DETERMINANTSOF COVERAGE AND QUALITY OF POTABLE WATER SUPPLY AND SANITATION IN RURAL AREA OF BORICHA WOREDA, SIDAMA REGIONAL STATE, ETHIOPIA

MSc RSEARCH THESIS

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DETERMINANT OF COVERAGE AND QUALITY OF POTABLE WATER SUPPLY AND SANITATION IN RURAL AREA BORICHA WOREDA, SIDAMA REGION, ETHIOPIA

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As thesis research advisor, I hereby certify that I have read and evaluated this thesis prepared under my direction, by Genet ZenebeHaile, entitled “Determinant of Coverage and Quality of Potable Water Supply and Sanitation in Rural Area Boricha Woreda, Sidama Region, Ethiopia and recommend that it be accepted as fulfilling the thesis requirement.

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As members of the Examining Board of the Final MSc Open Defense, we certify that we read and evaluated the thesis prepared by Genet Zenebe and recommend that it be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Department of Water Resource Engineering

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STATEMENT OF AUTHOR

First, I declare that this MSc. Thesis is my original work, and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirement for an advanced MSc degree at the Hawassa University and is deposited at the university library to be made available to borrowers under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree diploma or certificate.

Genet Zenebe Haile

Signature _______________

LIST OF ABBREVAITIONS AND ACRONYMS

BWFO	BorichaWoreda finance Office
BWHO	BorichaWoreda health organization
DIDE	Difference-in-Difference Estimation
EU	European Union
EWIM	Ethiopia Water and irrigation Minister
masl	meter above sea level
NGO	Non-Governmental Organizations
OWRMB	Oromia Water Resource Management Bureau
PASDEP	Plan for Accelerated sustained Development and to End Poverty
BWRAS	BorichaWoreda rural agricultural sector
SNNPR	South Nation nationality people region
SWMEB	Sidama Water Mining and Energy Bureau
SDA	Sustainable Development aims
UNDP	United Nation Development Program
UN-HSP	United Nations Human Settlements Program
UNICEF	United Nations Children’s Emergency Fund
WHO	World Health Organization
WWMEO	Woreda water mining energy

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ABSTRACT

Clean water is an essential element for human health, wellbeing, and prosperity. Everyhuman being has the right to access safe drinking water. But, nowadays, due to rapid population growth, lack of sustainable development, and climate change; people around the world face a problem of water scarcity. This study aimed to identify the determinants of coverage and quality of potable water supply and sanitation in rural area of Boricha woreda, Sidama regional state, Ethiopia.A community-based cross-sectional study was carried in 2022 from four rural kebeles. 13water samples were taken forphysico-chemical and bacteriological parameters analysis,Data collection samples were selected randomly to each kebeles' households. MS Excel and stata-14 were used to enter and analyze the data.85 households were selected from Four kebele by systematic sampling methods; from which 71(83.53%) men and 14(16.47%) were women. Based on the study undertaken, 79.41% of households used improved and 20.59 % of households used unimproved drinking water sources. Household's drinking water sources are significantly associated with age of the household head, educational level, hand washing facilities, defecation, the availability latrine, treatment method, cause of quality potable water and perception of the household head factors were significantly determining the sanitation with the drinking water sources.The average values physic-chemical parameters Temperature 20.98°C Turbidity 1.29 NTU, PH 6.65-6.08,Electro conductivity 400.11 μs/cm, Phosphate 4.07 mg/l, Total hardness 105.16 mg/l, Nitrate 3.37 mg/l and Chloride 5.28 mg/l. The average values Bacteriological parameters of drinking water in study area: Total coliform 23.25 cfu and Feacal coliform 3.17cfu the point of consumption and storage respectively. In terms of physic chemical parameter of drinking water: PH, total dissolved solid, electro conductivity, total hardness and nitrate values; are at allowable level comparing with WHO guide line. On other hand; the mean values of temperature, iron and fluoride were much greater than WHO guideline value. I conclude that, according to the finding access of quality drinking water coverage is very low and scarcity to meet the demands of the community.

Key words: Boricha Woreda, Water Source, Accessibility, sanitation, Waterquality

1. INTRODUCTION

1.1. Background

Clean water is an essential element for human health, wellbeing, and prosperity (Hannah *et al*., 2019). Every human being has the right to access safe drinking water. But, in now day, due to rapid population growth, illiteracy, lack of sustainable development, and climate change (drought and poverty) are still face a global challenge. Currently, about one billion people, who live in the developing world, don't have access to safe and adequate drinking water (UNICEF/WHO, 2012).

The 2030 Agenda for Sustainable Developmentaims to achieve universal and equitable access to safe and affordable drinking water, using the proportion of population using safely managed drinking water services as the associated indicator (UN, 2015). In 2022, 2.2 billion people still lacked safely managed drinking water, including 703 million without a basic water service; 3.5 billion people lacked safely managed sanitation, including 1.5 billion without basic sanitation services; and 2 billion lacked a basic handwashing facility, including 653 million with no handwashing facility at all, over 2 billion people lack safely managed drinking water and 785 million do not even have "basic" services (SDG,2023 and WHO/UNICEF, 2019). Progress to improve water security is most challenging in contexts where financial and institutional resources are limited and where water resources are threatened by chronic (e.g., groundwater contamination) and acute (e.g., floods and cyclones) threats.

Globally, between 2000 and 2015, the population using piped supplies increased from3.5billion to 4.7 billion, while the population using non-piped supplies increased from 1.7billion to 2.1 billion. Evidence shows that globally two out of five people in rural areas and four out of five people in urban areas use piped supplies (WHO and UN, 2017). About 748 million people, mostly the poor and marginalized, there is a scarcity of using an improved water source supply and of these, almost a quarter (173 million) rely on untreated surface water, and over 90% live in rural areas (JMP, 2014). According toAyat (2019), 42% of the population has access to a clean water supply and only 11% of that number has access to adequate sanitation services globally.

Sub-Saharan Africa,today only 27% of Sub-Saharan Africa's population has access to basic sanitation and 220 million people across the continent still practice open defecation – in some countries, this number is increasing, as service providers fail to keep pace with population growth (Ayat, 2019).

The Ethiopian Demographic and Health Survey (CSA and ICF, 2016) reported that 97% of urban households in Ethiopia have access to an improved source of drinking water and in rural areas, only 57% have improved water accessibility. But no reliable information is available on the readability of drinking water quality reports (Jouandot D, *et al*., 2014). As a previous report, Ethiopia is the country with the worst of all water quality problems in the world. It has the lowest water supply (42%) and sanitation coverage (27%) in sub-Saharan countries (Ayat, 2019). Ethiopia is considered as having one of the poorest sanitationsand drinking water infrastructures (Troyer N, *et al.,* 2016).About 52.1% of the population has been using unimproved sanitation facilities while 36% of them practiced open defecation (Beyene A., *et al.,* 2015). The discontinuity of drinking water supply affects the distribution of water to the community in need (Chalchisa D. *et al.,* 2018).

Due to the lack of accessibility of water in many rural areas, females are put to work on collecting water each morning to help their families (WHO, 2019). The burden of water collection does not fall equally on all household members; the gender breakdown is consistent for both urban and rural areas (ESS, 2017). The responsibility of collecting water-primarily falls on women, sons, or daughters of the households. Globally; women (64%), men (24%), girls (8%), and boys (4%) share the burden of collecting water (WHO,2018).Due to the presence of a burden on children, only 45% of kids attend primary education in Ethiopia (Chalchisa D., Megersa M. and Beyene A., 2018).Unsafe and inadequate water supply together with poor sanitary conditions result in higher rates of morbidity and mortality particularly in rural areas of the country(Begashaw, 2003). and also, water and sanitation-related sicknesses put severe burdens on health services and keep children out of school (Baba, S.A., 2017). Younger household members are more likely to collect water, but this differs by place of residence; while only 22 percent of those who collect water in urban areas are children (aged 7 to 14). In rural areas, nearly 37 percent of water collectors are children (UNCIF/WHO, 2016).

According to SRWMIB (2121) survey report, access to water supply in Sidama reginal state has been steadily improving over the past three years. In the Sidama region there are about 5350 water supply schemes operating throughout the region including 67 spring with distribution, 3118 spring on spot, 1971 shallow wells (including hand dug wells fitted with pump and roop pump), 193 deep bore hole with distribution and one surface water based pumped water supply systems constructed by the regional government and NGOs. Due to lack of sustainability of project aggravated the existing poor coverage of water and sanitation implying negative impacts on coverage and on the attainment of the plan. The functionality rate for improved water supply in the region is reported to be 80.2% in rural water supply schemes. However, it has been noted that about 27% of the water supply schemes are non-functional at any given time. The discontinuity of drinking water supply forces households to use water storage material or to use water from unimproved sources.

Boricha Woreda Water Resource Office information; most of the drinking water sources comes from the ground water. Mostly uses unsafe water from natural spring, Shallow well and local pond.The adequacy and accessibility of drinking water still blow when comparing to the demand of the rural community (Philipos, 2019) study the most of the rural communities were dependent up on alternatively unprotected drinking water source like hand dug well, local pond, Shallow well and on spot spring. Some of the infrastructure features of a rural water supply include Hand dug well, springs, Boreholes, Shallow well/Medium well, and roof rainwater catch tanks (Younger,2007). Irregularity of water supply was observed and the community is forced to use unprotected water storage materials. The water from unimproved water sources might be contaminated with animals, floods, and specks of dust through wind, animal and human wastes. This ultimately causes human sickness

As a result of different reasons, there was a continuing dearth of information on the identification of determining factors of using improved sources of potable water in the study area. Therefore, thestudyaddressed this knowledge gap and explored in detail determinant factors for coverage and quality of potable water supply and sanitation in rural area BorichaWoreda, Sidama region, Ethiopia.

1.2. Statement of the Problem

Ethiopia ranks among the lowest countries in the world in levels of safe water and sanitation coverage. 97 % of urban households in Ethiopia have access to an improved source of drinking water and in rural areas, only 57% have improved water accessibility (CSA % IFC,2016). 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).

Access to potable water substantially improved during the PASDEP period (2005/06 - 2009/10), increasing from 36% to 68.5% at the national level. In many local communities, however, access to potable water is still a great challenge, and the in all parts of Ethiopia.

The estimated water service level of Ethiopia in terms of coverage, quantity, quality, and reliability is among the lowest in the world. Sanitation facilities are also in worst condition. Due to unreliability of safe and sufficient water supply and adequate sanitation facilities the estimated service level could be in much less situation. These combine effect of the poor water supply and sanitation facilities in the country have high effect on the economic development of thecountry and the living condition of the communities (OWRMB, 2009).

Boricha Woreda community does not have access to potable water and basic sanitation adequately. Thus, the communities are forced to use water from unprotected water sources. Access and coverage of potable water supply and sanitation services are supposedly very sounding problem in study area (WWMEO, 2022). It was observed that there are several factors in the community that were likely resulting in water contamination at sources or during collection, storage and point of-use in household level. The other problems related to water, sanitation and hygiene in the study area are lack of awareness of people and microbiological pollution (BWHO, 2022).

This research, therefore, specifically investigated the determinants ofwater coverage, water quality and the gap associated to water sanitation to initiate intervention measures in order to address the specified problems in Boricha Woreda.

1.3. Objectives of the Study

1.3.1. General objective

The main objective of this study was to assess the determinants of coverage and quality of potable water supply and sanitation at the rural household level in Boricha Woreda of Sidama National Regional State.

1.3.2. Specific Objectives

1. To identify the types and nature of water supply sources in the Woreda,
2. To identify the gap between water supply and demandin the Woreda,

3. To quantify the determinants of sanitation at household level in the Woreda.
4. To assess determinantsof quality potable water supply to each improved water source observed by using selected physico-chemical and bacteriological parameter.

1.4 Research questions

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

1. What types/kinds and nature of sources of water in the Woreda?
2. What are the current status of water supply and demand in the Woreda?
3. What are the determinant factors of sanitation at household level in the Woreda?
4. What are determinants of the quality potable water supply to each improved water source?

1.5. Significance of the study

An in-depth study of effect of access to potable water and sanitation on rural healthhelp to improve households' attitude towards sanitation and hygiene and education practices. Research on issues concerning effect of access to potable water and sanitation on rural welfare is crucial for formulating programs for the reduction of diarrhea morbidity and pneumonia incidence. The study gives a clue for policy makers and planners towards major bottlenecks of rural welfare. The provision of clean drinking water and sanitation are the main problems in whole world predominantly in poor countries like Ethiopia. Moreover, this paper has two major contributions. First, existing studies that examine the determinants of storage water quality and its relationship with rural water supply sources and household's sanitary behaviors are quite limited: they primarily focus on the impact of water source types on storage water quality and ignore hygiene- and sanitation-related factors (Amenu*et al.* 2014; Yasin*et al.* 2015). Second, determinants of domestic water quality under multiple-use water systems is under researched (Scheelbeek 2005; Sutton *et al.* 2011). Hence, the study result shows that the existing water supply and sanitation situation of the rural inhabitants by investigating the sources of water, levels of sanitation services, causes of water sanitation and inaccessibility and their effects on the livelihood of the people and environment**.**It also provides insight to NGOs,community-based organizations and other stakeholders who are concerned with water supply andsanitationproblems. The study result might initiate other researchers to conduct different research works from different perspectives.

1.6. Scope of the Study

The focus of this study was on water supply and sanitation constructed in the rural part of BorichaWoreda. This study specifically was emphasis on determinants of rural water supply and sanitation. The study area was limited to rural kebeles in Woreda. The study was covering the selected kebeles of water supply and sanitation where data generated from selected household beneficiaries.

CHAPTER TWO

LITERATURE REVIEW

2.1 Water Supply and Sanitation

Access to water is a prerequisite for health and livelihood, which is why the MDG target is formulated in terms of sustainable access to affordable drinking water supply. The availability of improved and quality water supply and sanitation infrastructures are widely recognized as an essential component of human rights, social and economic development (ADF, 2005). The poor and marginalized people living in rural and peri-urban settlements are most in need for improved and safe drinking water, appropriate forms of sanitation and access to water for other domestic purposes (Crow, 2001). The WHO (2000) reports that polluted drinking water causes about1.8 million people die from diarrheal diseases annually worldwide. Ethiopia is a country in which the water supply and sanitation infrastructure endeavors are still low.

Even though improved water sources are available, they are often far away from the beneficiary households are located at inconvenient locations. The management system of stakeholders coupled with water quality problems and inaccessible water sources are some of the basic problems (Demeke, 2009; Bhandari and Grant, 2007). The topography of Ethiopia is characterized by rugged landscapes on which women and children travel long distances by carrying large containers up and down steep slopes. Full water cans may weigh up to 65 kilograms (Demeke, 2009). In addition to that, the lack of safe water supply has other series negative consequences such as the workload in fetching unsafe water from mostly distant unimproved or traditional water points make them vulnerable to health problems. As a result, most of the children miss the opportunity of attending school, while women spend 10-50% of their daytime fetching water from polluted water points, losing time on productive activities (Ethiopian Water Resources Management Policy, 1999; Crow, 2001). According toWHO, basic access can be defined as the availability of drinking water at least 25 liters per day per person, a distance of not more than 1 km from the source to the house and a maximum time taken to collect round trip of 30 minutes. The UNDP (2008) says the minimum absolute daily water need per person per day is 50 liters (13.2 gallons) which include: 5 liters for drinking, 20 for sanitation and hygiene, 15 for bathing and 10 for preparing food. However because of scarcity of drinking water, millions of people try to exist on 10 liters (2.6 gallons) a day (ADF, 2005). In densely populated areas, a water hauling trip of 30 minutes or less, including queuing time would be a more appropriate indicator of access. As indicated by ADF (2005), over one third of women in some of the regions spent more than two hours for each water collection trip. This fact is aggravated by the poor supply efficiency, resulting from bad condition, which cannot satisfy the entire populations from different villages sharing the same water source and increased queuing time is common during the dry seasons (Admasu et al., 2002). This will ultimately lead to household water insecurity (less water available than is needed for drinking, cooking, and sanitation) in rural areas, especially for those households for which the demand is higher due to large family size (Collick, 2008, as cited by Meseret, 2012). Because of these conditions, it is difficult to think about personal hygiene and sanitation especially for the rural communities. Despite the scarcity of water, many priorities give for drinking and cooking purposes. Rural communities use unprotected springs and hand-dug wells commonly for cooking and drinking purposes. Whereas rivers besides their use for washing clothes they also used for drinking purposes.

