

Impact of Bacteriological Water Quality and Sanitation Practices on
Public Health; Case of Gemechis Woreda of West Hararghe Zone,
Ethiopia



Tigist Gosaye Tesfaye

A Thesis Submitted to

The Department of Water Resources Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of The Requirements for The Degree of master's
in water supply and environmental Engineering.

Office of Graduate Studies

Adama Science and Technology University

January 2024
Adama, Ethiopia

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Advisor: Keredin Temam (PHD)

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DECLARATION

I hereby declare that this Master Thesis entitled “**Impact of Bacteriological Water Quality and Sanitation Practices on Public Health; Case of Gemechis Woreda of West Hararghe Zone, Ethiopia**” is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of material that are used for this thesis have been acknowledge through citation. It is being submitted for the partial fulfillment for the award of the degree of Master of Science in Water Supply and Environmental Engineering at Adama Science and Technology University School of Civil Engineering and Architecture

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Name of student

Signature

Date

RECOMMENDATION

I, the advisor(s) of this thesis, hereby certify that I have read the revised version of the thesis entitled “**Impact of Bacteriological Water Quality and Sanitation Practices on Public Health; Case of Gemechis Woreda of West Hararghe Zone, Ethiopia**” prepared under my guidance by Tigist Gosaye submitted in partial fulfillment of the requirements for the degree of Master’s of Science in Water Supply and Environmental Engineering. Therefore, I recommend the submission of a revised version of the thesis to the department following the applicable procedures.

Keredin Temam (PhD)

Major Advisor

Signature

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APPROVAL PAGE

I, the advisors of the thesis entitled “**Impact of Bacteriological Water Quality and Sanitation Practices on Public Health; Case of Gemechis Woreda of West Hararghe Zone, Ethiopia**” and developed by **Tigist Gosaye**; hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis Tigist Gosaye have read and evaluated the thesis entitled “**Impact of Bacteriological Water Quality and Sanitation Practices on Public Health; Case of Gemechis Woreda of West Hararghe Zone, Ethiopia**” and examined the candidate during open defense. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the degree of Master of Science in Water Supply and Environmental Engineering.

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ACKNOWLEDGEMENTS

First and foremost, I want to offer God all the glory for giving me an inexhaustible gift in life and the perseverance to go this far in my academic career. Next, I would like to express my sincere gratitude to Dr. Keredin Temam for his close advice, direction, and real aid with my paperwork from beginning to conclusion.

I appreciate the West Hararghe Zonal Health Office laboratory team for their assistance with the experiment and the Data collector team. I want to thank Mr. Mulu Mekasha and Nesir Abdela for their assistance and insightful criticism throughout the lab analysis.

Finally, I want to express my gratitude to my family, friends, and all the people in my community who helped me with my master's program.

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LIST OF ACRONYMS AND ABBREVIATION

ADB	African Development Bank
ADF	African Development Fund
APHA	American Public Health Association Guideline
BGLB	Brilliant Green Lactose Bile
CFU	Colony-Forming Unit
CFU	Colony Forming Unit
CSA	Central Statistics Agencies
EDHS	Ethiopian Demographical and Health Survey
EMB	Eosin Methylene Blue Agar
EPA	Environmental Protection Agencies
FMoH	Federal Ministry of Health
HHs	Households
HDWHP	Hand Dug Well fitted with Hand Pump
ISO	International Organization Standardization
JMP	Joint Monitoring Program
LES	Lawrence Experimental Station
MDG	Millennium Development Goal
Mfc	Membrane Fecal Coliform
MPN	Most Probable Number
PASDEP	Plan of Action for Sustainable Development of End Poverty
SDI	Species Diversity Index
SPSS	Statistical Package for Social Science

UN	United Nation
UNDP	United Nation Development Program
UNESCO	United Nation Educational Scientific and Cultural Organization
UNICEF	United Nation International Children’s Emergency Fund
VIP	Ventilated Improved Pit
WHO	World Health Organization

ABSTRACT

Water is an essential resource for survival and to secure good health. But people around the world face a problem of water scarcity. This study was conducted to assess the bacteriological water quality of drinking water supply, sanitary and hygienic practices in rural area of Gemechis Woreda, West Hararghe Zone, Ethiopia. The study was carried out in 2023 G.C from four rural kebeles and 11 water points were selected by using purposively sampling method; and 270 households were selected by systematic sampling methods; from which 180 were men's while 90 were women. Totally 42 water samples were collected and tested in a laboratory; to assess bacteriological parameters (Total and Fecal coliform) of the quality of the drinking water were analyzed by following WHO procedure. In rural area of the Woreda, source of drinking water 31.6% shallow well, 29.4% H.D.W.H.P water, 16.0 % public bono, 16.local pond and 6.0 % spring; sanitation condition 84.5% has their own latrine and hygienic facilities from those respondents that have toilet, large percentage (63.33%) use only water to wash hand after using toilet; those hand washing practices with only water is not sufficient to keep personal hygienic when compared with world standard of hygiene. The water consumption per person per day (i.e., 9.57 liters) and Bacteriological parameters of drinking water in study area: total coliform 16.5 cfu and fecal coliform 1.18cfu. According to the finding access of quality drinking water coverage is very low to meet the demands of the community. In terms of bacteriological quality of drinking water in study area has less quality when comparing with WHO Standard. The study concludes by providing recommendations for improving the drinking water quality and sanitation practice in the woreda, such as enhancing the water supply and distribution systems, promoting hygiene education and awareness, strengthening the health care and monitoring services, and involving the community and stakeholders in the decision-making and implementation processes.

