physico-chemical and bacteriological parameter for water sources on studied sample schemes.

Sample Code	PH	Turb	EC	Cl^-	F^-	Fe	Mn	TH	TDS	NO3	NO2	TC	FC
G1	8.44	28	94.66	1.4	0.05	0	0.002	56	63.4	4.4	0.04	13	8
G2	6.92	5.48	78.33	1.3	0.20	0.05	0.08	38	52.48	0.924	0.01	7	4
G3	6.24	6.80	93.66	1.3	0.50	0	0.003	6	62.75	1.364	0.003	10	4
H1	6.75	30.83	142.3	2.0	0.55	0.05	0.08	14	95.36	2.552	0.013	11	8
H2	7.96	2.56	103	2.0	0.20	0	0.006	26	69.01	1.98	0.023	6	3
H3	6.86	4.91	111.3	1.5	0.35	0	0.008	34	74.59	2.64	0.02	9	6
S1	8.08	21.36	86.66	2.6	0.30	0	0.023	26	58.06	1.76	0.003	15	7

S2	7.31	7.43	113.7	2.5	0.60	0	0.008	38	76.15	0	0	8	6
S3	7.67	1.53	121.3	3.8	0.70	0	0.007	18	81.29	2.068	0.003	8	5
R1	7.60	2.38	253	1.3	0.40	0	0.008	0	169.5	1.496	0.023	4	2
R2	8.03	1.75	249	1.3	0.55	1.2	2.5	38	166.8	1.848	0.003	5	3

Appendix: 9 Results of ANOVA analysis for each parameters

Parameters		Sum of Squares	df	Mean Square	F value	Pr > F
PH	Between Groups	13.955	10	1.396	5.794	<.0001
	Within Groups	5.299	22	.241		
	Total	19.254	32			
EC	Between Groups	113852.848	10	11385.285	583.407	<.0001
	Within Groups	429.333	22	19.515		
	Total	114282.182	32			
Cl	Between Groups	18.987	10	1.899	75.811	<.0001
	Within Groups	.551	22	.025		
	Total	19.538	32			
F	Between Groups	1.200	10	.120	48.175	<.0001
	Within Groups	.055	22	.002		

	Total	1.255	32			
Fe	Between Groups	3.874	10	.387	417.794	<.0001
	Within Groups	.020	22	.001		
	Total	3.894	32			
Mn	Between Groups	17.481	10	1.748	2294.918	<.0001
	Within Groups	.017	22	.001		
	Total	17.498	32			
TH	Between Groups	8021.394	10	802.139	311.419	<.0001
	Within Groups	56.667	22	2.576		
	Total	8078.061	32			
TDS	Between Groups	50969.363	10	5096.936	1875.968	<.0001
	Within Groups	59.773	22	2.717		
	Total	51029.136	32			
NO3	Between Groups	36.889	10	3.689	147.663	<.0001
	Within Groups	.550	22	.025		
	Total	37.439	32			
NO2	Between Groups	.005	10	.000	331.221	<.0001
	Within Groups	.000	22	.000		
	Total	.005	32			
Turbidity	Between Groups	3607.393	10	360.739	1252.989	<.0001
	Within Groups	6.334	22	.288		
	Total	3613.727	32			
TC	Between Groups	336.545	10	33.655	33.655	<.0001

	Within Groups	22.000	22	1.000		
	Total	358.545	32			
FC	Between Groups	128.727	10	12.873	12.873	<.0001
	Within Groups	22.000	22	1.000		
	Total	150.727	32			

Appendix: 10 Pit latrines with bowls covered and places for solid waste disposal

Parameters	**Frequency**	
	No	**Percentage**
Does the pit latrine have covered with bowls over the hole?	Yes 46	42.6
	No 62	57.4
What methods do you use for refusal of disposal?	**No**	**Percentage**
private sanitary pit	13	11
communal land fill	45	37.5
dispose every where	62	51.5

Appendix: 11 Habit of using latrine

How often do you use the latrine?	**Frequency**	
	No	**Percentage**
Very rarely	5	4.62
Rarely	24	22.22
Sometimes	29	26.85
Not at all	3	2.77
Always	47	43.51
Farther distance between farming place & home.	52	43.33

Feel uncomfortable using latrine	93	77.5
Bad smell developed around the compound	28	23.33

Appendix:12 Figures of water supply schemes, laboratory test and sanitary facilities

Fig.7.1 Pit latrine with no bowel taken from Howolso Kebele

Fig.7.2 UnProtected spring in Gonowagabalo Kebele

Fig.7.3 Protected spring in Howolso Kebele

Fig.7.4 Physico-chemical and bacteriological sample test on the laboratory

Appendix:13 Household questionnaire (Questionnaire for water users)