This results in not only sickness and death, but also economic crises. Therefore, safe drinking water is an essential component of primary health care and is vital forpoverty alleviation. Introducing improved water supply sources at the household level enhance personal and community knowledge as well as awareness of the importance of other factors, such as hygiene and sanitation (Sobsey, 2002).

2.2. Water Supply

2.2.1. Water supply in Ethiopia

Access to water supply and sanitation in Ethiopia is amongst the lowest in Sub-Saharan Africa and the entire world (WHO, UNICEF, 2008). While access has increased substantially with funding from external aid, much still remains to be done to achieve the Millennium Development Goal of halving the share of people without access to water and sanitation by 2015, to improve sustainability and to improve service quality (WHO, UNICEF, 2008).

Provision of safe and sufficient water supply and adequate sanitation services are indispensable components inthe sustainabledevelopment of Ethiopia’s urban and rural socio-economic 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).

In Ethiopia, the water supply service level, in terms of coverage quantity and quality, is very low due to factors like topography, sources of water reserve, distribution systems, treatment plants, and community health centers. The same is true in the case of poor sanitation facilities. Sanitation methods are dry sanitation practices, poor sewage systems, low septic tank provisions, and poor storm water drain systems (WMSR, 2006).

Due to its unreliability and non-sustainable nature, the existing service level in different parts of Ethiopia is lesser than the required levels. That is to say improved sanitation methods are required which are also expectations‟ of residents. The poor water supply and sanitation facilities, along with other infrastructure services, bear a high level of impact on national and regional development, inclusive of both urban and rural communities (WMSR, 2006).

According to Philipos (2019) cited, The Ethiopian government's efforts on implementing a water sector development programs are based on the national resource management policy. The national water resource sector strategy is part of the water sector development program. The government receives a credit or grant for the urban water supply and sanitation (UWSS) component of the project (WMSR, 2006). The five sources of drinking water in Ethiopia are:-1 Own tap, 2 Public tap (bono), 3 Protected well/spring, 4 Unprotected well/spring, and 5 Rivers or lakes.

2.2.2. Water supply in Sidama region

Access to water supply in Sidama reginal state has been steadily improving over the past three years. In the Sidama region there are about 5350 water supply schemes operating throughout the region including 67 spring with distribution, 3118 spring on spot, 1971 shallow wells (including hand dug wells fitted with pump and roop pump), 193 deep bore hole with distribution and one surface water based pumped water supply systems constructed by the regional government and NGOs . The predominant water supply technology used in Sidama region is spot spring approximately 58.3% of the population with access to safe water supplies in rural area is served by spot spring followed by shallow wells which is 36.8% (Feleke, 2018).However the average for Sidamaregion is 68.6%(SRWMEB,2021), for the rural Woreda about 33%(Zelalem, 2016).

Due to lack of sustainability of project aggravated the existing poor coverage of water and sanitation implying negative impacts on coverage and on the attainment of the plan.

The functionality rate for improved water supply in the region is reported to be 80.2% in rural water supply schemes (MWIE, 2021). However, it has been noted that about 27% of the water supply schemes are non-functional at any given time. The causes for non-functionality are; 52.1% shortage of spare parts,15.2% drying up water sources,7.8% technical break down ,6.6% pump failure and others like water quality, shortage of fuel or electricity and funds 19.3%(MWIE, 2021).

2.2.3. Water Supply in Boricha woreda

There are three main sources of water for commercial use and domestic consumption in study area namely: Piped water supply from National Water and Sewerage Corporation (NW&SC) supply mains, underground sources (spring wells, shallow wells and bore holes) and streams and Lakes (Philipos,2019). According to Boricha Water and Sewerage Plan Report 2011, 25 % of Woreda population had access to improved water from NW&SC of which it was very little compared to other. Boricha is located in an arid region, the district often experiences “dry years,” stressing that some school children miss several months of school because their families are constantly searching for water (Zelalem, 2016).

According to KPC (2011) Baseline survey data, 50.7% obtain drinking water from Shallow well; it was used for drinking and different purpose. The second highest proportion of peoples in the area was used water from tape water from public bono (29.6%) use only for drinking, which is safe for health and satisfaction. As it is observed, natural spring holds the third level by number of users (9.9%) for drinking purpose. Only few respondents use alternatively hand dug well and local pond (5.6%) and (4.2%) respectively for domestic purpose. A nearly similar assessment by the water development commission's draft Report on National WaSH Inventory-II & MIS (MWIE, 2021) accessed drinking water supply was around 38%. According to Philipos (2019), 64.8% woreda population mostly uses unsafe water from natural spring, Shallow well and local pond.

According to Philipos (2019), Boricha Woreda Water Resource Office information; most of the drinking water sources comes from the ground water. The adequacy and accessibility of drinking water still blew when comparing to the demand of the rural community. Since most of the rural communities were dependent up on alternatively unprotected drinking water source like hand dug well, Local pond, Shallow well and on spot spring. Some of the infrastructure features of a

RWS include Hand dug well, springs, Boreholes, Shallow well/Medium well, and roof rainwater catch tanks (Younger,2007).

2.2.3.1.Hand dug well

A hand dug well is a type of water well which is constructed by digging by hand and it is the most widely used method of well-constructed in many rural area of the world. Using simple construction techniques and suitable material, hand-dug well can provide reliable amount of water (IRC, 1987).

Hand dug wells (HDWs) are a common technology employed for rural water supply because of its relative ease in construction, low cost input and its familiarity to most communities. Nowadays, the technology has been modernized by using better linings and more pumps that are efficient in order to improve a well's performance. HDWs are shallow ranging in depths up to 20 meters and approximately 1.5 meters in diameter, which accommodates the digging process. These wells most often are dug down to tap water stored in perched water tables, clay, or other impermeable layers on which percolated water collects above the main water table. The addition of a lining to the HDWs decreases the likelihood of a well collapsing and excessive loss from seepage (Water Aid, 2011).

2.2.3.2. Spring

A spring is a place where groundwater naturally is released from the earth's surface. Spring water typically moves downhill through cracks and fissures in the bedrock until the grounds surface intersects the water table. They are usually used as water supplies and can be a reliable and relatively inexpensive source of drinking water if they are developed and maintained correctly (Stephanie et al., 2007). Spring located toward the top of the water table tend to dry out as the water table lowers during the dry season, while spring located lower on the water table only reduce their output (Eric, 2011). There are many different types of springs falling under two categories, according to the condition under which water flows to them: gravity springs and artesian springs (Jo and Christine, 2002).

Groundwater seepingfrom the ground tothe surface at springs provides anexcellent water supply source if it is developed appropriately and remains free from pollution. Springs have variable flow so their low regime must be checked to determine whether it is sufficient for the demand. Low flows coincide with the very beginning the rainy season or at the end of the dry season. According to Water Aid (2011), a flow of 0.1 liters per second (Lps) would result in a daily flow of about 3,000 liters which would supply a community of 150 people with their water requirements (20L per person per day). However, an addition of a spring collection box or tank would allow even lower flows (< 0.1L) be considered for water supply.

2.2.3.3. Medium/Shallow well

Shallow wells are deeper than 30 m but lesser in depth than Boreholes, which are much deeper (up to > 100m) and have a smaller diameter, approximately 100 to 150 mm. Boreholes or shallow wells often reach the main aquifer where sufficient water can obtain. However, pumping is the only option to extract the water from these wells. Similar to HDWs, a borehole will have an internal lining, an apron and cover for situating a pump. The actual excavation of the well is the challenge (Water Aid's, 2011).

Poorly designed and constructed well will quickly become expensive to maintain and eventually unstable, possibly even collapse. In order to design a borehole a general understanding of water occurrence and movement through rocks (science of hydrogeology) is important. In addition, the selection of the most appropriate equipment is an important process that should be carefully considered and continuously reviewed (IRC, 1987).

According to Harevy (2007) for boreholes and medium wells to be sustainable there need to be active community mobilization in site selection, during drilling, post drilling, installation and management otherwise this can have a significant negative impact on poor rural communities, particularly in the dry season when alternative water source are scarce.

2.2.3.4.Hand Pumps

A hand pump is composed of a pumping arm, a piston or plunger, valves, pump rods and pump cylinder. The arm is pumped by hand and drives the piston and pump rods up and down within the pump cylinder causing the different valves positioned above and below the piston to open and close depending on whether water is being pulled in or pushed up (Water Aid, 2011).

Hand pumps are installed on hand-dug, shallow, and deep wells in order to lift water from below the ground surface to the users at the surface. A bucket and rope system is the traditional lifting device but requires excessive effort and strength to lift the water, entails frequent replacement, and subject to pollution from both the ground surface and the bucket and rope. There are several types of hand pump exist and used throughout rural Ethiopia.

2.3. Water demand and Supply in Boricha

According toPhilipos (2019), access to safe drinking water is low since the availability of drinking water is not adequate to meet the demand of the community. Average drinking water supply coverage of studied four kebeles of Boricha was found to be 35.75%. The average quantity of water used by a person per households is 9.57 liters with average distance about 0.989 k.m by average time 37minut which is significantly less than the WHO and Ministry of Water and Energy of Ethiopia guide line values.

According to the Boricha Woreda Water mining and energy officeinformation; most of the drinking water sources comes from the ground water. The adequacy and accessibility of drinking water still blow when comparing to the demand of the rural community. Since most of the rural communities were dependent up on alternatively unprotected drinking water source like hand dug well, Local pond, Shallow well and on spot spring. Most of the communities in study area were used Local ponds as alternative water sources for bathing, washing clothes, livestock drinking.

There was significant shortage of safe drinking water that translates into high prevalence of water borne and related diseases and high incidence of diarrhoea (CSA, 2006). According to Philipos (2019), investigated that peoples (64.8%) mostly use unsafe water from natural spring, Shallow well and local pond; occasional when public tape water fails to function due to break down of the schemes, Electrical system and poor maintenance service.

2.4.Water Sanitation

2.4.1. Sanitation in Ethiopia

Ethiopia like many other countries in Sub-Saharan Africa has low levels of water, sanitation and hygiene facilities and practices. The national coverage figures for access to safe rural water supply within 1.5km are quoted to be 41% and access to safe urban water supply within 0.5 km to be 78%. Sanitation coverage is quoted to be 18% in rural areas and 57% in urban areas (USAID, 2015). It has been reported that 60% of overall diseases is related to poor sanitation and hygiene in Ethiopia (WHO, 2014). A diarrheal disease represents more than 75% of outpatient cases in Ethiopia and contributes to malnutrition.

There is also a high prevalence of worm infestations (causing anemia). This, in turn, impacts on school attendance and level of education attained (FDRE,MoH,2005).This is actually contributed due to poor sanitation practices such as open defecation, a low level of hygiene practices, and improper waste disposal. In general, more than 80% of communicable diseases in Ethiopia are believed to be preventable using environmental health interventions, so targeting hygiene and sanitation is vital for improving the health of the population at large (CSA,2011)

Among the main problems which are responsible for this situation are: lack of priority given to the sector, lack of financial resources, lack of sustainability of water supply and sanitation services, poor hygiene behaviors, and inadequate sanitation in public places including hospitals, health centers and schools. Providing access to sufficient quantities of safe water, the provision of facilities for a sanitary disposal of excreta, and introducing sound hygiene behaviors are of capital importance to reduce the burden of disease caused by these risk factors (Esrey et al., 2011)

2.4.2 Sanitation in Sidama Region

The availability of safe drinking water is one of the biggest difficulties plaguing the people of Ethiopia's Sidama region. The Sidama Zone aims have access to safe and affordable drinking water and to enable the effective operation and sustainable management of sanitation facilities. Special emphasis is given to the needs of women, girls and people in difficult socio-economic situations (Adam, 2019). The situation in rural areas of Sidama region, drinking water quality, accessibility, sanitation and hygienic facilities are also very low. Many households in the Woreda use simple traditional pit latrine irregularly and some of them use open area for defecation. Also, conventional water treatment techniques are not used to ensure safe drinking water supply to the community according to the information obtained from reginal health bureau.

According to a 2009 IRC baseline KPC survey conducted in the Sidama Zone, only 7% of households reported using a latrine, whilst 93% percent practiced open defecation (KPC, 2009). There have been outbreaks of acute watery diarrhea in Sidama**.** The 2009–2011 Emergency

Preparedness and Response Plan (EPRP) for SNNPR estimated that up to 65,260 people were affected by acute watery diarrhea in 2009 (DSEPR , 2011).

Sanitation coverage is quoted to be 38% in rural areas and 57% in urban areas. In the rural areas long queues around safe drinking water points are not uncommon. Some 60% rural households have access to latrine facilities compared to 80% in urban areas (national figure 63%). Local environmental conditions, such as loose soils, high groundwater tables, floods, termites attacking construction timber, and lack of timber threaten. However, to make the lifetime of latrines short; i.e. questions do arise as to the sustainability of this wave of latrine construction (e.g. need for technical innovative improvements) if HHs are not to drop off the sanitation ladder and stop using latrine (BoH, 2015).

2.4.3. 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).

Table 2.1 Elaborates about the improved and unimproved water, Source: JMP, 2006

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

2.5.Determinants of Household Drinking Water Quality

Progress in water supply and sanitation should not be viewed just in terms of achieving the specific water and sanitation of the MDGs. Access to improved water supplies and sanitation facilities, coupled with improved hygiene practices such as hand washing, are prerequisites for achieving most of the other MDGs, particularly those on child mortality reduction, achieving universal primary education, combating diseases and promoting gender equality and empowering women.

The main contaminants of water sources are human excreta, animal waste, effluent agricultural practices, floods, and droughts as well as a lack of knowledge among end-users about hygiene and environmental cleanliness; storage and disposal must be considered for the preservation of water resources (Amenu et al., 2013, Meride and Ayenew, 2016). The study suggests the association of the types of sources of drinking water from improved sources was determined by different demographic, socio-economic, sanitation, and hygiene-related factors. Based on our investigation, being an older age group of the head of the household, being government employer, merchant and self-employed, being a higher income group, the presence of all facilities in the area, lived in a clean surrounding and lower family size are the determinant factors of using drinking water from improved sources. In conclusion, the using of drinking water from improved sources was determined by different demographic, socio-economic, sanitation, and hygiene-related factors (Emebet Y. *et al*, 2020).

Children are particularly sensitive to microbial contaminants because their immune systems are less developed than those of most adults (WHO, 2019) and they tend to take in more water relative to their body weight than adults do, and have higher exposure to drinking water contaminants (EPA, 2015). These microbial contaminants are linked to the transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid, and polio (WHO, 2019).

Thus, the majority of rural communities use water from contaminated or doubtful sources, which exposes the people to various water-borne diseases (Amenu et al., 2013, MerideandAyenew, 2016). Even if the source is safe, water may also become facially contaminated during collection, transportation, storage, and drawing in the home (Amenu et al., 2013). Unless the water is made safe or treated for human consumption, it may be hazardous to health and transmit diseases.

2.6. Water Quality

Water quality is a measure of the condition of water relative to the requirements of one or more biotic species and to any human need or purpose and it is most frequently used by reference to a set of standards against which compliance can be assessed (Diersing- Nancy, 2009). Water quality parameters include the physical, chemical, and biological characteristics of water. Monitoring the quality of water facilitates evaluation of nature and extent of pollution, effectiveness of pollutant control measures, water quality trends and prioritization of pollution control efforts (Abed et al., 2005).