Key words: Accessibility, Bacteriological, Households, Gemechis Woreda, hygienic, Latrine, Sanitary, Water quality

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Eight out of ten of the more than 771 million people who lack access to better water sources worldwide reside in rural regions. According to (WHO/UNICEF 2022), over one-fourth of the world's population, or 1.5 billion people, lack access to better sanitation facilities, and of them, one billion people perform open defecation. The world's regions with the lowest coverage of improved sanitation are Sub-Saharan Africa and Southern and Eastern Asia. Simultaneously, illnesses including diarrhea, skin infections, and trachoma that are associated with water, sanitation, and hygiene (WASH) affect millions of people globally. Unsafe water, insufficient sanitation and poor hygiene are associated to 88% of diarrhea cases worldwide and result in more than 1.5 million children's deaths each year - predominantly among children under the age of five (WHO/UNICEF, WATER QUALITY AND SCARCITY 2019).

Water quality is one of the major challenges facing society across the globe during the 21st century, and failure to address this grand challenge will likely have serious repercussions for several sustainable development goals (SDGs) (Plessis 2022). Water degradation threatens human health, reduces ecosystem functioning, and hinders socioeconomic growth. Two million tons of sewage, industrial, and agricultural waste is released into water around the world daily, leading to infectious waterborne diseases such as diarrhea, cholera, dysentery, and typhoid, all attributing to more human deaths per annum than from war and other forms of violence. Approximately 44% of wastewater generated by households are not treated, nor do they meet the required standards when deposited into water bodies (Plessis 2022).

Storage of collected water from rivers, springs, community standpipes, and boreholes is a common practice in communities that lack potable water supplies piped into their homes. Even when water is piped into the home, it is often not available on a continuous basis, and water storage is still necessary (Plessis 2022). Water is stored in various containers which include jerry cans, buckets, drums, basins, and local pots. It has been reported that when collection of water from sources of high quality is possible, contamination during transport, handling and

storage and poor hygienic practices often results and can cause poor health outcomes (García Betancourt et.al,2015).

In 2022, globally, at least 1.7 billion people use a drinking water source contaminated with feces. Microbial contamination of drinking-water because of contamination with feces poses the greatest risk to drinking-water safety (WHO 2023).

About 2.4 billion people lack access to improved sanitation including one billion who practice open defecation. Moreover, nearly 1 in 4 people in developing countries were practicing open defecation (Genet.G, 2017).

Approximately eighty-eight per cent of cases of diarrhea worldwide are attributable to unsafe water, inadequate sanitation, or insufficient hygiene (G.Genet, 2017). The proportion of population in rural areas with access to safe drinking water and sanitary latrines has a direct impact on the health of the masses (Ogunyemi et.al, 2021).

The impact of the scarcity of safe drinking water and sanitation services in Africa falls chiefly on the poor populations, with women and children being the main victims. As a results, women and children are forced to carry water containers over long distances daily. Moreover, they turned to endure the indignity, shame, and disease that result from a lack of hygiene and sanitation (Ogunyemi et.al, 2021). It has been reported that higher levels of microbial contamination are associated with storage vessels having wide openings (e.g., buckets, plastic drums, and big clay pots), and by dipping drinking vessels (cups/copper or plastic mugs) or unwashed hands into the water storage containers (Ogunyemi et.al, 2021).

In many parts of the country, rural residents use borehole or spring water for their domestic and drinking consumption without strict water quality monitoring (T. Ahmad,2017). Groundwater projects are hardly supervised by trained groundwater professionals (Ogunyemi et.al, 2021). Like many developing regions, there exist few data for the general state of groundwater quality across Ethiopia (Shigut G et.al, 2017).

Approximately 85% of Ethiopia's 96 million citizens, making it the second most populous country in Africa, reside in rural regions. Malnutrition and mortality are major health issues among the nation's under-five population. Ethiopia was placed 27th in the world in the 2017 estimates of the under-five child death rate, despite having cut the country's under-five

mortality rate by more than half since 1990 (UNICEF 2012). (UNICEF 2019). Ethiopia has some of the highest rates of child mortality in the world, according to the World Bank's 2015 Country Status Report on Health and Poverty. Almost one in ten babies born there (97 out of 1000) do not live to see their first birthday, and one in six children pass away before turning five. (Plessis, 2022) To better understand the scope of the drinking water quality and sanitation issues and prioritize actions for the prevention of environmental sanitation and hygiene-related diseases, research was done in the rural setting of, Ethiopia. Specifically, the study looked at the impact of drinking water quality and sanitation practices on public health in Gemechis woreda of West Hararghe zone of Oromia region, Ethiopia.