1 General information respondents' background

Interviewer: --

Date of interview ---

Checked by:-------------------------------Date----------------------

1.1 Name of the respondents (optional)____________________

1. 2 Sex: 1) Male 2) Female

1.3 How old are you (optional)? __________________________

1.4 Marital status: 1) Single 2) Married 3) Divorced

1.5 Name of the Kebele:________________________________

1.6 Name of the village________________________________

1.7 No people live in your household __________________

1.8 What is the highest level of education you have attained?

1)Primary 3) Tertiary 4) Non-formal education

2) Secondary 5) Never been to school

1.9 Occupation

1) Farming 2) Small scale business 3) Gov't employee 4) Private work

2 .Questionnaire for water supply and sanitation related information

1. What is the principal source of drinking water for members of your household?

1) Protected well 3) Public tap 5) Unprotected springs

2) Unprotected well 4) Protected spring 6) Surface water

2. If the principal source of water is protected one (such as, public hand pump, pipe line, protected springs), are you satisfied with the quantity of water you get from this schemes?

1) Yes 2) No

3. If your answer for question 2 is No what are the reasons?

1) Low quantity of the water 3) Scheme is non-function 5) Low reliability of the scheme

2) Delay for maintenance 4) Long distance to the scheme

4. Are you satisfied with quality of water from Q2 sources? 1) Yes 2) No

5. If your answer for question 4 is No, what are the reasons?

1) It is salty 3) It has bad smell 5) It has bad taste

2) It is middy 4) It has worms

6. For what purpose are you using the water supply?

1) Drinking and cooking 3) Washing clothes and bathing

2) Irrigation/vegetation production 4) Livestock/animal watering

7. How much water do you use in your household on average per day in liters/ jerry can?

8. Are you satisfied with this amount water available to your household daily for drinking,

cooking and sanitation? 1) Yes 2) No

9. Water collection frequency per day is? 1) Once 2) Twice 3) Three times and above

10. How long does it take (in min) to go to your principal water source & come back?___

11. In your house, water for drinking is stored in a separate container from water intended for other Purposes? 1) Yes 2) No

12. How long is the average waiting time (in minutes) at the water source?____________

13. Do you use any particular treatment for your drinking water?

1) Yes 2) No

14) What uses do you allocate to the water from your private source?

1) Drinking 2) Cooking 3) Washing 4) Cleaning 5) Other please specify

15. The drinking water that you take from the storage containers has no contact with your hand. 1) Yes 2) No

16. What are the average working hours per day of the water supply scheme?

1) 1-3 2) 3-6 3) 6-9

17. Does the source get dry during some periods in a years 1) Yes 2) No

18. If your answer to the above question is yes, when does it dry?

1) Winter (Jan - March) 3) Summer (Jun -August)

2) Autumn (Sep-Dec) 4) Spring (April- June)

19. What do you use to carry water to the house hold?

1) Jerry can 3) Pot 2) Bucket 4) Drum(barrels)

20. How often do you clean your water collection containers?

1) Daily 3) Weekly 5) I don'tknow

2) Every other day 4) When it is dirty

21. Does this household have a latrine? 1) Yes 2) No

22. If yes, what type of latrine facility do you have?

1) Open pit latrine/ without house 3) Pit latrine with closed wall and roof

2) Pit latrine without closed wall but with roof

23. If the latrine is available who construct it? 1) Men 2) Women 3) NGO

24. If no toilet, where do you go for defecation?

1) Bush/ garden 3) Neighbors latrine

2) Public toilet 4) Dug hole

25. Do you share this latrine facility with other households? 1) Yes 2) No

26. How satisfied are you with the latrine you have?

1) Very satisfied 2) Not satisfied 3) Satisfied

27. If not satisfied, why? 1) Too many people use it 2) Too smelly 3) Roof leaks

4) Farther distance between farming place and home house

28. What methods do you use for refusal of disposal?

1) Private sanitary pit 3) Communal land fill

2) Used as soil conditioner 4) Dispose every where

29. Does the pit latrine have covered with bowls over the hole? 1) Yes 2) No

30. Does the latrine have faces and urine on floor? 1) Yes 2) No

31. Does the latrine have bad smell? 1) Yes 2) No

3. Questionnaire for assessment of hygienic behavior of the respondent

32. How often do you use the latrine? 1) Very rarely 3) Some times

2) Rarely 4) Not at all

33. When is it important to wash your hands?

1) Before eating 3) Before preparing food 5) Before feeding children

2) After handling/ cleaning babies 4) After defecating 6) Rarely

34. Is hand washing facilities available near the latrine? 1) Yes 2) No

35. Does the hand washing facility contain water? 1) Yes 2) No

36. The washing materials used most of the time after defecating is?

1) Water only 3) Water and soap

2) Water and ash 4) Don't use water at all

37. Where do you dispose feces of the children?

1) Inside the compound 3) In the latrine

2) In the field outside their compound

38. How often do you take the bath?

1) Daily 3) Every two weeks 5) Not at all

2) Twice a week 4) Occasionally 6) Once a week

Appendix: 14 Observation checklist

Location information

1. Woreda ___________________ Kebele ____________________________
2. Specific location name of the water point/source______________________________
3. GPS coordinate of the water point/source