Apart from quantities consumed, water quality compromised by various factors that require measurement. Some factors such as physical, chemical and bacteriological processes because the quality of surface water to vary during the years (Rainer, 1990). The available sources for a potable water supply are groundwater and surface water. Therefore, it should be protected, used, and maintained in an appropriate way. There are several parameters used to determine the suitability of water and the health contaminants such as microbiological, physical, chemical, and microscopic examinations, which may be found both in untreated and treated water (Chinn, 2003).

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 qualities assessed by comparisons of water samples to drinking water quality guidelines or standards. These guidelines and standards provide for the protection of human health by ensuring that clean and safe water is available for human consumption (WHO, 2008).

2.7. Water quality parameters

Drinking water, or potable water, is defined as having acceptable quality in terms of its physical, chemical, bacteriological parameters so that it can be safely used for drinking and cooking (WHO, 2004). WHO defines drinking water to be safe if and only if no any significant health risks during its lifespan of the scheme and when it is consumed? This thesis focuses on water quality for drinking and domestic uses.

2.7.1 Perception of drinking water

In terms of drinking water quality, user perception is one of the most important things, sometimes exceeding actual quality of water especially when it concerns the quality of drinking water for the user communities (Sheat 1992, Doria 2010). There are different factors that influence the perception of drinking water quality, including:

- Human sensory perceptions of taste, odor and color of water are related with mental factors and some extent taste, which is the more important because it may detect water contamination related to chemicals.

- People may perceive risks if they experience health problem caused by water.

- Experience with the previous water source status based on its taste, color and odor change. For example, the change in the color of water from yellowish to bluish may feel that the water is perceived not good water (Doria, 2010).

2.7.2 Bacteriological parameters

The diseases caused by water related microorganisms can be divided into different categories: Water-borne diseases: caused by water that has been contaminated by human, animal or chemical wastes. Examples include cholera, typhoid, meningitis, dysentery, hepatitis and diarrhea. Diarrhoea is caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water (WHO, 2006). Poor nutrition resulting from frequent attacks of diarrhoea is the primary cause for stunted growth for millions of children in the developing world (Gadgil, 1998).

Water-related vector diseases: These are diseases transmitted by vectors, such as mosquitoes that breed or live near water. Examples include malaria, yellow fever, dengue fever and filariasis. Malaria causes over 1 million deaths a year alone (WHO, 2006). Stagnant and poorly managed waters provide the breeding grounds for malaria-carrying mosquitoes.

Water-based diseases: These are caused by parasitic aquatic organisms referred to as helminths and can be transmitted via skin penetration or contact. Examples include Guinea worm disease, filariasis, paragonimiasis, clonorchiasis and schistosomiasis.

Water-scarce diseases: These diseases flourish in conditions where freshwater is scarce and sanitation is poor. Examples include trachoma and tuberculosis.

Testing the bacterial contaminants in water can be simplified by utilizing the presence of an indicator organism. 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 (Gadgil, 1998). Traditionally, total coliform bacteria have been used to indicate the presence of fecal contamination; however, this parameter has been found to exist and grow in soil and water environments and is therefore considered a poor parameter for measuring the presence of pathogens (Stevens et al., 2003). Studies also show that due to their ability to grow in drinking water distribution systems and their unpredictable presence in water supplies during outbreaks of waterborne disease, the sanitary significance or quality of water is difficult to interpret in the presence of total coliforms (Stevens et al., 2003). An exception is *Escherichia coli* (*E.coli*), a thermos tolerant coliform, the most numerous of the total coliform group found in animal or human feces, rarely grows in the environment and is considered the most specific indicator of fecal contamination in drinking-water (WHO, 2004). The presence of *E. coli* provides strong evidence of recent fecal contamination (WHO, 2004, Stevens et al., 2003). The risk of coliform presence can depend on the health or sensitivity of the consumer. The risks of *E. coli* presence, slightly greater than WHO Guideline’s zero count per 100ml may be of only low or intermediate risk.

2.7.3. Physico-Chemical Parameters Water Quality Aspects

Physico-chemical parameters are the physical and chemical parameters associated with water which have an influence on its quality and also affect the biological constituents of the water (Oluyemi et al, 2010).

Turbidity is a measure of the cloudiness of water and 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, 2003). Higher turbidity levels are often associatedwith 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 microorganism, which have health, risk (Cairncross, 1990; 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 Ritabrata R¸2019**)** The WHO recommended limit of TDS concentration of drinking water should be 1000mg/l (Hutton, 1996).

PH is one important water quality parameter, the pH of water, affects the biochemical processing 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 (WHO, 2011).**pH** can control the solubility and reaction rates of most metal species involved in corrosion reactions (WHO, 2004).

Electrical Conductivity (EC): is the electrical conductivity (EC) of a water a measure of its ability to carry an electric current; the more dissolved ions solutes in a water, the greater its electric conductivity. Conductivity can be regarded as a crude indicator of water quality for many purposes, since it is related to the sum of all ionized solutes or total dissolved solid (TDS) content (Alley2007). Pure water is a poor conductor of electricity. Water shows significant conductivity when dissolved salts are presented (Alley 2007). The health Effect of EC will be the function of TDS in the drinking water. (Alley 2007).States that, Health effect related to TDS are minimal at concentration below 2,000-3,000 mg/l TDS. In contrast, high concentration of salts imparts an unpleasant taste to water and may also adversely affect the kidneys.

Temperature in analysis of the Physico- chemical quality of pipe water samples, temperature is considered as a critical parameter. It has an impact on many reactions including the rate of disinfectant decay and by-product formation (Volk et al., 2002).

According to Collicottet al. (2003) cited in Solomon (2011), as the water temperature increases, the disinfectant demand and by-product formation, nitrification, microbial activity, algal growth,taste andodour episodes, and lead and copper solubility increases. Moreover, sand calcium carbonate ($CaCO_3$) precipitation also increases.

An aesthetic objective is set for maximum water temperature to aid in selection of the best water source or the best placement for a water intake. It is desirable that the temperature of drinking water should not exceed 15C^o because the palatability of water is enhanced by its coolness. In addition to cool water tasting better than warm water, temperatures above 15 degree Celsius can speed up the growth of nuisance organisms such as algae, which can intensify, taste, odour and colour problems. Temperature also affects water treatment (TID, 2000). If nutrients are available, the microbial activity (as measured by hetero plate count) increases significantly at water temperatures above 15ºC in the absence of a disinfectant residual.

Therefore, water supplies generally tend to keep the temperature as low as possible in order to minimize the bacterial growth. Keeping the temperature low reduces the risk for pathogenic proliferation and survival since the optimal temperature for most pathogens is close to the human body temperature (Boe-Hansen, 2002).

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 (APHA, 2010).

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 drinkingwater is critical when considering the strength of growing teeth andbones (APHA, 2010). Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis (WHO, 2008).

Chlorine as the chloride ion is the major constituent in water and wastewater 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 watercourses. 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 (Benoit et al.., 2005)

Nitrates are the most oxidized forms of nitrogen and the end product of the aerobic decomposition of organic nitrogenous matter. The significant sources of nitrates are chemical fertilizers from cultivated lands, drainage from livestock feeds, as well as domestic and industrial sources. Natural waters in their unpolluted state contain only minute quantities of nitrates. High nitrate levels in water can cause methemoglobinemia or blue baby syndrome, a condition found especially in infants less than six months. The stomach acid of an infant is not as strong as in older children and adults. This causes an increase in bacteria that can readily convert nitrate to nitrite (NO_2^-). The WHO standard for nitrate in drinking water is 50 mg/L for short time exposure. The health effects of nitrate in drinking water are shortness of breath and blue-baby syndrome and other disorders (WHO, 2004).

Iron is one of the most abundant metals in the earth's crust. Iron contamination is a particular problem for anaerobic groundwater supplies, but iron can get into drinking-water from the use of iron coagulants or from corrosion of galvanized iron, steel and cast-iron pipes in the distribution system. Iron also promotes the growth of iron bacteria, which oxidize ferrous iron to ferric iron, and in the process corrode the piping and deposit a slimy coating on its surface (Howard et al., 2003; WHO, 2004). Some surface waters also have iron problems, particularly related to colloidal iron.

Total chlorine or residual chlorine in areas where there is little risk of a water borne 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 is some of factors that affect the quality of water in Ethiopia (Davis, 2008). Therefore, when water leaves the treatment plant residual free chlorine of about 1 mg/l is needed for health reasons and itis recommended that such level is maintained at points of consumption ((Sobsey, 2002).

2.7.4 Physical and aesthetic parameters

Consumer perception and acceptability of their drinking water quality depends on user sense of taste, odor and appearance (Sheat 1992; Doria 2010). That is why consumers have differing opinion about the aesthetic values of water quality. Relying on their own senses may lead to avoidance of highly turbid or colored but otherwise safe waters in favor of more aesthetically acceptable but potentially unsafe water sources (WHO, 2004).

Taste and odor can originate from various natural chemical contaminants, biological sources, microbial activity, from corrosion or as a result of water treatment (e.g. chlorination) (WHO, 2004). Color, cloudiness, particulate matter and visible organisms can also contribute to unacceptability of water sources. These factors can vary for each community and are dependent on local conditions and characteristics. The following lists a number of primary aesthetic indicators that can cause water to be perceived as unacceptable:

- True color (the color that remains after any suspended particles are removed);

- Turbidity (the cloudiness caused by particulate matter present in source water, re suspension of sediment in the distribution system, the presence of inorganic particulate matter in some groundwater or sloughing of bio-film within the distribution system (WHO, 2004).

- unusual taste, odor and „feel" problems (usually due to total dissolved solids)

2.8. Water Quality Standards and Guidelines

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 2.2: Maximum allowable concentrations of selected water quality variables for drinking uses (WHO, 2008; ES, 2002).

Parameters		**Unit**	**WHO guideline**	**Ethiopian Standard**
Physical parameters	Turbidity	NTU	5	7
Chemical parameters	PH	PH	6.5-8.5	6.5-8.5
	TDS(mg/l)	mg/l	1000	1000
	Nitrate	mg/l	50	50
	Chloride	mg/l	250	250
	Fluoride	mg/l	1.5	1.5
	Total Hardness	mg/l	300	300
	Iron	mg/l	0.3	0.4
	Manganese	mg/l	0.1	0.8
	Chlorine	mg/l	5	5
Bacteriological parameters	E.Coli/thermo tolerant coli form bacteria		0/100ml	0/100ml

2.9. summary of determinants

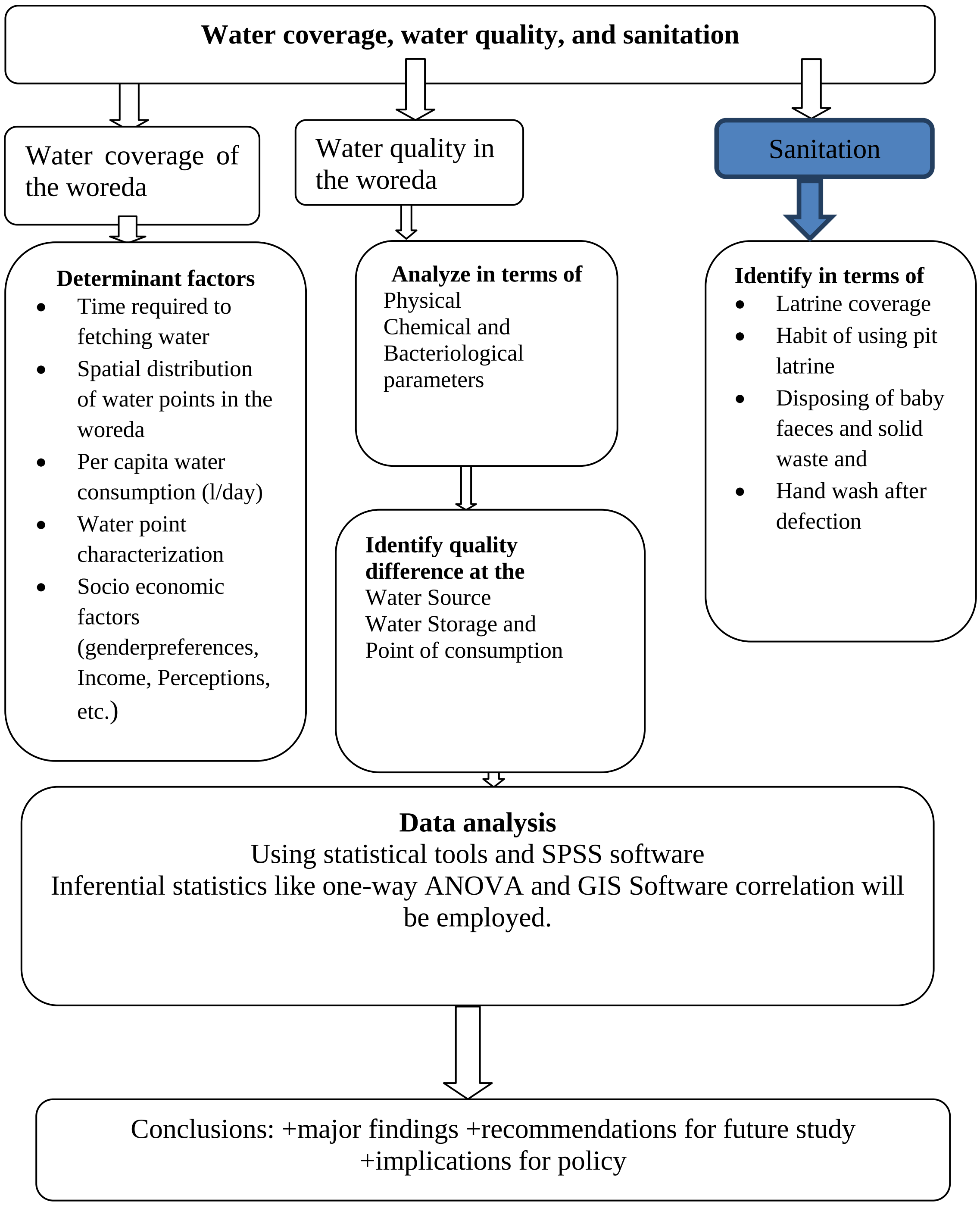

Figure 2.1: conceptual framework of the study

CHAPTER THREE

METHODOLOGY

3.1 Description of Study area

3.1.1 Geographical Location

The study was conducted in Sidama region, BorichaWoreda. The total area of the woreda is estimated to be 97.3 km^2. The Woreda was located between$6^0$59’11’’-6°50'58"N latitude and $38^0$17’9’’E- 38°24'43" E longitude .The administrative Woreda is bordered on the north by Dorebafano, on the south by Shebedino on the west by Bilatezuryaand Derara Woreda, on the northwest by Bilatezurya, and on the north-east by DorebafanoWoreda. It consists of 13 peasants and one urban kebeles (Woreda administration).