1.2 Statement of the Problems

The quality of drinking water and sanitation practices are crucial factors for public health, especially in developing countries where waterborne diseases are prevalent. However, in Gemechis woreda, a rural district in Ethiopia, the access to safe and adequate water supply and sanitation facilities is limited and unevenly distributed. According to the 2017 census, only 54.8% of the households in Gemechis woreda had access to improved water sources, and only 11.4% had access to improved sanitation facilities (Wu 2019). Moreover, the water quality in the district is often compromised by microbial and chemical contamination from various sources, such as agricultural runoff, human and animal waste, and industrial (Muryani 2021). As a result, the residents of Gemechis woreda are exposed to high risks of water-related diseases, such as diarrhea, dysentery, cholera, typhoid, and schistosomiasis, which can cause morbidity and mortality, especially among children under five years old (Adnew 2022). Therefore, there is a need to assess the impact of drinking water quality and sanitation practice on public health in Gemechis woreda, and to identify the factors that influence the water quality and sanitation behavior of the local population. This study aims to address the following research questions:

1.3 Objective of the Study

1.3.1 General Objective

To assess the impact of drinking water quality and sanitation practice on public health in Gemechis woreda of West Hararghe zone of Oromia region, Ethiopia.

1.3.2 Specific Objective

The specific objective of this study is.

- ✓ To evaluate the sanitation practice and facilities in the study area and to explore the challenges and factors influencing them.
- ✓ To evaluate Bacteriological water quality of drinking water of the study area.
- ✓ To assess prevalence of waterborne and water related diseases in the study area.

1.4 Research Questions

- What is the status of sanitation practices and facilities in the study area?
- What is the current state of drinking water quality in the area?
- What is the prevalence of waterborne and water related disease?

1.5 Significance of the Study

The study adds knowledge on impacts of poor sanitation practice and water quality on prevalence of water borne and water related disease. the study provides important input for decision makers to evaluate current impacts of WASH interventions on public health status and prevalence of waterborne and water related diseases on overall socio-economic status of the local community. Thus, the findings from the study will benefit to develop protective measure in Gemechis woreda. In addition, the study lays bare other issues that will generate further research into the issue of Water, Sanitation and Hygiene Practices (WASH) and WASH-related diseases.

1.6 Scope of the Study

The research was carried out in Gemechis woreda of West Hararghe, Ethiopia. The study was focus on impact of sanitation practices, status and quality of drinking water on water borne diseases in this woreda. The study was assessing the effectiveness of sanitation interventions and evaluate drinking water quality on water born disease and water related disease, as well as to assess the challenges and factors contributing current level of sanitation practices in the study area. This study will only focus on the rural population of the Woreda and does not include the urban populations.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Water Quality and Sanitations

Safe and adequate water supply is a vital element to preserve human health; however, access to clean water is limited in many developing countries. Furthermore, improved water sources are often contaminated with fecal matters and consumption of unsafe water poses a great public health risk (Nicolas et.al,2016).

Access to clean water and sanitation is a universal need and a basic human right. As a matter of fact, people around the globe face a problem of water scarcity. Today, close to a billion people living in the developing world does not have access to safe and adequate water (UNICEF/WHO 2016). This scarcity of water forced people around the world to use unsafe water for drinking and other domestic uses (WHO, 10 facts about water scarcity 2017). According to world health organization more than 80% of diseases in the world are attributed to unsafe drinking water (WHO, 10 facts about water scarcity 2017). According to world health organization more than 80% of diseases in the world are attributed to unsafe drinking water (WHO, 10 facts about water scarcity 2017).

About a billion people in developing countries have not had a safe and sustainable water supply for several decades (VJ Jadhav, 2018).

Nearly half of the global population does not have access to safe sanitation. Two billion people do not have access to handwashing facilities with soap. Still, 419 million people practice open defecation (UNICEF ,2023).

The prevention of waterborne diseases may include improving access to safe water, improving water quality at the source, treating household water, and storing it safely, improving access to adequate sanitation facilities, and encouraging good hygiene practices, particularly proper hand washing with antiseptic solution. Water sources, such as household connection, public standpipe, and borehole condition, protected dug well, protected spring, and rainwater collection should be safe and accessible. Regular monitoring of drinking water for various

infectious agents should be applied as it will certainly reduce the incidence of waterborne diseases (Ayele and M Hadush, 2018).

In Sub-Saharan Africa, especially in rural areas, there is low basic water and sanitation coverage. Thus, people living in those areas are less likely to have access to improved water and sanitation services and infrastructure (Bockarie Popay, 2022). Improved drinking water sources include public taps or standpipes, tube wells or boreholes, protected dug wells or springs, rainwater collection and piped household water on premises or shared. Improved sanitation facilities include flush/pour flush toilets, piped sewer system, septic tank, pit latrines and composting toilets (WHO/UNICEF, joint Monitoring Programme Progress on Drinking Water, Sanitation and Hygiene 2017).