X coordinate (Northing) ______Y coordinate (UTM) _______Altitude (*m.a.s.l*)_____

4. Water source/point.No (E.g. 01,02,03,……)
5. Current status of the water point 1) Functional 2) Non-functional
6. Number of households using the scheme_________________
7. Has the water point been chlorinated? 1) Yes 2) No

	Sanitary surveillance			
No	**General topics**	**Yes**	**No**	**Remark**
9	Is there washing and bathing near the scheme?			

10	Are natural (vegetative) barriers constructed?			
11	Is the scheme well fenced to prevent animals from contaminating the source?			
12	Is there catchment control (with people's participation)?			
13	Does water color changes after heavy rain?			
14	Is the scheme guarded?			
15	Has the scheme be ever treated with chlorine for disinfection?			
16	Is there a pit latrine within 30m from the dug well?			
17	Are there other sources of pollution within 10m around the scheme (e.g.animal breeding, cultivation, roads, industry, etc)?			
18	Is there stagnant water around the water point/source?			

Appendix:15 Interview for Shebedino woreda BWMEO officers

1. What are the basic problems in the community?
2. Is there sufficient water for all community members at any time?
3. Is the water quality sufficient for drinking?
4. Is the water supply system technically sound and feasible for the needs in the community?
5. How many people does one scheme serve?
6. State the difference in distance with in which the schemes are constructed?
7. Do you contribute to creating awareness about using safe water?
8. Are there NGOs working on water development activities?
9. Are there competition and conflicts over water by the kebele inhabitants?
10. Have you recognized any problems caused by unsafe water consumption?
11. Do the government and NGOs attempt to promote public participation in water related development activities, and in what ways?

12. Is there committee of working on water supply and sanitation in your community?

    1) Yes 2) No

13. If yes, How do you relate existence of such committee with water supply and service?
14. Do the political leaders participate in water committee of the community?
15. Is there any legal ground to enforce individuals in the community to participate in water supply and sanitation committee?
16. If there is such enforcement, how does this affect the existing water supply and sanitation system of your community?
17. How is responsibility distribution among the community regarding water supply and sanitation managements. 1)Participatory 2) Held by some leaders
18. What is your opinion about participation of the whole community in contributing construction, operation, and maintenance costs?

    1) Actively participate 2) Not participate

19. How do you state participation of women in water and sanitation activities in your community?
20. How does this participation of different community classes affect water supply and sanitation in the community?
21. Your suggestions for improving water supply and sanitation improving health and overall standard of living.

Appendix:16 Interview for group discussion and health extension worker in the Kebele

Interview for group discussion

1. What are the basic problems in the community?
2. Do you think the current water and sanitation facilities are satisfactory to the community members?
3. How do you relate water supply and sanitation of your community with environmental improvement?
4. How does improved water supply and sanitation system affects cultural view towards water use and sanitation of your community?

Interview for health extension workers in the Kebele

1. Background: age, sex, education, etc.

2. Year of service, in other place and current kebele
3. Major activities of health extension worker
4. What are the basic problems in this community?
5. Are the diseases are related to unsafe drinking water and poor sanitation?
6. What role do you play to minimize the exposition of the community members to water diseases?
7. Do you believe that the training you have had allows you to address most problems you encounter at community level?
8. Do you contribute to creating awareness about using safe water?
9. Do you advise and train community members to take care in preventive actions?
10. What are the perceived health problems owing to reliance on unsafe water?
11. Which types of diseases are the most prevalent water-borne, water washed or water related?
12. What are the perceived health problems because of poor water and sanitation?
13. What types of households are most susceptible to water-related diseases?
14. Do you think there is a linkage between poor accessibility of water and sanitation ?

BIOGRAPHICAL SKETCH

Daniel Sokamo was born in Shebedino Woreda, Sidama Zone, South Nation Nationalities and People's Region. He attended his elementary school at Leku Primary and Junior Secondary and completed his high school at Leku Senior Secondary and Preparatory School. He then joined Hawassa University,Wondo Genet College of Forestry and Natural Resources Faculty of Natural Resource Management with Bachelor of Science in 2008.

He was employed by the Ministry of Agriculture and Natural Resources Department in Sidama Zone. Since then, he has been working as a Soil and Water Conservation expert.

After enormous commitment and hard work, he continued his studies in a Master's program at School of Biosystems and Environmental Engineering, Institute of Technology of Hawassa University in mid of 2015.