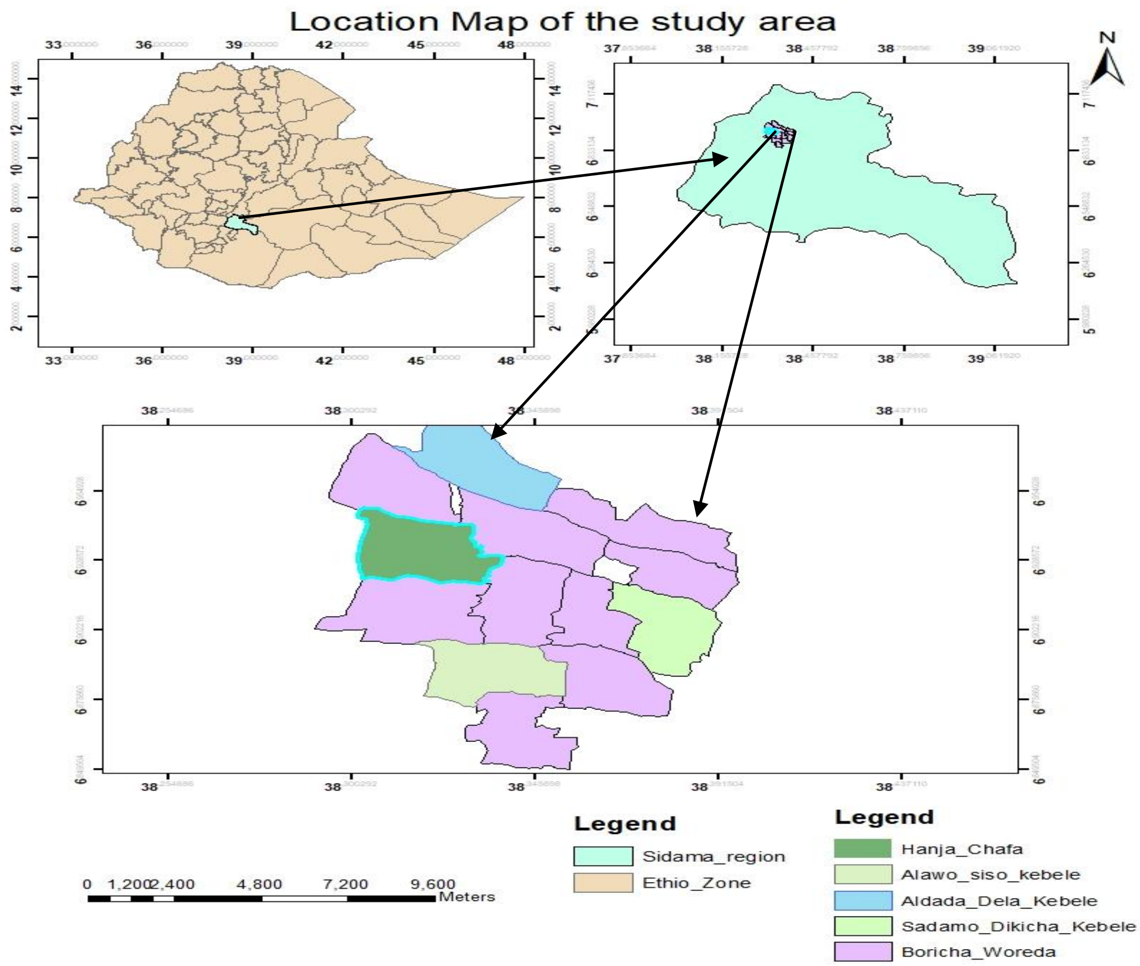

Figure 3.1: Map of the study area (my combination, 2023)

3.1.2. Woreda Population

According to the data from Borich Woreda Finance and Economic Development Office (BFEDO), the total population of the Woreda is estimated to be 134276 Out of which 64452are male and 69823are female. Among them 13% of total population were urban dwellers and 87% of the population were rural dwellers. Boricha is one of the highest population density areas in the Sidama region which is estimatedan average 276 households per square kilometers (BFEDO,2020).

3.1.3. Climate and Vegetation

The Woreda is generally categorized in middle altitude and low landagro climatic Zones. The annual average rainfall is estimated to vary from 1100 to 1200 mm and the average temperature varies from 15^0c to 26^0c(South district of Ethiopian metrology agency). Wet and dry season of the Woreda are June to September and November to February respectively. The Woreda is covered by green vegetation consisting of inset, coffee and different type of mature indigenous trees, shade trees for coffee plant and increasingly expanding eucalyptus trees. According to BorichaWoredaRural Agricultural Sector (ACRAS, 2020), the average elevation ranges from 1850 m.a.s.l.

3.1.4. Economy and Land Use

According to the Agriculture office, agriculture is the major source of income with a major production of maize, coffee, inset, livestock (cattle, goat, sheep….), haricot bean and sweat potato, and non-agricultural activities like petty trade, laborer and carpentry.

3.2. Data sources and collection instruments

Multiple data gathering instruments was employed for this study. The questionnaires were both close and open-ended questions. The questionnaires were supported by personal in-depth interview and transect walk. Structured and unstructured interview, personal observation and document used for gathering the data. The researcher supervised and managed the interview of the key informant. Interviewers were recruited and given short-term training, so that they would collect the primary data using structured questionnaires. The water source/points of the Woreda, the spatial distribution of water source/point is carried out using GPS and Arc GIS software.

3.3.1. Primary data collection

Primary data collected from the respondents is used for household surveys, key informant interviews, and personal observations (structured and unstructured interviews) of water supply and sanitation conditions of the study area. water quality data was collected by conducting laboratory test of water samples taken from thirteen different water schemes selected from four studied kebeles. From all of the eight selected schemes, population of selected schemes was taken by the replication of three times to take mean result of the values.Geographical Positioning System (GPS) reading was used for mapping.

For Physico-chemical quality data, samples 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 sidama region water miming and energy bureau

for bacteriological quality data, water sample was tested according to the WHO, Guidelines for drinking water quality assessment (WHO, 2006 and ES,2002) and American Public Health Association guideline (APHA, 1998). Culture media preparation was followed the standard procedure and manufacturer's instructions (APHA, 1998): lactose broth, brilliant green lactose broth (BGLB), tryptone broth, Eosine Methylene blue agar (EMB).

In addition,the data is collected the access to water supply, operation and maintenance, hygiene and sanitation, and community participation. Three enumerators had been qualified for diploma qualifications and trained for two days on how to manage the data collection work. The data collection there was due supervision of the researcher, from a sample of rural water supply systems Focus group discussions, Key informant interviews, Personal observation, and site visits were held at each kebeles.

3.3.2. Secondary data collection

Secondary data was collected from different data sources such as publications, research documents, and reports of various organizations. Specifically, related documents on water supply systems, water quality systems, and sanitation. Moreover, regular and statistical reports were gathered from the ministry of water, Mines, Energy, and Irrigation, CSA, and NGOs.

3.4. Sampling techniques

Boricha Woreda hasknown middle and semi-aridagro-climatic zones. For this study, from the 13 rural kebeles administrations in Boricha Woreda four Kebeles were selected a random sampling technique is used for household water use patterns and sanitation.The four kebeles AldadaDela, HanjaChefe,AlawoSiso and SadamoDikichawere selected randomly.Finally, probability proportional sampling techniques were used to select the households from each sampled kebeles.

3.5. Sample Size Determination

The sample size is determined by a sampling technique (formula) developed by (Cochran, 1977) used to determine sample size (n´). As beneficiaries were the main primary data sources in this study was 85 households selected from sample kebeles' resulting in a total of 7188 households. For sampling, four kebeles namely; AldadaDela, Hanja Chefe, AlawoSiso, and SadamoDikicha were selected.

Cochran pointed out that if the population is finite, then the sample size can be reduced slightly. This is due to the fact that a very large population provides proportionally more information than that of a smaller population. He proposed a correction formula to calculate the final sample size.

$$n' = \frac{z^2 pq_n}{d^2} \quad \text{……………………..…………………..…….……………………….…….3.1}$$

Where, n' = desired sample size when the population is infinite:

$$n' = \frac{(1.96)^2 * 0.05 * 0.95}{(0.05)^2} = 73$$

But in this study the population was finite due to that reason use a formula to calculate finite population. Cochran's formula for calculating sample size when the population is finite:

$$n = \frac{n'}{1 + \frac{n' - 1}{N}} \quad \text{………………………………………….....……………………………………3.2}$$

$$= \frac{73}{1 + \frac{73-1}{7188}} = 72$$

Where, n= desired sample size when the population is finite:

$\boldsymbol{samplesizeofHousehold}$,

P= Households variable (residential houses=0.05) q= Non-residential houses = 1- P=0.95; N= Total number of HH; Z= Standardized normal variable & its value =that corresponds to 95% confidence interval equals 1.96; d = Allowable error (0.05). As per the statistical data collected from the Woreda, there are 23364 households in rural resident. Out of the total population in the woreda, 87% are rural residents while only 13% are urban residents and the average number of households on single kebele was 1797. Since the populations (HHs) of the kebele involved in the study area was 7188HH. By using above equation to determine the sample size required for this study were (n= 72).The sample size required (n´) in the study area was based on the above formula is 72 HHs. For the better represent of sample size other 13 key informant's community leaders are participated and included during data collection.Totally the sample size was 85HHs.The sample size was selected from each kebele based on the total population size.

Table 3.1: Total number of Sampled HHs for Target kebeles

No	Kebeles	Total HHs	Sampling HHs	Sample size
1	AldadaDela	1620	22%	19
2	Hanja Chefe	1700	24%	20
3	Alawosiso	1693	23%	20
4	SadamoDikicha	2175	31%	26
Total		7188	100%	85

3.6. Method of Data Analysis

3.6.1 Descriptive method

Descriptive method analysis is employed to explain the demographic behavior of household characteristics. It is mainly used to compare and contrast the nature of demographic and other socio-economic behavior of households along with their implications the coverage and quality of potable water supply and sanitation status. The specific methods of data analysis involved tabulation, frequency, percentages, and computation of descriptive statistics such as mean and standard deviation.

3.6.2 Econometric Model of Analysis

Model Specification

One of the main objectives of the study was to analyze the determinants of sanitation water at the household level in Woreda, and the effect on water supply, coverage, and quality of potable water at the household level. To examine this, the binary choice model is employed to show the functional form and relationship ‘’yes’’ or ‘’no ‘’ determinant of sanitation with the rural water supply of the household. When the explanatory variable(s) was (were) non-continuous, one can represent them as dummy variables and proceed to non-linear regression analysis. As the dependent variable is binary, (Pindyck And Rubinfeld, 1981) a binary choice model assumes that individuals are faced with choices between two alternatives. Thus, one purpose of a qualitative choice with a given set of attributes would make one choice of the alternative. There are several methods to analyze the data involving binary outcomes.

If the error term is normally distributed the discriminant analysis estimator which follows ordinary least square procedures (OLS) is the true maximum likelihood estimator (MLE) and therefore asymptotically more efficient than the probit/logit model which requires the maximum likelihood method. However, if the error term is not normally y distributed, the discriminant analysis estimator is not consistent, whereas the probit MLE is consistent and therefore more robust (Davidson, R. and J. MacKinnon (1984).

Therefore, Hosmer and Lemeshew (1989) cited in Biriha (2013) pointed out that probit has advantages over the other in the analysis of dichotomous outcome variables in that it is an extremely flexible and easily usable model from a mathematical point of view and results in a meaningful interpretation. Both qualitative and quantitative approaches will be used to examine the effect of water and sanitation facilities on the reduction of death, sickness, diarrhea morbidity, and pneumonia morbidity at the household level. Although it seems plausible to use a difference-in-difference model for estimation in this data type, missing value of baseline data for most variables (outcome and explanatory variables) in the data set restricts the use of DID estimation model and if tried the biggest worry is that the most important variables will be missing that will cause inconsistency and inefficient which in turn leads to bias estimation and wrong inferences

Thus, the researcher found that DID is not an appropriate model for this data set type. Hence, the missing value of important variables forced the researcher to select one of the binary models. From the point of view of these facts, the probit function is selected for this study. Theprobit model can answer the question that a limited dependent variable Y is a binary variable, Y (0.1)

Verbeek (2004) stipulated that standard normal distribution has zero means, and unit variance and its density is described as follows

$$\text{Ø} (\epsilon) = \frac{1}{\sqrt{2\pi}} exp \left(-\frac{\epsilon^2}{2} \right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.2$$

The general expression of the model is as follows

$$Y^* = \alpha + ß\square^i + \varepsilon$$

$$where = \begin{cases} yi = 1 \\ yi = 0 \end{cases} \quad if = \begin{cases} y* \geq 0 \\ y* < 0 \end{cases}$$

Y* is unobserved it is referred to as latent variable.

Latent variables as opposed to observable variables are variables that are not directly observed but inferred (through a mathematical model) from other variables that are observed (directly measured). In this study, if Y*>0 marginal benefit of households from participating in the package is greater than zero. Thus, we find them the determinant of sanitation, they build latrines with superstructures; participate in hygiene education, develop habits of liquid waste management, wash water storage, and the other variables which are determinants of household welfare. X is the vector of explanatory variables that were supposed to determine the hygiene and sanitation indicators of the households.

So the form shows as follows

$$P(y_i = 1) = ø(ßx') \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.3$$

Once the factors that influence household water sanitation are identified probit regression function is employed Where the dependent variable Yi represents household sanitation and, were the cumulative standard normal distribution function, hygiene education and sanitation practice, level of education of the household head, awareness of water contamination during storage, cause of water quality, latrine ….are determinants of the household's water sanitation. It was used the probit model for the functional relationship of the dependent variables (water sanitation) and its determinants can be given by:

$Pr(Y=1/Xi) = \phi\ (B_0\ sanitation_{+}\ \beta_1 agehh + \beta_2 famsize + \beta_3 educhh + \beta_4 income + \beta_5 sourceunp\ \beta_6 fitch + \beta_7\ perception + \beta_8 causeway + \beta_9 convient + \beta_{10} qualitywater + \beta_{11} healthext + \beta_{12} falilysick + \beta_{13} latrine + 14 participation + \beta_{15} disposal + \beta_{16} washhand + \beta_{17} usesoap)$

3.7. Water Quality assessment

3.7.1. Sample Size

Spatial variation of water quality analysis is very important for the water sampling points to evaluate the water quality changes at one sampling point to the next sampling points respectively. Physico-chemical and bacteriological were analyzed by using the parameters from the selected water source quality, storage quality, point of used quality based on Physiochemical and bacteriological parameters.

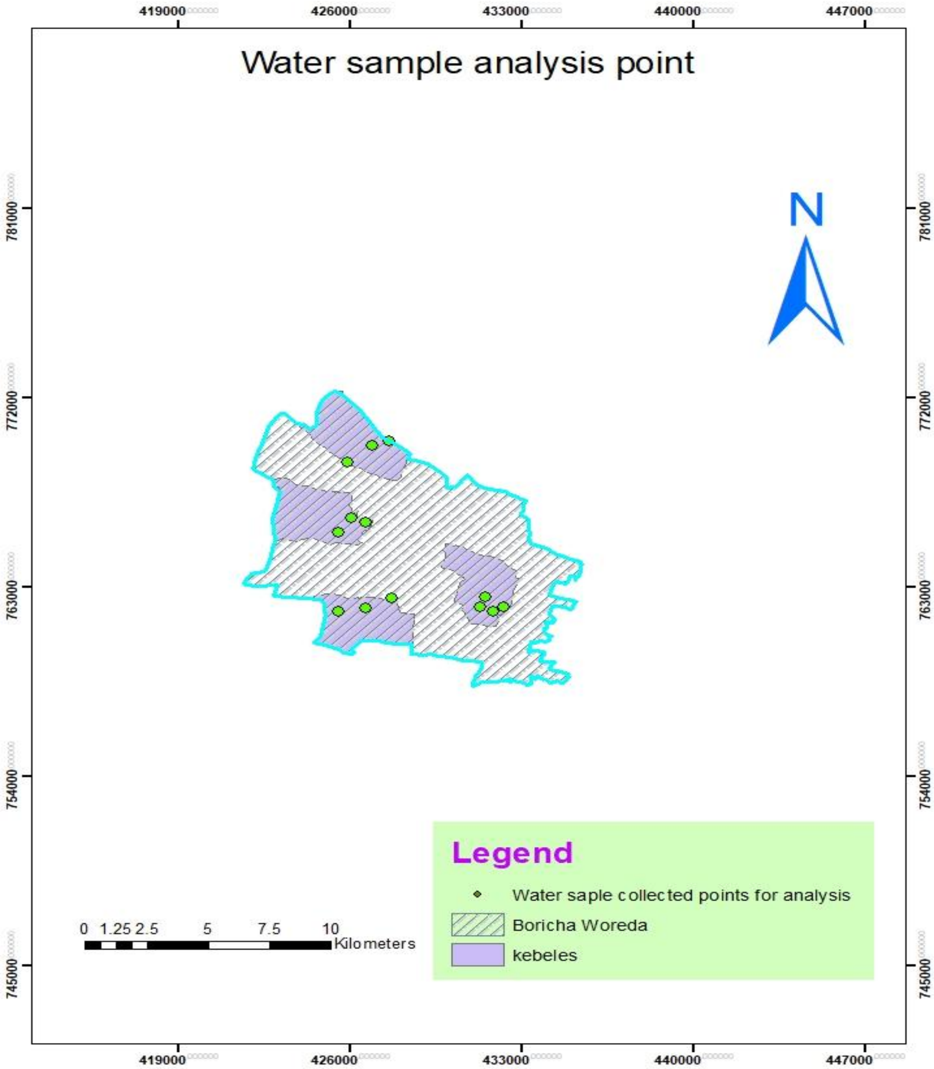

Figure 3.2: Map of water sample collected point in studied kebeles,

3.7.2. Sampling Procedure

Water samples were collected in 1000ml polyethylene plastic bottles for different parameters from sampling points. Triplicate water samples from each sampling site were taken and analyzed for selected physiochemical and bacteriological parameters. Water sampling and preservation techniques are used as standard methods of water sampling and preservation techniques (APHA, 1998; Hutton, 1996). Before collection, bottles were washed with concentrated nitric acid and distilled water to avoid contamination. The water samples were handled aseptically in sterile glass bottles, labeled, and kept in an ice box during transport to the laboratory of the Sidama region water mining and energy bureau.