2.4 billion people around the world lack access to safe drinkable water, 4.2 billion do not have access to safely managed sanitation, while 673 million are still practicing open defecation in 2017 (U. a. WHO, Water Quality and Sanitation 2019). These statistics are worse in Sub-Saharan Africa (SSA) where most countries have less than 40% and 70% access rates to improved sanitation and safe drinkable water, respectively.

In Ethiopia Sanitation practices have a major effect on community and household water issues. In most rural communities, the use of on-site sanitation is a common tradition, which is not hygienic for health (Genet Gedamu, 2019).

2.2 Drinking Water Quality in Rural Area of Ethiopia

Around 31% (95% CI: 30%, 32%) of the population in Ethiopia uses unimproved sources of drinking water with significant spatial variation across the country. Households aged 41–60 [AOR = 0.69; 95%CI; 0.53, 0.89] as compared to the households aged 10–25, households having middle wealth index [AOR = 0.48; 95%CI; 0.40, 0.59], and households having a rich wealth index [AOR = 0.31; 95%CI; 0.25, 0.39] as compared to the poor households, living in high community literacy level [AOR = 0.36; 95%CI; 0.16, 0.80], living in high-level community poverty [AOR = 3.03; 95%CI; 1.32, 6.98], rural residence [AOR = 7.88; 95%CI; 2.74, 22.67] were significant predictors of use of unimproved source of drinking water (Amensisa .H and Mehari .W, 2023).

In Ethiopia, only 57% of households have access to an improved drinking water source, with a higher (93%) proportion among urban residents and a lower (49%) proportion among rural residents. This clearly indicates that there is a wide disparity between urban and rural communities with respect to safe drinking water supply coverage (Motuma Abegaz 2021;WHO/UNICEF 2015). Hence, most rural communities in the country have no access to piped water and improved water sources. Consequently, their primary water sources are mostly developed springs and hand-dug wells, shallow and deep-drilled wells, and ponds (Motuma Abegaz 2021;WHO/UNICEF 2015).

2.3 Sustainability of Rural Water Quality

Enough access to high-quality water is essential for all living things, including humans, animals, and plants. Thus, ensuring a steady and sufficient supply of clean water has a significant impact on people's health, productivity, and quality of life in addition to promoting sustainable socioeconomic growth (Foster 2018).. Water needs to be delivered where and when they are needed to increase access to a clean water supply and meet sanitary demands. Nonetheless, there is a significant global shortage of water supplies and sanitary facilities. There is not much clean water available in the world.

In 2015, 844 million people worldwide lacked access to basic drinking water services, and 2.3 billion people lacked basic sanitation, according to a joint UNICEF and World Health Organization (WHO, access to drinking water quality 2019). Africa and Asia are home to most the world's population who lack access to better sanitation facilities or water supplies. The inefficiency of better rural drinking water supply systems and the greater number of hand pumps in Africa that break down frequently could be two contributing factors (Foster 2018). In sub-Saharan Africa, about one-third of all rural water supply systems are thought to be non-operational at any given moment (Foster 2018). Access to clean drinking water is thus hampered in large part by the unsustainable nature of the water supply.

The population may be exposed to a variety of risks pertaining to socioeconomic activity and health if drinking water access and safety are not guaranteed (Foxwood 2015). For example, according to a joint WHO and UNICEF report from 2017, the absence of access to clean water, sanitary conditions, and good hygiene kills up to 850,000 people annually. Furthermore, diarrheal illnesses claim the lives of around 360,000 children under the age of five. In

addition, waterborne illnesses brought on by inadequate sanitation drive rural populations to spend a large percentage of their meager income on medical care and prescription drugs (Foxwood 2015). The health of women and the education of their children are also heavily impacted by this issue. Girls and women spend a lot of time walking great distances while carrying heavy objects. These activities put a lot of physical pressure on their health and, if they are pregnant, the health of their unborn children. According to WHO and UNICEF (2017), girls spend 200 hours a year on average gathering water, and those who go large distances in the early morning to obtain water either drop out of school or don't attend at all.

The direct financial benefits of preventing diarrheal illnesses include complete health care expenditures, direct costs to the non-health sector, and cost savings from the decreased incidence of diarrheal sickness. The productivity gains from better health as well as the non-health benefits of better access to water and sanitation facilities are examples of the indirect economic benefits.

Table 2. 1 : -Primary and Economic Benefits Associated with Improved sanitation Options.

Improvement	Primary benefits	Economic benefit
closer latrine access	less open defecation	Saved healthcare cost
Improved latrine	Less latrine access time	Improved aesthetic
Population ratio	Intangible user benefit	Increase school participation
	improved health status due to less exposure to pathogens	Value of saved life
	Less use of public latrine	Better living standards
		Rises household income and labor productivity

Source: WSP-EPA, 2018

2.4 Parameters of Drinking Water Quality

There are strict requirements for the quality of water that drink or use in industrial or municipal procedures. For example, the EPA has established legally mandated thresholds for over ninety distinct toxins that are present in water. These restrictions are required to guarantee

that impurities that may harm human health or lead to the emergence of waterborne illnesses do not endanger the safety of drinking water (AOS Treatment Solutions 2024).