Bottles were preserved using an icebox and water samples from each sample site of the study area were taken and analyzed for the selected physicochemical and bacteriological parameters.

Table 3.2 Major Physico-chemical and bacteriological parameters for the water sample

S. No.	Physico-chemical parameters	Bacteriological parameters
1	PH	E. coli/Thermo tolerant coliform bacteria
2	Temperature	
3	Electrical conductivity	
4	Turbidity	
5	Total hardness	
6	Nitrate	
7	Chloride	
8	Fluoride	
9	Iron	
10	Manganese	
11	Total /residual/free chlorine	
12	Total dissolved solids	

3.7.3. Method of water quality analysis and instruments

A. Analysis of Physico-chemical Parameters

The turbidity of collected water samples was measured by a digital turbidity meter 2100A instrument, in which international standard samples with different turbidity ranges that observed from the reading instrument. EC and pH were measured by EC meter (JENWAY4200) and pH meter (JENWAY 430) respectively.EC meter and pH meter were calibrated by using 0.01N KCland buffer standards of pH 4 and 7 respectively. Total solids and total dissolved solids (TDS) were determined by putting a 50ml water sample into the crucible and putting it in the oven and vaporizing the collected and measured water of the remaining solids on the crucible. The determination of total hardness and free residual chloride was carried out by titration methods by which 0.02N of H_2SO_4, $AgNO_3$, or EDTA was used as a titer. The nitrate and Fluoride amount of the collected water sample was analyzed calorimetrically using HACH DR/4000 spectrophotometer by keeping their reaction periods and analytical reagents. A colorimetric method was used to determine free chlorine in water at concentrations of 0.1–10 mg/liter

B. Analysis of Bacteriological Parameters

Escherichia coli (or, alternatively, thermo-tolerant coliforms) was generally measured in 100 ml samples of water. The procedures were including membrane filtration followed by incubation of the membranes on selective media at 44°C to 45 °C and counting of colonies after 24 hours.The Composite samples were used to improve the precision of the estimated average contaminant concentrations. In the laboratory, the three samples from each site were mixed into one and a composite sample was subjected to membrane filter analysis of fecal coli forms (TTC).

The composite samples were mixed thoroughly by shaking and filtered under a laboratory hood, using WagTech Membrane Filtration apparatus and membranes, pore size 0.45μm, 47mm diameter, sterile, and gridded. The membrane was transferred aseptically to m-FC agar with rosolic acid in glass Petri dishes for TTC. Prepared culture dishes were inverted and incubated for 24h at 44.5°C. Upon completion of the incubation period, typical blue colored for TTC on the surface of the membrane was filtered and counted by using a low-power binocular wide field-dissecting microscope, with a cool white fluorescent light source for optimal viewing sheen.

3.8. Assessment of Sanitation Condition of the Woreda

The assessment of the sanitation condition of the study area was conducted by using a structured questionnaire. Accordingly, data related to sanitation and hygienic condition like toilet availability and type, hand washing facility, and disposal of waste were collected from the households. The questionnaire was supported by a household survey, key informant interview, and personal observation.

3.9. Study variables

The variables included in this study are taken based on perceptions of households and not verifiable water quality measures were undertaken.

3.9.1 Dependent variables

The dependent variable is sources of drinking water (improved, unimproved). Based on WHO guidelines improved water sources consisted of piped water (into dwelling, yard/plot, and public tap/stand-pipe), tube-well/ bore-hole, protected well, protected spring, and rainwater. Unprotected wells, unprotected springs, tanker trucks, a cart with tank/drum, and surface water were considered as ’unimproved water sources.

3.9.2 Independent variables

The independent variables included Potential determinants of access to improved drinking water sources were identified the literature review in this study are demographic, socio-economic, and sanitation and hygiene perception characteristics.

• The perceptions of households using water from unimproved sources (income, distance from home to water source, the presence of alternative water source, quality of water perception, adequacy of water, waiting time to fetch water, personal interest, and other reasons).

• The presence of scarcity of water in the area (yes, no).

• The reason that households believe the presence of the scarcity of water has occurred (government weakness, a local people problem, and both local people and government problems, low water resource investigation, weather condition).

• The perception of households of the water they consume has a safety status (not safe at all, somewhat safe, partially safe, safe, and highly safe).

• Households’ perception of the indicator of water quality (color, taste, odor, disease attack, and the presence of all the cases).

• Households’ perception of the taste, odor, and color of the water from the improved and unimproved sources was the same (yes, no).

• The causes of water quality problem households perceive (water-containing material, animal wastes, human wastes, flood, and all cases).

• Treatment measures households had undertaken during unsafe drinking water (no use at all, boiling, sedimentation, using wuha agar, other methods, and use all measures).

• The number of times household members had got sickness due to water-related disease and visited health centers for physician assistance within one year before the survey time (not at all, once, twice, three times, more than three times).

• The presence of health extension workers’ assistance (yes, no) and the number of times the family was visited by health extension workers within one year before the survey (not at all, once, twice, three times, more than three times).

• Previous participation of household members in educational and awareness activities about sanitation and hygiene in their locality (yes, no). The presence of a latrine facility in the household compound (yes, no) and who have used the latrine (wife, husband, children, and all families, except children).The place household members were defecating (public, neighbor, open place, own toilet), and the presence of the culture of households washing hands after defecation

3.10. Data Analysis

After gathering the data, relevant statistical methods of analysis areused in order to come up with the appropriate result. The results were presented in both quantitative and qualitative terms. The stata-14 and statistical tools like percentages, arithmetic means, min, max, standard deviation, ratios, tables, maps, histograms, bar graphs, pie charts, timeseries graphand explanationbuilding descriptive statistical methods and graphswasused to analyze the findings. The inferential statistics like one-way ANOVA and regression analysis were employed to see the statistical significances and associations of the variables respectively. Deduction was made from these measures and compared with the existing literature to arrive at the conclusion of the study. Results of water quality analyses of the source, storage and point of use(consumption) were compared against standards set by WHO (2008) and the Ethiopian drinking water quality standards (ES, 2002). And finally identify determinant of water quality result variation at source, storage and point of use.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Social and demographic characteristics of sample households

4.1.1. Family size and age structure

The average family size of the sampled households was 5.15 with a minimum of 2 and a maximum household size of 8. The result implies that the mean household size in the study area is relatively higher than the average household size in Ethiopia household size, which is about 4.6 persons per household (MoFED,2018). The average age of the sampled households, during the survey period, was about 40.1 year with a minimum of 20 and a maximum of 61.

Table 4.1; Age and family structure of sample households during 2022

Variable	Observations	Mean	Minimum	Maximum
Age of house holds	85	40.01	20	61
Family size	85	5.15	2	8

With regards to the sex of respondents, about 71(83.53%) of the sample households were male-headed and the remaining 14(16.47%) were female-headed. The survey results showed that the total number of single, married, divorced, and widow households during the survey period was 1.18 %,92.94 %, 1.18 %, and 4.71 %, respectively.

Table 4.2: family structure and marital status of sample households during 2022

Gender characteristics	Variable	Frequency	Percent
	Male	71	83.53
Sex	Female	14	16.47
Marital status	Married	79	92.94
	Divorced	1	1.18
	Widow	4	4.71
	Single	1	1.18

Education is an instrument to enhance the water source use, quality of water, sanitation and hygiene perception through improving managerial skills and the tendency to adopt new technologies. Education together with increased experience could guide households to better manage their water sanitation activities. The average years of out of the total sampled households, only 20% cannot read and write; 27.06 % can read and write and the remaining households could formal educated households from grade 1-6, grade 1-12, and college graduate were 30.59%,21.18% and 1.18 % respectively.

Table 4.3: Education status of sampled household heads during 2022

Education	Frequency	Percent
Unable write and read	17	20
read and write	23	27.06
Education grade 1-6	26	30.59
Education grade 7-12	18	21.18
College graduate	1	1.18

4.1.2. Economic status and income sources

For our study income sources were categorized into three groups; nonagricultural activities, annual crop production, and Livestock production. The off and/or non-farm income of sampled households, during the survey period, included house rent at yirba town, daily labor, and small petty trade together with on-farm income. The study area was well known for its productivity and long years of experience in annual and perennial crop production such as maize, enset, and coffee. On average, sample households nearly 0.25 ha of land for maize, 0.15 ha of land for coffee production, one to two cattle and three to five sheep and gouts.The other income was obtained from livestock production fattening, poultry, and milk and milk byproducts. Generally, the total income from on-farm and off-farm of sampled households during the survey period was 37668.24 birr/year on average, 16000 birr and 80,000 birr, the minimum and maximum income respectively.

Table 4.4: Distribution of income on/off farm among sampled households in 2022

Variable	Observations	Mean	Min	Max
Income of HH	85	37668.24	16000	80000

4.1.3. Institutional aspect on Boricha woreda

In order to give effective coverage and quality of potable water supply and sanitation extension service to the households, the Boricha woreda water mining and energy office and health officer assigned water supply and health extension workers at woreda level and one health extension agent to each kebeles. The health and water supply workers graduated from different health training colleges and universities specializing in health extension and water supply and hygiene professionals. Most of the respondents reported that they have been in any educational and awareness activities about sanitation and hygiene and the extension workers visit households at different intervals. On average, households were being visited by health extension workers 8-10times per year. The survey further indicated that most of the total households have been receiving special training on water supply and sanitation. The training and education covered a wide range of topics such as solid waste management systems, wastewater management systems, sanitation and water hygiene, water borne diseases, and drainage system management practices.

4.2. Existing Water Supply Situation

4.2.1 Water Supply Sources

The household water consumption behavior under this study determines those primary and secondary or alternative water supply sources. Despite to deal with household water consumption from improved sources, unimproved secondary sources were included. As per data obtained from Boricha WWMEO, the total number of protected water supply schemes in the woreda at the end of 2022 were 139 (39hand pump, 2 Shallow Well (SW), 3 Deep well, 94 Public tapes and 1 Protected Spring (PS). The total number of developed water supply schemes in the studied sample kebeles were reported to 14 (11Public tapes (PT) and 2 SWs) for the same period. Even though complete data were lacking on the status of the water supply schemes that exist in the woreda as a whole, out of the total water supply schemes exist in the sample kebeles, 5schemes or 35 % the schemes were not functioning during the time of the survey.

The results presented here (Table 4.5) are based on the main source of drinking water supply for the respondents during the time of the survey. The survey result shows that 7(8.24%) of the totalrespondent’s protected spring, 2(3.35 %) handpumps, 61(71.17%) bore hole and 15(17.6%) Ponds surface water. As can be seen from the table below, the main sources of water supply in the study area were about17(20.59%) of the samplerespondentsmainly getting drinking water from unimproved sources, while the remaining 68(79.41%) were obtained from improved sources. The majority of respondents reported that traditional water sources as their main source of drinking water were due to the inadequacy of water supply from their scheme.

Table 4.5; water supply schemes sampled household heads during 2022

Source of water	Frequency	Percent
Protected spring	7	8.24
Hand pump	2	2.35
bore hole	61	71.17
Ponds surface water	15	17.6

4.2.2. Unimproved Water source using Practice

The population of the rural area used both improved and unimproved water sources for their daily consumption. Households use unimproved sources of water that were associated with several reasons such as- income, distance of water source, presence of alternative sources, adequacy, waiting for time to fetch and other cases. The survey was result showed that 38(44.7%) unprotected wells 20(23.53%) tanker a cart with tank/drum, 4(4.7%) Hand pump and23(27.1%) surfacewater ponds.

About 95.29% of the studied area of rural population was under the problem of drinking water scarcity. It indicates the supply is below 10%. According to KPC (2011) Baseline survey data report and Philipos (2019) indicates that of the rural population in Borichahad access to an improved source of drinking water 29.6% and 38% respectively. Additionally,Boricha woreda water mining and energy office2022 year the annual water coverage reports 54%, even if it was not clear about its waterquality, but, in the current setting, the supply was below 10%.

In the study area, 95.5 % of the rural population perceived that the scarcity of water was associated with the local (2.35%), regional and national government poor administration factors 6(7.06%), scarcity of water resource in vicinity (37.65%), inadequate water potential investigation(41.18%) and power supply discontinuity (11.76%). A similar report indicated and problem reason out by a different factor(WHO,2015), absence of infrastructure (N. D. Troyer.et al ,2016) and discontinuous supply of drinking water (Chalchisa D., Megersa M. and Beyene A., 2018) and drought and other different factors (Zelalem G. 2005).

Table 4.6: water supply unimproved source and reason scarcity sampled household heads during 2022

Source	Variables	Frequency	Percent
Source of unimproved water	unprotected wells	38	44.7
	Cart tanker	20	23.53
	Hand pump	4	4.7
	Ponds (surfacewater)	23	27.1
Reason of scarcity	Local people problem	2	2.35
	Both local people and government problem	6	7.06
	Scarcity of water in vicinity	32	37.65
	inadequate water resource invest in vicinity	35	41.18
	power supply discontinuity	10	11.76

4.3. Water quality perception of households

Households use different perceptions to identify the quality of water they consume daily. They have used color, taste, disease attack, and odor preferences. About 8(9.41%) of the study population couldn't determine the water quality they consumed. Households have got the water they consume from improved and unimproved sources. "Are the water perceptions similar from those two sources?" was asked of households.

Of all of the household respondents, 77(90.59%) had a perception of the quality of water. Consumers concerning their drinking water said aesthetic factors such as test, odor, color and disease attack, and other factors were very important; likewise, drinking water trustworthiness depends on the perception of the consumer and the resulting complaints due to testes, odor, color, and disease attack or other particulate matter. Among the 85 household respondents about water quality measured and believed all aesthetic factors 36(42%), tested 12(14.32%), disease attack 20(23.63%), odor 7(8.24%), and about 8 (9.41%) of the population couldn't differentiate the quality of water using taste, odor, and color either it was from improved or unimproved sources. According to the survey results, 63 (74.12%) of the respondents believed that the case of water containedmaterials, 5(5.88%) the turbidity of water is animals waste, 4 (4.71%) believed in human waste and 6 (7.06%) of the respondents believed in that other factors like flood and 7(8.24%) respondents were believed that in all factors that reduced the quality of water

Table 4.7: Water quality perception and cause of water quality of sample households in 2022

cause water quality	variables	Frequency	Percent
Households Perception	Color	2	2.35
	Test	12	14.12
	Odor	7	8.24
	Disease attack	20	23.53
	Couldn't differentiate	8	9.41
	All of them	36	42.35
Aesthetic factors	Animal waste	5	5.88
	Human waste	4	4.71
	Water cont. Materials	63	74.12
	Others factors	6	7.06
	All of them	7	8.24

4.4. Demand of the Community for the Water Supply Service

Water demand is defined as the volume of water quested by users to satisfy their needs. In a simplified way it is often considered equal to water consumption, although conceptually the two terms do not have the same meaning (Wallingford HR., 2003).In most developing countries, the theoretical water demand considerably exceeds the actual consumptive water use (lit/cap/day) (Mwendera E.J., et al 2003).As indicated in the literature part, development projects which were based on demand of the end users tend to be more sustainable than those projects with less or absence of demands. In relation to this, respondents were asked whether or not they had demand for developed water source priorto its implementation.

In assessing who was initiated to provide their existing water supply schemes, 34(40%) of the respondents reported community, 38(44.71%) government, 8 (9.41%) NGOs, 5(5.88%) replied all in collaboration both community and government. Still in all cases,communities were the main actors in initiating their water supply schemes to be developed. This can help communities to have positive attitude for the developed scheme a similar report with obtained (Siraj A, et al, 2020).

As the survey of household indicated, about 2(2.36%) respondents had got water 5-10 lit, 69(81.17%) got 25-30lit, 10(11.77%) respondent had got 30-40litersand only 4(4.71%) respondents had got 50 lit for the weekly household consumption. According to this study, the summary result of access of water to respondent 24.94lit per week for 5.15 people. There is a highly significant variation between daily water supply and demand which was less than 1 lit/person, which isseverely inaccessibility of water supply in study area. Therefore, to full fill this demand it required to improve the water supplying system. This result was also below the threshold level of Ethiopian standard, which is 25 liters per person per day (UAP, 2015). These inaccessibility causes for many problems which has great effect to sustainable livelihood conditions.

In the study area there was no balanced system for supply-demand. There was huge variationbetween supply-demand. Households was converted to per capital consumption, which is very less while considering the minimum and maximum variations were from 5 to 50lit/HH for5.15 family's week respectively.

In the study area there were many factors that affect water consumption such as; long distance of the sources from the settlement, availability of the sources depends on seasonal, amount of water supply less, power supply discontinuity, quality of the sources, livestock watering and other challenges may affect and limit the daily water consumption.

4.5. Sanitation and Hygiene Practice

The participation of household members in educational and awareness activities about sanitation and hygiene played a great role in a healthy community and a clean environment. Of 85 households included in the survey about 48(56.47%) had participated; while about 37 (47.53%) hadn't participated in educational and awareness activities concerning sanitation and hygiene in their locality. Community education and awareness activities about good health, quality of life, sanitation, and hygiene are given by health extension workers (HEWs) in the area. Regarding the availability of latrines in the households, about 51(60%) households have their own latrines in the compound for defecation; while about 34(40%) households didn't have latrines.

Of those who have latrines 51(60%) households, all households were accessible toilets to all families. About 52(62.35%) used open pit toilets, about 21(21.74%) used open latrines to have no slab and 11(11.92%) used pit latrines to have concrete slab. Open field toilet defecation was found within dense trees and drainage areas, which easily could disturb the surrounding environment and be eroded by the flood.

The culture of household members washing their hands after defecation, of 85 respondents 49(57.65%) households had washed their hands, while the other 36(42.35%) households hadn't adopted the culture of washing hands after defecation. Among 49(57.65%) households had washed their hands24(48.97%) household had washedwith water and soap but inconsistently using soaps and 25(51.03%) did not wash their hand with the soap.

4.6. Treatment measures used by household respondents

Among the total sampled, 40 (47.07%) of the household respondents were known about the water treatment measures. In this study; but still, most of the households treated the water unsafe way by using traditional methods before consumed. In the present study, the most dominant water treatment method used in the study area was using boiling 24 (24.71%) followed by chemical treatment by wuha agar 18 (21.18%) and sedimentation 1(1.18%) of the household respondents respectively. water was treated by chlorine chemical method by WWMEO once a month before distributing tape water system to the site. Water treatment awareness was still very low, so it needs to give awareness to the whole community.

Table 4.8 Treatment measures used by household

Treatments method	Frequency	Percent
not treated	45	52.94
Boiling	21	24.71
Sedimentation	1	1.18
Treatment chemicals	18	21.18
Total	85	100

4.7. DeterminantsAnalysis Result

Prior to the estimation of the parameters of the model, it would be necessary to check the problem of multicollinearity or associations among the potential explanatory variables. If there was a multicollinearity problem standard errors are inflated (Wooldridge, 2003).

Before running the econometric model, it was tested against econometric problems. In this study, the value of VIF for all the variables entered into the model was below 10, which indicates the absence of a severe multi-collinearity problem among the explanatory variables. Moreover, the Breusch-Pagan test method was also used to detect the presence of heteroscedasticity. A multicollinearity test for all variables was also done using the Variance Inflation Factor (VIF).

Specific to dummy variables contingency coefficient was calculated to test for the existence of a multicollinearity problem. Test for multicollinearity using both methodologies also confirms that there is no serious linear relation among explanatory variables. Moreover, specification tests were done to improve the fitness of the model.

4.7.1. Determinant of sanitation on quality drinking water

The chi-square test of association and the binary logistic regression results in the determinant of sanitation to improved sources of drinking water in the studied area were shown in (Table 4.9). The quantifier of sanitation variables was estimated by using the estimation approach of the logistic regression technique. The same estimation technique is also used by (Emebet Y. *et al*, 2020) &Biriha, 2013). Detailed interpretation and discussion of the statistically significant variables in (Table 4.9) would be presented as the following.

Table .4.9: Marginal effects after logistic regression ofdeterminants of sanitation

Variables	dy/dx	Std. Err.	Z	P>z
Age of house hold	-0.0221081	0.010**	-2.04	0.042
Family size HH	0.0327097	0.052	-0.62	0.537
Education level	0.1766235	0.09*	-1.88	0.06
Income of HH	0.0000009	0	1.13	0.258
Water source	-0.0095813	0.04	-0.21	0.836
Fetching	0.0104732	0.064	-0.16	0.87
Perception	0.2253168	0.10**	2.18	0.029
Cause of water quality	0.0905763	0.052*	1.74	0.082
Water treatments	0.1321175	0.069*	1.91	0.056
Health extensions	0.0847211	0.191	0.44	0.658
Education participation	0.4422842	0.15**	2.82	0.005
Hygiene of HH	-0.0348829	0.202	-0.17	0.863
Latrine of HH	0.3925543	0.20*	-1.95	0.051
Defecation of HH	0.4284482	0.18**	2.36	0.018
Waste deposal of HH	0.3387353	0.21	1.59	0.112
Hand washing of HH	-0.2550868	0.14*	-1.74	0.082
Use of soup HH	0.2353254	0.15234	1.54	0.122

(*) dy/dx is for discrete change of dummy variable from 0 to 1
***,p<0.1,**p<.0.05,*p<0.01

Household age, the estimated coefficient of household age for sanitation on potable water quality had positive and significant at a 5% significant level. This result indicated as age household head increased their sanitation on potable water experience increased as a result their water quality improvement also rises. Similarly report (Emebet Y. *et al,* 2020), There was a significant association between the age of the household and the type of water source used by residents, and The accessibility of improved sources of drinking water is lower in the older age group (> 45 years) than medium age group (18-30 and 31-45 years), but better than the younger (below 18 years).

Education level had a positive and significant effect on sanitation and hygiene with expected signs at a 10% significance level. education enhances the acquisition and utilization of information on improved water supply and sanitation management the results showed that households with more years of formal schooling were more efficient than their counterparts. the significant effect of education on the sanitation of quality water supply in the rural area confirms the importance the efficiency of improved water supply. Similarly finding report (Biriha T., 2013), the study result indicates that the level of education one of the determinants of households' welfare and it is significant at 5% level of significance with a positive relationship to diarrhea reduction. This is due to the fact that educational attainment by the households may lead to awareness of the possible advantage of access to potable water, sanitation, and hygiene education practices on their welfare.

Water quality perception had a positive and significant effect on sanitation with expected signs at a 5% significance level. Consumers concerning their drinking water said aesthetic factors such as test, odor, color and disease attack, and other factors were very important; likewise, drinking water trustworthiness depends on the perception of the consumer and the resulting complaints due to testes, odor, color, and disease attack or other particulate matter. Perception attainment by the households may lead to awareness of the possible advantage of access to potable water, sanitation, and hygiene practices in rural areas.

Cause of quality potable water had a positive and significant effect on sanitation with an expected sign at a 10% significance level. Consumers concerning their drinking water said aesthetic factors such as test, odor, color and disease attack, and other factors were very important. Households believed that the case of quality water problem like watercontained materials, animal waste, human waste, and other factors like floods lead to access to potable water, and sanitation problems in rural areas. Similar finding report (Emebet Y. *et al*, 2020), and Biriha T., 2013) compared to no clean surroundings were observed to determine the source of water from improved sources.

The water treatment method had a positive and significant effect on sanitation with expected signs at a 10% significance level. Even though Water treatment practices were still very low in the studied area, the households believed that the possible advantage of access to potable quality water, water treatment method maintaining sanitation, and hygiene tape water system to the site.

Latrine had a positive and significant effect on sanitation with expected signs at 10% significance level. Latrine with supper structure in households' compound: based on the study result potable water sanitation incidence is reduced and in those households that build latrines with supper structure compared to open field toilet defecation was found within dense trees and drainage areas This finding is consistent with the results by (Emebet Y. *et al*, 2020), and Biriha T., 2013).

Defecation had a positive and significant effect on sanitationwith expected sign at 5% significance level. Households in the studied area defecated in open fields compared to toilet defecation were found within dense trees and drainage areas, which easily could disturb the surrounding environment and be eroded by the flood This finding is supported by (BirihaT.2013&Esrey ,1996).

Hand washing facilities installed and washing hands after critical times in the study result indicated that hand washing facilities and usage were one of the determinant factors of household's health and it was a significant 5% level of significance with a positive effect in sanitation reduction of quality water. This finding is supported by (Biriha T.2013&Esrey ,1996), and who stated that lower diarrhea morbidity prevalence is the most direct presumed effect of improved water and sanitation infrastructure.

4.8.Physico-chemical and bacteriological quality of drinking water

Drinking water is a potential source of human disease when it contains chemicals and microbes (Malek et al., 2019). Therefore, this study aimed at investigating the physicochemical and bacteriological quality of drinking waterdeterminant in the Boricha woreda

4.8.1. Physico-chemical quality of drinking water

Physico-chemical analysis for the source, storage and point of use in Water quality criteria, standards and the related legislation are used to interpret water quality characterization. The most common national requirements are suitability of water quality for drinking and domestic purpose. Many countries base their own standards on the standards of world health organization (WHO) guidelines for drinking water quality (WHO, 2004).The World Health Organization (WHO), drinking water quality guidelines provide international norms on water quality and human health be used as the basis for regulation and standard setting in developing and developed countries worldwide. These guidelines 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. The analyzed laboratory result was taken two samples from the source, 3 samples from storage(reservoirs) and 8 samples from point of-use (4 public tap and 4 household storage). Totally, 13 samples were taken to evaluate the average mean values for selected physico-chemical and bacteriological parameters. Then compared with the Ethiopia and WHO drinking water quality standards and interpreted in accordance with the result obtained.

Table 4.10: Mean value of physico-chemical parameters for the source, storage and point of-use during survey time.

Parameters	**Units**	**Source**		**Storage**		**Point of use**		**Standards**	
Physical		**Meant**	**Std**	**Mean**	**Std**	**Mean**	**Std**	**ES**	**WHO**
Temp.	^oC	22.2	1.27	20.99	1.58	19.75	0.89	-	<15
EC	µs/cm	472.5	388.2	447	256.61	281.75	265.38	1500	1000
PH	P^H	6.65	0.21	7.76	0.49	7.58	0.16	6.5-8.5	6.5-8.5
Turbidity	NTU	1.5	0.7	1.33	0.57	1.05	0.1	7	5
Chemical									
TDS	Mg/l	259	220.61	180.3	146.95	152.5	126.35	1000	1000
TH(CaCO3)	Mg/l	117.5	10.6	100	10	98	13.08	300	300
Nitrate	Mg/l	3.25	0.77	3.5	0.9	3.37	0.86	50	50
Chloride	Mg/l	8.05	0.77	4.7	0.5	3.1	0.42	250	250
Fluoride	Mg/l	1.625	1.47	0.99	0.9	0.81	0.79	3	1.5
Iron	Mg/l	0.13	0.15	0.3	0.226	0.32	0.19	0.4	0.3
Magnesium	Mg/l	11.9	0.7	11.33	2.82	10.21	2.60	50	50
Phosphate	Mg/l	0.86	0.905	1.16	0.87	10.21	2.6	0.02	0.005

Temperature

According to Philipos(2019) cited, the determination of temperature of water is very important, because it has an effect on most chemical reactions that occur in natural water systems and it also has pronounced effect on the solubility of gases in water WHO, (2004). When water temperature increases, disinfectant demand and microbial activity will also increase so that palatability of water quality decreases. According to WHO, (2004) high water temperature enhances the growth of micro-organisms and chemical reaction may increase taste, odor, color, corrosion problems and makes difficult to drink. To one side from this, the amount of any gas, including oxygen, dissolved in water is inversely proportional to the temperature of the water; as temperature increases, the amount of dissolved oxygen (gas) decreases and vice versa.

It was one of the physical parameters used to evaluate the quality of drinking water. The mean values of temperature for the source, storage, and point of use were 22.2±1.27^{o}C, 20.99±1.58^{0}C, and 19.752±0.89^{o}C, respectively. The minimum is 18.5^{o}C from SadamoDikicha kebele at water pointand the maximum was 23.3^{o}C from the source of Awada kebele on the water source site .The Water temperature obtained during the sampling period for all sites varies from 18.5 C to 23.3°C; it was considered a higher result as compared to the WHO, guideline permissible limit (WHO, 2008). According to WHO guideline, the maximum permissible limit for drinking water should not be greater than 15 °C. In terms of temperature the study area drinking water not suitable for drinking purpose.

PH

PH values vary from a minimum of 6.65 and a maximum of 8.08. According to the WHO, the minimum and maximum allowable pH ranges from 6.5 to 8.5 for portable water. The result of laboratory analysis revealed that the mean values of pH for the source, storage, and point of use were 6.65±0.21pH, 7.76±0.49pH, and 7.5±0.16pH, respectively. This finding agreed with the ES and WHO standards. Among the three sampled points the maximum pH value of 8.1 was recorded in a water sample collected from the storage of Hanja chefa kebele and the minimum pH of 6.5 was recorded in a water sample collected from the storage of Awada kebele at the water source site. A consistent finding was obtained by Philipos(2019 Boricha woreda the pH ranges of the study area were 6.8 – 8.08; Tsegaye A. et al., (2022) in the North Ethiopia area with an average of 7.2 ± 0.42 the pH ranges of the study area were 6.8 – 8.08.

Turbidity

Turbiditydissolved solids, due to suspended chemical and biological elements can have together water security and aesthetic consequences for drinking-water provisions (WHO, 2017). The finding indicated that the mean TDS values were the value of turbidity for the source, storage and water point of use were 1.5±0.7071NTU, 1.33±0.57NTU and 1.5±0.1NTU, respectively. Which is less than WHO standards of 5 NTU and the tastiness of drinking water has suggested TDS levels of 600 ppm (WHO, 2004). Thus, turbidity in this study area could not represent a key issue regarding the microbiological quality and disinfection of water.