Water in industrial facilities occasionally needs to be treated to guarantee that the quality is suitable for a variety of crucial operations. Physical, chemical, and biological parameters are the three elements of water quality parameters that are used to gauge the quality of the water. Color, taste, flavor, temperature, turbidity, solids, and electrical conductivity are among the physical characteristics (AOS Treatment Solutions 2024).

Conversely, chemical parameters can include hardness, dissolved oxygen, pH, acidity, alkalinity, chlorine, and biological oxygen demand. Biological parameters, which include bacteria, algae, and viruses, make up the third category of parameters. Because different applications may have distinct needs, water quality criteria are important (AOS Treatment Solutions 2024).

2.4.1 Biological Parameters of Water Quality

One of the most helpful indicators of water quality may be the presence or lack of living organisms (Nayla Omer 2020;APHA 2017). The biological content of water is measured to monitor the presence of pathogens and microbiological organisms in a municipal water supply. Harmful pathogens can enter the water supply via untreated sewage or naturally from rivers and lakes (AOS Treatment Solutions 2024). Bacteriological quality of drinking water deteriorated from source to point of use in Harari region of eastern Ethiopia. Accordingly, high proportions of households' sampled drinking water contaminated by thermotolerant coliform (Asefa Alemu 2021).

The existence or absence of living things in the water can be one of the most useful indications of its quality. An aquatic body with many well-balanced species is thought to be a healthy system because biologists may survey the fish and insect life in natural waters and evaluate the water quality using a computed species diversity index (SDI). Because of their established tolerance for a particular pollutant, certain species can be employed as indicators of the presence of pollutants (Asefa Alemu 2021). In nature, microorganisms can be found everywhere. In the digestive tract, human bodies sustain a typical population of germs, a significant fraction of which are coliform bacteria. Wastewater contains millions of bacteria

every milliliter, yet most of them are benign. The likelihood of hazardous bacteria in wastewater is only present when it comprises the waste products of diseased individual (Asefa Alemu 2021).

Most of the millions of microorganisms in our drinking water are completely harmless. However, when people have infectious diseases and their bodily waste enters the drinking water system, it becomes vastly more likely that others will get sick (Torrent Laboratory, 2022).

2.4.1.1 Indicator organisms

Coliform bacteria are a significant biological water quality indicator of pollution and drinking water. Humans' intestinal systems are always home to millions of pathogenic coliforms, which are expelled along with bodily waste. As a result, coliforms are invariably present in water that has recently been contaminated with sewage (Worako 2015).

Escherichia coli, or *E. coli*, is a specific type of pathogenic coliform indicator that is discovered in home sewage. They are very likely to be discovered if the water is even marginally contaminated unless the sampled water is contaminated with feces and harmful microorganisms (Omar 2020). Coliform bacteria are more resilient in the water than most other diseases and are aggressive creatures. The significance of coliform bacteria testing in identifying bacteriological water quality status assessments is highlighted in the upcoming section (Tebeje, 2023)

2.4.1.2 Sampling for bacteriological examination

Water samples were collected according to the WHO Guidelines. Suggested sample volumes for membrane filtration to detect fecal coliforms (WHO, 2019). Note that filtering of 0.01 ml of sample is the same as filtering 1 ml of a 1/100 dilution of the original sample (UNICEF 2023). Or drinking water quality assessment (drinking water must be collected aseptically using a sterile bottle and bacteriological analysis should be performed within 6 h of sample collection (Atsibeha Goitom 2016). The samples were collected from hand pumps (264 samples) and springs (26 samples) by trained data collectors that are used directly for drinking purposes in the community (Atsibeha Goitom 2016). When collecting the sample, the interior or mouth of the container and container caps were never touched with fingers, clothing, or unsterile objects. Before taking samples from hand pumps, the hand pump water was flushed

for 2 min and then the mouth of the hand pump was sterilized with a spirit of lamp flame and then cooled by running water (Atsibeha Goitom 2016. Water (200 ml) samples from water sources were collected in 300 ml glass bottles (sterilized by hot air oven at 160°C for 2 h) and transported within 30 min in a cold box to Adigrat University Department of Medical Laboratory Sciences skill laboratory. Samples containing residual chlorine were neutralized by adding 0.2 ml sodium thiosulphate per 200 ml of water sample. The samples were stored at 2°C – 8°C in a dark area to avoid changes in microbial count until analysis. Microbiological investigations were performed within 6 h after collection (Andualem Abate 2014). In addition to that, the contaminant risks of water sources were assessed using the WHO sanitary observation check list for drinking water sources. The sanitary observation check list was used to assess potential risk factors for drinking water sources (Fox wood 2020).