Electrical conductivity (EC)

According to the current study, conductivity is the ability of water to carry an electric current. The conductivity indicates the water mineralization which varies by the concentration of dissolved salts and is habitually subjective by temperature (Benrabah et al., 2016). The mean value of EC for source, storage, and point of use was 472.5±388.2µs/cm, 447±256.61µs/cm, and 281.75±265.38µs/cm respectively. The EC minimum value was 88µs/cm from Aldadadela kebele point of water to useand the maximum value was taken from Konsore anno kebele 747µs/cm at the water source site. Nearly a consistent finding by FelekeL. (2018), The EC value was rated under excellent classes for all human, livestock, and poultry watering purposes (WHO, 2008),i.e.,<1000 µS/cm.

Total dissolved solids (TDS)

Total dissolved solids values <1000 considered fresh water and values >1000 mg/l considered brackish water (Dagnewet al., 2007). Mean value of TDS for source, storage and point of-use were 259±220.6mg/l, 180.33±146.9569mg/l and 152.5±126.35mg/l, respectively. From the result of analyzed samples the value of TDS was found within the acceptable range of WHO and also according to this studied result it is possible to consider the Woreda water supply as fresh water with respect to TDS concentration. According to mihiret et al., (2021), TDS level higher than 1000 mg/L is not suitable for consumption and the values higher than 1200 mg/L significantly affects the consumers and acceptable standards given by both WHO and FAO, (2008).

The minimum and maximum TDS values obtained on the site were 87mg/L to 415mg/L at hanjachafaat the point of use and Konsoreanokebele at water source site respectively. Nearly a consistent finding by Philipos (2019), ranging from 16.00mg/L to 74.00 mg/L and the overall mean value was 31.64 ±18.89mg/L and this was within acceptable standards given by both WHO and FAO, (2008).

Total Hardness

The result of laboratory analysis revealed that the mean value of TH for the source, storage, and point of use was 117.5± 10.60mg/l,100±10mg/l, and 98±13.08mg/l, respectively. The maximum and minimum hardness values recorded from Konsore anno kebele were 112mg/l from the water source site and 80mg/l from the storage site at Alabosiso kebele. Thus, the recorded values of total hardness for all sampling sites were within the permissible limit of WHO (2008) standard.

Total hardness level showed that there is variation from source to point to use. The source has high value of total hardness due to high quantity of magnesium or calcium ions on the source than storage and point of-use value. This finding consistent with by Douhri et al (2015), i.e. the total Hardness at source varied between 8.17 and 70.31 (mg/l) and total Hardness values range from 10 mg/L to 50 mg/L and the overall mean was 30.63 ± 11.66 mg/L (Philiposl,2019). According to SAWQG, (1996) classification, sites of water sources were categorized under Soft water (≤50 CaCO3 mg/l). Indicating that as it was below the recommended value of the WHO,2008 water quality guide line set as it to be 200mg/l for a safe drinking water. Thus, there is no significance harm effect on human health.

Nitrate

According toPhilipos(2019) cited, Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater disposal and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks (WHO, 2008).

The result of laboratory analysis revealed that the mean values of nitrate for the source, storage and point of-use were 3.25 ± 0.77mg/l, 3.5 ± 0.9mg/land 3.37 ± 0.86mg/l respectively. The minimum and maximum values for nitrate were 2.2 mg/l at Aldadadelakebele at the point to using siteand storage site to 4.4mg/l at Sadamodikichakebele respectively. The laboratory result showed that within the acceptable limits of ES,2002 and WHO,2008 for potable water quality.

Chloride and Fluoride

Chlorination can kill many pathogenic, disease-causing microorganisms such as E-coli, but others, like Cryptosporidium and Giardia, are very resistant to chlorine and require other measures to properly remove them. Therefore, it is important to make sure there is enough chlorine to efficiently disinfect even at the far ends of the distribution system (WHO, 2003). The chlorine will decrease in concentration with distance from the source, until it reaches the point where the chlorine level can become ineffective as a disinfectant. Bacterial growth will occur in distribution systems when very low levels of chlorine are encountered (WHO, 2003)

The mean value of free residual chlorine in the drinking water samples was lower as compared with the WHO standard. Free chlorine residue is the greatest effective and widespread because of its tall response in safeguarding quick and high levels of inactivation of bacteria and viruses (Gray, 2014). Such low free residual chlorine concentration might be influenced by the network of pipelines and wall material like the level of corrosion and the age of the pipe (Neff, 2018). Consequently, free chlorine residuals may not remain for very long within the water. However, free chlorine has an important potential as a substitute indicator of pathogenic infection.

The result of laboratory analysis revealed that the mean values of chloride for the source, storage and point of-use were less than 10mg/l. The result of laboratory analysis revealed that the mean values of chloride for the source, storage and point of-use were less than10±0.77mg/l, 10±0.5mg/l and 10±0 .77mg/l respectively, free residual chlorine concentration might be influenced by the network of pipelines leakage and contact with surrounding materials that reduce the concentration of chlorine residual ,the concentration of chlorine added to the water sources are miss balanced with the volume of water discharged and microorganisms.The laboratory result showed that the mean values of Fluoride for source, storage, and point of use were 1.625±1.47mg/l,0.99±0.0.90mg/l and 0.8125±0.79851mg/l, respectively due to dilution different source waters .The average value of the study area; chlorine residual was below the minimum recommended standards of the World Health Organization guidance level for drinking water supply recommends a minimum of 0.2 mg/l and a maximum of 5mg/l residual chlorine (WHO, 2003). Fluoride was the highest value found in the Konsore anno Kebele from the water source and 0.39 mg/l of the smallest value that was found in the Aldadadela kebele from the public point-to-use site.

Phosphate

The result of laboratory analysis revealed that the mean values of phosphate for the source, storage, and point of use were 0.86±0.90mg/l, 0.96±0.82mg/l and 0.69±0.49mg/ respectively. The minimum and maximum values for phosphate were 0.21mg/l Sadamodikicha kebele on the public water point using the site to 1.25 mg/l and Aldadadela kebele on the reservoir (storage) site respectively. The finding of this study was in agreement with previous research by Douhri et al., (2015). The laboratory result showed that above the acceptable limits of ES,2002 and WHO ,2008 for potable water quality. Statistical analysis showed that, the differences in the mean from source, storage, and point of the use of the value of nitrate and phosphate from sampled sites. The phosphate ion increases by erosion problem as a result application of different blended potash type fertilizers and deforestation to the extensive agricultural practices in the area.

Iron and Magnesium

According to Feleke L. (2018) cited, tiny amount or trace levels of dissolved metals in surface water are essential for proper biological functioning. Many are important in basic physiological functions in both plants and animals, as blood components or cofactors in enzyme reactions (Dagnew et al, 2007). The result of laboratory analysis revealed that the mean values of iron and magnesium for source, storage andpoint to use were (0.13±0.155mg/l, 0.31±0.18and 0.32±0.19mg/l) and (11.9±0.71, 12.15±0.2.82 and 10.21±2.6mg/L), respectively. The statistical analysis showed that the mean difference from the source, storage and point of-use for iron and magnesium. The analyzed laboratory result of magnesium concentration obtained from the sampled sites was below the maximum permissible limit of ES,2002 and WHO,2008 standards.Iron was found lowest and highest concentration was found in sadamodikicha0.03/100ml in storage (reservoir) site and Hanja chafa kebeles 0.47/100ml drinking water tap respectively, which was higher than the recommended WHO (2008) standard due to concentration varies from different area naturally and corrosion ofdistribution system pipeline. A consistent finding byMihretU.*et al., (*2021);Feleke L. (2018)could be attributable to plumbing, water distribution system piping, and widespread agriculture practices.

4.8.2. Bacteriologicalquality of drinking water

Measuring the bacteriological quality of drinking water is the major parameter that should be reflected in any water quality checking. Especially, fecal coliform is an indicator of the occurrence of fecal material from warm- blooded animals and can be used as a bacteriological surrogate for water quality checkups (Motlagh and Yang, 2019).For water to be potable, it must be free of any bacterial contaminants. An important indicator of water quality is the number of bacteria present in the water. Though it would be difficult to determine the presence of all bacteria in a sample, certain types of microorganisms can serve as indicators of pollution. Chief among these are the coliform bacteria, which survive better, longer and are easier to detect than other pathogens (Kegley and Andrews, 1998).

The result of laboratory analysis revealed that the mean values of E. coli or total caliform for the source, storage and point of-use were 0mg/l, 3±1.7321 mg/l1 and 23.25±3.6547mg/ol respectively. The highest number of Feacal coliform (i.e.30cfu/100ml) was found in the Sadamo Dikicha Kebele at beneficiary household level samples. Those Kebeles in which Feacal coliform was not exist at Konsoreano and Awada at source water supply and gradually increase from source to beneficiary household. The reason that the number fecal coliforms increase were the society uses the same material to collect and store water from both improved and unimproved source of water ,improperly clean water collected materials , water supply line leakage, and hygienic practice of the family this gives opportunity to develop microorganisms in distribution system of water supply. The value of feacal coliform in the study are a permissible value of water quality guideline of WHO (2008) as shown in (Table 4.11). water from improved sources were free from microorganisms and contaminated in distribution system and point of use. The society use water treatments and the government should be improving unimproved water supply sources. A similar finding by Tsegaye A. et al., 2022, this might be due to the fact that the family size would be the barrier to securing the hygienic practice of the family and result in fecal contamination of household drinking water; family size, latrine availability, and the use of a separate can to take water were recognized as predictors of the bacteriological quality of drinking water.

Table 4.11; Mean value of bacteriological parameter for the source, storage and point of use.

Parameters	Units	Source		Storage		Point of-use		Standards	
		Mean	Std	Mean	Std	Mean	Std	ES	WHO
TC	CFU	0	1.41	3.17	2	15	23.25	0	0

CHAPTER FIVE

CONCUSSIONS AND SUMMARY

5.1. Conclusions

This study provides data on access, usage, and practices of water source among rural households in Sidama Region, Ethiopia. It provides a valuable insight into access to safe water and consequent demographic, socio-economic conditions such as income, distances, and family size, sanitation and hygiene perceptions of households that can be associated with access to improved sources of water.

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. The major findings suggest that 79.59% of households used improved and 19.41% of households used unimproved water sources. Based on the report evidence, the scarcity of water especially from improved source is very severe. There is huge variation between supply-demand. In considering the minimum & maximum variations were from 5 lit/ to 50 lit/householdper week respectively. The average quantity of water used by a person per households is less than**1**liters with average distance about **1**k.m by average time **30** minute which is significantly less than the WHO and Ethiopia drinking water guide line values.

Increasing demand with a population of safe and quality water puts in force the governments to increase the supply. But, due to the lower supply of pure water to households, people put in force for using water from unimproved sources, which have a possibility to contaminate many infectious microorganisms and cause water-borne diseases.

The study suggests the association of the types of sources of drinking water with the age of the household head, educational level,hand washing facilities, defecation, the availability latrine, and the water treatment method, cause of quality potable water and perceptionof the household head significantly determineof sanitation and hygiene to improved sources of drinking water in the studied area.

Physico-chemical water quality parameters such as mean value of PH, Total dissolved solid, Electro conductivity, Total hardiness, Chloride and Nitrate for in most studied kebeles werenot exceed as compared with the WHO standardof drinking water quality. WhereasIron and fluoride was slightly higher than the recommended WHO standard around thesource, reservoir and point to use. On the other hand, the study revealed that mean concentration of Temperatureand Phosphate were in study area is higher than WHO guideline values and not suitable for drinking purpose.

The Bacteriological water quality test, in the point of consumption and storage area had mean of total coliform and fecal coliforms 23.25 cfu and 3.17 cfu respectively. This result implied that drinking water supply in the woreda was of less quality and contaminated by fecal coliform.

5.2. Recommendations

It is recommended that the local, regional, and national governments and other supporting organizations shall improve the accessibility and adequacy of drinking water from improved sources through short and long-time plan for the well-being of the community in the area.

- The development of new water source and expansion of the existing sources should take place in order to improve low water provision and consumption of the Woreda (l/p/d).
- The available quantity of water from all sources of supply schemes should be accessed to all the people on fair distribution basis.
- Despite maintaining strong physical structure, many schemes are in need of different types of repair. Therefore, the management system needs to review its approaches on how to establish institutional mechanisms related to operation and maintenance and ensure that they remain active throughout the designated lifespan of each scheme.
- Attempts are necessary to improve the safety of all water supply schemes from the source. This can be made by source disinfection mechanisms like chlorination, point of use disinfection mechanisms such as boiling and other household water treatment measures to decrease the bacteriological health hazards and regular cleaning of water containers and drinking cup system may improve the conditions significantly.
- More private sanitary pit and communal landfills have to be established to ensure proper solid and liquid waste collection.
- Many awareness creation activities should be done on sanitation and hygiene through all concerned bodies and extension workers for not only preparing latrines but also regular use of the latrines and hand washing practices

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BIOGRAPHICAL SKETCH

The author, Genet Zenebe was born in 1992G.C at Sidama region, Boricha woreda. She attended her elementary school at yirba Yanase Elementary school education and junior and secondary school education at Hawassa Betekinet Junior school and she has completed his high school education at Hawassa tabor Secondary School, after completion of her high school education, she joined at Arbamich University science and technology in October 2010 and graduated with in degree program in Geology in 2014 .

Soon after graduation, she joined at south water work construction enterprise in 2015 as a geologist and now in Sidama region water mining and energy bureau she works as hydrogeologist for six years. In October 2020 she joined Institute of Technology, Graduate Studies of Hawassa University, Department of Water Resource Engineering and Management.

APPENDIX

Southern Nations, Nationalities and People's Regional State
Water Irrigation and Mine Development Bureau
Water Resouce Study and Management Directorate

Bacteriological Analysis Report
(Drinking Water Quality)

Client	Genet zenebe	Zone		sidam region
Contact Person	Genet zenebe	Woreda/Town		Boricha
Sample Number	9668B	Kebele		Hanga chefa
Date of Sampling	04/05/2015 (Ethiopian, EC)	Village		
Date of Testing	#N/A (Ethiopian, EC)	Site Name		Buster station
	(International)	GPS	Northing	764979
Nature of Sample		(UTM)	Easting	424725
Source	H HOLDE	Alttitude [m]		1862
Depth [m]		Sample taken by		Genet zenebe

Analysis results

Items	Result	Unit	Reference			
			WHO Guideline	Incubation		Media
				Temperature	Time	
Total Coliform	55	[CFU/100mL]	0	37 ℃	-broth hours	m-Colibule 24-broth
E.*Coli* (Fecal Coliforms)	55	[CFU/100mL]	0	37 ℃	-broth hours	m-Colibule 24-broth

Note:
The underline shows values that exceed WHO guideline values set for drinking water

Remark:

There are55 colony forming units of bacteria in 100ml water sample. Note that, according to WHO guideline and Ethiopian standard set for drinking water, no coliform bacteria should be detected in 100ml sample of water. Therefore, Sanitary inspection and regular disinfection is required.

Analyzed on 04/05/2015 *by* Zerihun sebsibe *Signature*

Approved on 08/05/2015 *by* W/R/S/M/D *Signature*

Southern Nations Nationalities and People's Regional State Water, Irrigation and Mine Development Bureau

Habtemariam Tilahun
Water Resource Study & Management Directorate Director

Southern Nations, Nationalities and People's Regional State
Water Irrigation and Mine Development Bureau
Water Resouce Study and Management Directorate

Bacteriological Analysis Report
(Drinking Water Quality)

Client	Genet zenebe	Zone	sidam region
Contact Person	Genet zenebe	Woreda/Town	Boricha
Sample Number	9670B	Kebele	Aldada Dela
Date of Sampling	04/05/2015 (Ethiopian, EC)	Village	
Date of Testing	#N/A (Ethiopian, EC)	Site Name	H HOLDE
	(International)	GPS Northing	769737
Nature of Sample		(UTM) Easting	426901
Source	H HOLDE	Alttitude [m]	1879
Depth [m]		Sample taken by	Genet zenebe

Analysis results

Items	Result	Unit	Reference			
			WHO Guideline	Incubation Temperature	Incubation Time	Media
Total Coliform	44	[CFU/100mL]	0	37 ℃	-broth hours	m-Colibule 24-broth
E.*Coli* (Fecal Coliforms)	44	[CFU/100mL]	0	37 ℃	-broth hours	m-Colibule 24-broth

Note:
The underline shows values that exceed WHO guideline values set for drinking water

Remark:

There are 44colony forming units of bacteria in 100ml water sample. Note that, according to WHO guideline and Ethiopian standard set for drinking water, no coliform bacteria should be detected in 100ml sample of water. Therefore, Sanitary inspection and regular disinfection is required.