Presumptive coliform test was performed using MacConkey broth (Oxoid). All the tubes contained Durham tubes before sterilization (Foster 2018). The first set of three tubes had 10 ml of sterile double strength broth and the second and the third sets had 10 ml of single strength broth. The three sets of tubes would receive 10 ml, 1 ml and 0.1 ml quantities of water samples using sterile syringes respectively and were incubated for 48 h at 37 °C. Tubes showing gas formation were considered presumptive coliform positive (Foster 2018). The most probable number (MPN) was then estimated from the table for three tube tests. Confirmatory testing was carried out by transferring a loop full of culture from each tube which showed acid and gas in the presumptive test and inoculating it into Brilliant Green Lactose Bile (BGLB) broth (Oxoid) and Escherichia coli (E. coli) medium (Bockarie Popay,2022). The inoculated tubes were incubated at 37 °C for 48 h for total coliforms and 44.5 °C for 24 h for thermotolerant coliforms in water bath. Then, after 24–48 h of incubation, samples were monitored for gas production and standard biochemical testing was performed to identify water contaminants up to genus level (Bockarie Popay,2022).

a. Membrane Filtration

The membrane filtration technique is used to examine water samples from different sources. An appropriate volume of the sample is filtered through a membrane with a pore size of 0.45 mm. The membrane is incubated on an agar plate. Bacterial (and other) cells trapped on the membrane will grow into colonies that can be counted, and a bacterial density can be

calculated. When using the membrane filtration technique to test for the presence of indicator microorganisms, different filtration volumes are suggested depending on the source of the water sample (Tables 2.2 and 2.3) Table 2.2 Suggested sample volumes for membrane filtration to detect total coliforms. Note that filtering of 0.01 ml of sample is the same as filtering 1 ml of a 1/100 dilution of the original sample.

Table 2. 2: - Suggested sample volumes for membrane filtration to detect total coliforms.

Source	100	50	10	1	0.1	0.01	0.001	0.0001
Drinking Water	X							
Swimming Pool	X							
Wells, Springs	X	X	X					
Lakes, Reservoir	X	X	X					
Water Supply Intake			X	X	X			
Bathing Beaches			X	X	X			
River Water				X	X	X	X	
Chlorinated Sewage				X	X	X		
Raw Sewage					X	X	X	X

Source: ES ISO standard 7855-1

Table 2. 3 : - Suggested sample volumes for membrane filtration to detect total coliforms.

Source	100	50	10	1	0.1	0.01	0.001	0.0001
Lakes, reservoirs	X	X						
Wells, springs	X	X						
Water supply intakes		X	X	X				
Natural Bathing waters		X	X	X				
Sewage treatment plant			X	X	X			
Farm ponds, rivers				X	X	X		

Storm water runoff				X	X	X		
Raw sewage					X	X	X	
Feedlot runoff					X	X	X	
Sewage sludge						X	X	X

Note: - that filtering of 0.01 ml of sample is the same as filtering 1 ml of a 1/100 dilution of the original sample.

Source: ES ISO standard 7855-2

It is suggested that duplicate volumes are filtered for drinking water, and three different volumes (or dilutions) are filtered for all other sample sources. The membrane filtration technique exhibits a high degree of reproducibility and may be used to detect other types of organisms when in combination with an appropriate medium. It has the potential of having a very low detection limit, since large volumes of sample can be filtered. However, the turbidity of the sample may limit the volume of sample that is practical to filter. High numbers of background bacteria or toxic substances may interfere with the test and result in underestimation of the density of coliform.

b. Detection of Total Coliforms and Fecal Coliforms

The characteristics that define the total coliform and fecal coliform groups are easily tested in the laboratory using culture media and incubation conditions that are selective for Gram-negative rods and/or differential for lactose fermenters (AOS Treatment Solutions 2017). Growth media that are used include:

Detection of total coliforms – mEndo agar LES This growth medium contains lactose and a pH indicator that changes color when acid is produced (from lactose fermentation). Coliforms

typically will produce metallic (golden) sheen, which is due to the extensive production of aldehydes and acid from the fermentation of lactose. Some total coliforms may also be dark red, mucoid or have a dark center but without a metallic sheen; these are atypical total coliform colonies (AOS Treatment Solutions 2024). *E. coli* will form colonies with a metallic sheen. It is important to note that some non-coliforms may exhibit red colonies. Filters used to detect the presence of total coliforms in a sample of water should be incubated at 35°C for 22 - 24 hours (Motuma Abegaz 2021;WHO/UNICEF 2015).

Detection of fecal coliforms - mFC agar. This growth medium contains bile salts. Enteric bacteria can grow in the presence of bile salts, while others cannot. mFC agar also contains rosolic acid, which inhibits bacteria other than fecal coliforms (AOS Treatment Solutions 2024). Aniline blue, a pH indicator, turns dark blue upon acid production, helping in the identification of lactose-fermenting bacteria. Fecal coliforms form blue colonies on this medium; *E. coli* will form flat dark blue colonies (Motuma Abegaz 2021;WHO/UNICEF 2015). While rosolic acid is commonly used as part of mFC agar, it has been suggested that rosolic acid is not a necessary component of this medium. Filters used to detect the presence of fecal coliforms in a sample of water should be incubated at 44.5° C for 22 – 26 hours.

Either liquid broth or a solid medium may be used for these assays. Solid media are commonly used and are specified in this protocol. When reporting total and fecal coliforms in water samples, it is standard to use colony-forming units (CFU)/100 ml of sample (Motuma Abegaz 2021;WHO/UNICEF 2015).

c. Safety

The ASM advocates that students must successfully demonstrate the ability to explain and practice safe laboratory techniques. Care should be taken while working near a Bunsen burner. Ethanol and nitrocellulose membranes are flammable (Bockarie Popay,2022). Proper laboratory procedures should be followed when working with materials that may harbor microorganisms (Bockarie Popay,2022).

It is recommended that the dilutions (step 1) be performed. Otherwise, it may become difficult to determine the accurate cell density of coliforms present in water samples. Demonstration

that some bacteria in water can, indeed pass through a 0.45 µm pore-size filter can readily be demonstrated. Simply remove 5 – 10 mL of filtrate from the catchment vessel and inoculate a flask or test tube with a general-purpose liquid growth medium, such as tryptic soy broth. Incubate the inoculated media at 35°C for 24 to 48 hours (Bockarie Popay,2022). The growth medium will be turbid, indicating that small but viable bacterial cells passed through the filter. A smaller pore-size filter (0.22 µm) is typically used to “filter-sterilize” water samples.

d. Frequency of sampling

Sampling should be regular, and its frequency should be mainly depending on the following factor.

- Quality of the water harnessed.
- Type of treatment for drinking worthiness.
- Background of public water supply network and Number of people served.

Table 2. 4: -Minimum sampling frequencies for drinking water in the distribution system.

Population served	Samples to be taken monthly
Less than 5,000	1 Sample
5,000-100,000	1 Sample per 5,000 Population
Mor than 100,0000	1 Sample per 10,000 Population plus 10 additional samples

Collection, transportation, and storage for samples shall be in accordance with ES ISO 5667-

e. Bacteriological requirements

When tested with corresponding test method, the bacteriological requirements of treated drinking water shall not exceed the levels shown.

Table 2. 5: - Bacteriological levels

Organism	Maximum permissible level	Tested method
Total viable organisms, colonies per ml	Must not be detectable	ES ISO 4833
Fecal streptococci per 100ml	Must not be detectable	ES ISO 7899-1 ES ISO 7899-2
Coliform organism, number per 10ml	Must not be detectable	ES ISO 9308-1
E. coli, number per 100ml	Must not be detectable	ES ISO 9308-1 ES ISO 9308-2

2.5 Community Perception on Drinking Water Quality

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,2010 and Doira,2019) 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 (Doria, 2019). In schools and in some public places, we are getting familiar with a slogan which states “water is life” it is true. Without Water which any living things cannot exist, but it would have been better if the slogan is replaced” clean water is life”; because we have learnt that everyday many peoples are dying because of water borne and water related diseases (JMP, 2016). 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 (Doria, 2019).

Water qualities degradation may be caused by point or nonpoint source pollutants; point source pollutants are being identified as all dry weather pollutants that enter water sources through pipe or channels (Weiner 2013). Ground water pollutants can originate, for example, from wastewater stabilization ponds, sludge lagoons, barnyard runoff, septic tank leaching fields and the deep well disposal of certain industrial wastes or treatment plant effluents (Zanon 2020) Surface water is often contaminated through the release of industrial and domestic effluents directly into pond, dug well, lakes and rivers; from pesticide run-off from fields (UNICEF 2018) Storm drainage, even though the water may enter watercourses by way of pipes or channels, is considered nonpoint source pollution (Weiner, 2013).

Other nonpoint source pollution comes from agricultural runoff, construction sites, and other land disturbances may affect the quality of water (Weiner, 20013). Discharges from industrial premises and sewage treatment works are point sources and as such are more readily identifiable and controlled; run off from agricultural land and from hard surfaces, such as roads, are not so obvious, or easily controlled (Fawell ,2013).

Manufacturing industries like chemical, oil refining, steel etc. contribute many of the most highly toxic pollutants, including a variety of organic chemicals and heavy metals (Mc Kinney, 2007). Sediments and suspended solids consist of mostly inorganic material washed into a stream because of land cultivation, construction, demolition, and mining operations (Weiner, 20013). There are also various micro-biological agents that include bacteria, viruses and protozoa which can also cause water pollution and may cause various water-borne diseases (WHO, 2020).

2.6 Microbial Factor of Water Quality Degradation

The contamination of drinking water by pathogens causing diarrheal disease is the most important aspect of drinking water quality (Hunter 2017). The problem arises because of contamination of water by fecal matter, particularly human fecal matter, containing pathogenic organisms. In many parts of the developing world, it remains a major cause of disease (Chorus, 2019). It is therefore essential to break the fecal–oral cycle by preventing fecal matter from entering water sources and/or by treating drinking water to kill the pathogens. However, these approaches need to operate alongside hygiene practices such as hand washing, which reduce the level of person-to-person infection (Fawel, 20017).

i. The coliform group

The coliform group is made up of bacteria with defined biochemical and growth characteristics that are used to identify bacteria that are related to fecal contaminants (Weiner, 2015). The Total Coliform represent the whole group and are bacteria that multiply at 37°C. The thermos tolerant coliforms are bacteria that grow at a higher temperature 44.2°C and *Escherichia coli* is a thermos tolerant species that is specifically of fecal origin (Weiner, 2015).