Analyzed on 04/05/2015 *by* Zerihun sebsibe *Signature*

Approved on 08/05/2015 *by* W/R/S/M/D *Signature*

Southern Nations, Nationalities and People's Regional State Water, Irrigation and Mine Development Bureau

Southern Nations, Nationalities and People's Regional State
Water Irrigation and Mine Development Bureau
Water Resouce Study and Management Directorate

Bacteriological Analysis Report

(Drinking Water Quality)

Client	Genet zenebe	Zone	sidam region
Contact Person	Genet zenebe	Woreda/Town	Boricha
Sample Number	9671B	Kebele	SADAMO DIKICHA
Date of Sampling	04/05/2015 (Ethiopian, EC)	Village	
Date of Testing	#N/A (Ethiopian, EC)	Site Name	H HOLDE
	(International)	GPS Northing	762580
Nature of Sample		(UTM) Easting	431733
Source	H HOLDE	Alttitude [m]	1939
Depth [m]		Sample taken by	Genet zenebe

Analysis results

Items	Result	Unit	Reference			
			WHO Guideline	Incubation Temperature	Incubation Time	Media
Total Coliform	<u>**25**</u>	[CFU/100mL]	0	37 ℃	-broth hours	m-Colibule 24-broth
E.*Coli* (Fecal Coliforms)	<u>**25**</u>	[CFU/100mL]	0	37 ℃	-broth hours	m-Colibule 24-broth

Note:

The underline shows values that exceed WHO guideline values set for drinking water

Remark:

There are 25 colony forming units of bacteria in 100ml water sample. Note that, according to WHO guideline and Ethiopian standard set for drinking water, no coliform bacteria should be detected in 100ml sample of water. Therefore, Sanitary inspection and regular disinfection is required.

Analyzed on *04/05/2015* *by* *Zerihun sebsibe* *Signature*

Approved on *08/05/2015* *by* *W/R/S/M/D* *Signature*

Southern Nations, Nationalities and People's Regional State
Water Irrigation and Mine Development Bureau
Water Resouce Study and Management Directorate

Physico-Chemical Analysis Report

(Drinking Water Quality)

Client	Genet zenebe	Zone	sidam region
Contact person	Genet zenebe	Woreda	Boricha
Sample Number	9667C	Kebele	Aldada dela
Date of Sampling	04/05/2015 (Ethiopian, EC)	Village	
Date of Testing (dd/mm/yyyy)	08/05/2015 (Ethiopian, EC) (International)	Site Name	publice tap
		GPS (UTM) Northing	769737
Nature of Sample		Easting	426901
Source	sp	Alttitude [m]	1879
Depth [m]		Sample taken by	Genet zenebe

Analysis results

Item	Unit	Result	Standard
pH	-	7.8	6.5 - 8.5
Temperature	[°C]	21.4	-
Conductivity	[µS/cm]	195	-
TDS	[mg/L]	98	1000
Turbidity	[FTU]	3	5
Total Chlorine [Cl_2]	[mg/L]	0.08	5
Total Hardness	[mg/L as $CaCO_3$]	100	300
Calcium Hardness	[mg/L as $CaCO_3$]	40	-
Magnesium Hardness	[mg/L as $CaCO_3$]	60	-
Total Alkalinity	[mg/L as $CaCO_3$]	130	500
Bicarbonate Alkalinity	[mg/L as $CaCO_3$]	130	-
Carbonate Alkalinity	[mg/L as $CaCO_3$]	0	-
Hydroxide Alkalinity	[mg/L as $CaCO_3$]	0	-
Dissolved NH_3	[mg/L]	0.54	1.5
NH_4^+ Ammonium	[mg/L]	0.69	-
Na^+ Sodium	[mg/L]	11.0	-

Item		Unit	Result	Standard
K^+	Potassium	[mg/L]	9.0	-
Ca^+	Calcium	[mg/L]	16.0	100
Mg^+	Magnesium	[mg/L]	14.6	30
Fe	Iron	[mg/L]	<u>0.45</u>	0.3
Cu^{2+}	Copper	[mg/L]	0.33	2
Mn^{2+}	Manganese	[mg/L]	0.10	0.5
Cr^{6+}	Chromium	[mg/L]	0.03	0.05
Cl^-	Chloride	[mg/L]	<10	250
F^-	Fluoride	[mg/L]	0.46	1.5
Br_2	Bromine	[mg/L]	0.17	-
NO_2^-	Nitrite	[mg/L]	0.01	3
NO_3^-	Nitrate	[mg/L]	2.6	50
SO_4^{2-}	Sulfate	[mg/L]	3	250
PO_4^{3-}	Phosphate	[mg/L]	1.25	-
HCO_3^-	Bicarbonate	[mg/L]	159	-
CO_3^{2-}	Carbonate	[mg/L]	0	-

Note:

Values that exceed WHO guidline are underlined.

Remark:

Iron Content of the analysed water sample exceeds the WHO guideline and Ethiopian standard set for drinking water.Therefore,the water is not suitable for drinking purpose unless it is treated before supply to the community.Note that the water sample was taken by the client.

Analyzed on 08/05/2015 *by* ***Zerihun sebsibe*** *Signature*

Approved on 08/05/2015 *by* W/G/S/ADD *Signature*

Habtemariam Tilahun Beyene
Water Resource Study & Management
Directorate Director

Southern Nations, Nationalities and People's Regional State
Water Irrigation and Mine Development Bureau
Water Resouce Study and Management Directorate

Physico-Chemical Analysis Report

(Drinking Water Quality)

Client	Genet zenebe	Zone	sidam region
Contact person	Genet zenebe	Woreda	Boricha
Sample Number	9664c	Kebele	konsore Ano
Date of Sampling	04/05/2015 (Ethiopian, EC)	Village	
Date of Testing	05/05/2015 (Ethiopian, EC)	Site Name	publice tap
(dd/mm/yyyy)	(International)	GPS (UTM) Northing	762349
Nature of Sample		Easting	433932
Source	publice tap	Alttitude [m]	1861
Depth [m]		Sample taken by	Genet zenebe

Analysis results

Item	Unit	Result	Standard	Item	Unit	Result	Standard
pH	-	8.0	6.5 - 8.5	K^+ Potassium	[mg/L]	15.0	-
Temperature	[°C]	20.7	-	Ca^+ Calcium	[mg/L]	20.0	100
Conductivity	[μS/cm]	699	-	Mg^+ Magnesium	[mg/L]	9.7	30
TDS	[mg/L]	350	1000	Fe Iron	[mg/L]	0.04	0.3
Turbidity	[FTU]	3	5	Cu^{2+} Copper	[mg/L]	<0.04	2
Total Chlorine [Cl_2]	[mg/L]	0.11	5	Mn^{2+} Manganese	[mg/L]	0.20	0.5
Total Hardness	[mg/L as $CaCO_3$]	90	300	Cr^{6+} Chromium	[mg/L]	0.06	0.05
Calcium Hardness	[mg/L as $CaCO_3$]	50	-	Cl^- Chloride	[mg/L]	<10	250
Magnesium Hardness	[mg/L as $CaCO_3$]	40	-	F^- Fluoride	[mg/L]	<u>2.04</u>	1.5
Total Alkalinity	[mg/L as $CaCO_3$]	150	500	Br_2 Bromine	[mg/L]	0.23	-
Bicarbonate Alkalinity	[mg/L as $CaCO_3$]	150	-	NO_2^- Nitrite	[mg/L]	0.03	3
Carbonate Alkalinity	[mg/L as $CaCO_3$]	0	-	NO_3^- Nitrate	[mg/L]	4.4	50
Hydroxide Alkalinity	[mg/L as $CaCO_3$]	0	-	SO_4^{2-} Sulfate	[mg/L]	5	250
Dissolved NH_3	[mg/L]	0.13	1.5	PO_4^{3-} Phosphate	[mg/L]	0.25	-
NH_4^+ Ammonium	[mg/L]	0.17	-	HCO_3^- Bicarbonate	[mg/L]	183	-
Na^+ Sodium	[mg/L]	25.1	-	CO_3^{2-} Carbonate	[mg/L]	0	-

Note:

Values that exceed WHO guidline are underlined.

Remark:

Fluoride Content of the analysed water sample exceeds the WHO guideline and Ethiopian standard set for drinking water.Therefore,the water is not suitable for drinking purpose unless it is treated before supply to the community.Note that the water sample was taken by the client.

Analyzed on 05/05/2015 *by* ***Zerihun Sebsibe*** *Signature*

Approved on 08/05/2015 *by* W/R/S/M/D *Signature*

Habtemariam Tilahun Bey
Water Resource Study & Man...
Directorate Director

Southern Nations, Nationalities and People's Regional State
Water Irrigation and Mine Development Bureau
Water Resouce Study and Management Directorate

Physico-Chemical Analysis Report

(Drinking Water Quality)

Client	Genet zenebe	Zone	sidam region
Contact person	Genet zenebe	Woreda	Boricha
Sample Number	9665c	Kebele	Hanga chefa
Date of Sampling	04/05/2015 (Ethiopian, EC)	Village	
Date of Testing (dd/mm/yyyy)	05/05/2015 (Ethiopian, EC) (International)	Site Name	Buster station
		GPS (UTM) Northing	764979
Nature of Sample		Easting	424725
Source	SP	Alttitude [m]	1862
Depth [m]		Sample taken by	Genet zenebe

Analysis results

Item	Unit	Result	Standard
pH	-	8.1	6.5 - 8.5
Temperature	[°C]	22.7	-
Conductivity	[µS/cm]	186	-
TDS	[mg/L]	93	1000
Turbidity	[FTU]	2	5
Total Chlorine [Cl_2]	[mg/L]	0.05	5
Total Hardness	[mg/L as $CaCO_3$]	110	300
Calcium Hardness	[mg/L as $CaCO_3$]	70	-
Magnesium Hardness	[mg/L as $CaCO_3$]	40	-
Total Alkalinity	[mg/L as $CaCO_3$]	130	500
Bicarbonate Alkalinity	[mg/L as $CaCO_3$]	130	-
Carbonate Alkalinity	[mg/L as $CaCO_3$]	0	-
Hydroxide Alkalinity	[mg/L as $CaCO_3$]	0	-
Dissolved NH_3	[mg/L]	0.43	1.5
NH_4^+ Ammonium	[mg/L]	0.55	-
Na^+ Sodium	[mg/L]	7.9	-

Item		Unit	Result	Standard
K^+	Potassium	[mg/L]	10.0	-
Ca^+	Calcium	[mg/L]	28.0	100
Mg^+	Magnesium	[mg/L]	9.7	30
Fe	Iron	[mg/L]	<u>0.41</u>	0.3
Cu^{2+}	Copper	[mg/L]	0.38	2
Mn^{2+}	Manganese	[mg/L]	0.50	0.5
Cr^{6+}	Chromium	[mg/L]	0.05	0.05
Cl^-	Chloride	[mg/L]	<10	250
F^-	Fluoride	[mg/L]	0.47	1.5
Br_2	Bromine	[mg/L]	0.11	-
NO_2^-	Nitrite	[mg/L]	0.03	3
NO_3^-	Nitrate	[mg/L]	3.5	50
SO_4^{2-}	Sulfate	[mg/L]	6	250
PO_4^{3-}	Phosphate	[mg/L]	2.00	-
HCO_3^-	Bicarbonate	[mg/L]	159	-
CO_3^{2-}	Carbonate	[mg/L]	0	-

Note:

Values that exceed WHO guidline are underlined.

Remark:

Iron Content of the analysed water sample exceeds the WHO guideline and Ethiopian standard set for drinking water.Therefore,the water is not suitable for drinking purpose unless it is treated before supply to the community.Note that the water sample was taken by the client.

Analyzed on 05/05/2015 *by* ***Zerihun sebsibe*** *Signature* ______

Approved on 08/05/2015 *by* WRS/MD *Signature* ______

Southern Nations, Nationalities and People's Regional State
Water Irrigation and Mine Development Bureau
Water Resouce Study and Management Directorate

Physico-Chemical Analysis Report

(Drinking Water Quality)

Client	Genet zenebe	Zone	sidam region
Contact person	Genet zenebe	Woreda	Boricha
Sample Number	9666C	Kebele	Alawo siso
Date of Sampling	04/05/2015 (Ethiopian, EC)	Village	
Date of Testing (dd/mm/yyyy)	08/05/2015 (Ethiopian, EC) (International)	Site Name	publice tap
		GPS (UTM) Northing	762457
Nature of Sample		GPS (UTM) Easting	427683
Source	sp	Alttitude [m]	1965
Depth [m]		Sample taken by	Genet zenebe

Analysis results

Item	Unit	Result	Standard
pH	-	8.0	6.5 - 8.5
Temperature	[℃]	21.6	-
Conductivity	[µS/cm]	200	-
TDS	[mg/L]	100	1000
Turbidity	[FTU]	4	5
Total Chlorine [Cl_2]	[mg/L]	0.06	5
Total Hardness	[mg/L as $CaCO_3$]	120	300
Calcium Hardness	[mg/L as $CaCO_3$]	60	-
Magnesium Hardness	[mg/L as $CaCO_3$]	60	-
Total Alkalinity	[mg/L as $CaCO_3$]	160	500
Bicarbonate Alkalinity	[mg/L as $CaCO_3$]	160	-
Carbonate Alkalinity	[mg/L as $CaCO_3$]	0	-
Hydroxide Alkalinity	[mg/L as $CaCO_3$]	0	-
Dissolved NH_3	[mg/L]	0.40	1.5
NH_4^+ Ammonium	[mg/L]	0.52	-
Na^+ Sodium	[mg/L]	14.3	-

Item		Unit	Result	Standard
K^+	Potassium	[mg/L]	12.0	-
Ca^+	Calcium	[mg/L]	24.0	100
Mg^+	Magnesium	[mg/L]	14.6	30
Fe	Iron	[mg/L]	<u>0.35</u>	0.3
Cu^{2+}	Copper	[mg/L]	0.25	2
Mn^{2+}	Manganese	[mg/L]	0.30	0.5
Cr^{6+}	Chromium	[mg/L]	0.02	0.05
Cl^-	Chloride	[mg/L]	<10	250
F^-	Fluoride	[mg/L]	0.69	1.5
Br_2	Bromine	[mg/L]	0.13	-
NO_2^-	Nitrite	[mg/L]	0.02	3
NO_3^-	Nitrate	[mg/L]	3.1	50
SO_4^{2-}	Sulfate	[mg/L]	4	250
PO_4^{3-}	Phosphate	[mg/L]	0.35	-
HCO_3^-	Bicarbonate	[mg/L]	195	-
CO_3^{2-}	Carbonate	[mg/L]	0	-

Note:

Values that exceed WHO guidline are underlined.

Remark:

Iron Content of the analysed water sample exceeds the WHO guideline and Ethiopian standard set for drinking water.Therefore,the water is not suitable for drinking purpose unless it is treated before supply to the community.Note that the water sample was taken by the client.

Analyzed on 08/05/2015 *by* ***Zerihun sebsibe*** *Signature*

Approved on 08/05/2015 *by* *W/R/S/M/D* *Signature*

Southern Nations, Nationalities and Peoples Regional State Water, Irrigation and Mine Development Bureau

Habtemariam Tilahun ... Water Resource Study & Ma... Directorate Director