Microbiological testing of water is commonly done by using total coli forms or thermos tolerant fecal coli forms (from here on referred to as fecal coliforms) as indicator species; both types are found in the intestines and feces of warm-blooded animals (Weiner, 2018). Total coliforms also naturally exist in plant material and soil, and their presence in water does thus not provide conclusive evidence of fecal contamination. Fecal coliforms are safer indicators as they are more exclusively found in intestines and feces, but they include one genus (*Klebsiella*) that can also come from non-fecal sources (Weiner, 2018).

According to (Hurst *et.al*, 2016) states the health hazards which caused by pathogens are divided into four categories based upon the source of the pathogen spread and the route by which human recipients encounter that pathogen. Those categories could be defined as follows:

- Water-borne diseases, infections spread through water supplies: e.g. Cholera, Typhoid, infectious hepatitis
- Water-washed diseases, diseases due to lack of water for personal hygiene: e.g., skin and eye infections (Scabies, Trachoma)
- Water-based disease, infections transmitted through an aquatic intermediate animal e.g., Schistosomiasis.
- Water related insect vectors, infections spread by insects that depend on water: e.g., Malaria, Yellow fever, Trypanosomiasis (Hurst *et al.*, 2002).

2.7 Sanitation and Hygiene in Rural Area

With around the world 52 million people living without sanitation provision (UNDP ,2014) Ethiopia has one of the lowest rates of sanitation in the world. In rural areas most people still practice open defecation, a tradition that has remained widespread through a lack of hygiene awareness and technical knowledge on the part of villagers, and in adequate policy, investment, and implementation on the part of the government (Water Aid, 2015).

Although less people are living in urban centers, urbanization is rapidly growing indicating the need to work more in urban sanitation. The nationwide access to sanitation is extremely very low 6% as compared to 43% of African average (ADB, 2015).

Ethiopia's Health policy (2015) gives priority to disease prevention through the provision of safe water and sanitation to the public. To accelerate the attainment of better socioeconomic and health of the population, the Government of Ethiopia and its partners in the private sector and civil society are implementing the Plan of Action for Sustainable Development of End Poverty (PASDEP). The Water Supply, Sanitation and Hygiene sector has gone few steps to support PASDEP.

The National water Supply and Sanitation program of the Government of Ethiopia has set targets to increase rural water supply coverage to 71 % and rural sanitation coverage to 24 %.

The targets have been brought in line with the MDG targets of reducing by half the proportion of people lacking access to adequate water and sanitation services. The MDG targets aim to increase the rural water supply coverage from 24% in 2004 to 62% by 2015 and rural sanitation coverage from 8% in 2004 to 54% by 2015. These figures are still lower from the African Development Fund's Rural Water Supply and Sanitation Indicator targets which seek to achieve 80% for both rural water supply and sanitation by 2015 (ADB, 2005). Absence of basic sanitation and hygienic practices are associated with high morbidity and mortality from excreta related diseases (WHO, 2018). Water may be contaminated with pathogens at the source, but contamination may also occur during distribution, transportation, or handling in households or other working places (Lechevallier, 2014). Diseases caused by contaminated water consumption and poor hygiene practices are the leading causes of death among children worldwide (WHO, 2014). Statistics on wastewater treatment revealed that almost 85% of global wastewater is discharged without treatment leading to serious impacts on public health and the receiving water environmental (WHO, 2016). According to the study (Clasen, 2015) treating water at the point of use can result in a 35% reduction in diarrheal disease. Inadequate protection of water collection and storage containers and unhygienic conditions contribute to contamination at home (Nath *et.al*, 2016). There are significant disparities between rural and urban areas regarding sanitation (WHO/ UNICEF, 2020). Rural areas continue to have a lower percentage of population using improved sanitation and a higher number of people without improved facilities. Of the approximately 1.3 billion people who gained access to improved sanitation during the period 1990-2014, 64% live in urban areas (WHO/UNICEF, 2015). However urban areas, though better served than rural areas, are struggling to keep up with the growth of the urban population (WHO/ UNICEF, 2010). estimated that water, sanitation, and hygiene was responsible for 4.0 % of all deaths and 5.7 % of the total disease burden occurring worldwide accounting for diarrheal diseases, schistosomiasis, trachoma, ascariasis, trichiniasis and hookworm disease(Pruss *et.al*,2011). Waterborne diseases also inflict significant economic burden through the loss of productivity in the workforce and through increasing national health care cost (Elimelech, 2016) However, removing fecal safely from the environment eliminates the main source of water pollution. The proper use and maintenance of water facilities and the hygienic transport and storage of water protects the water supply chain from fecal contamination (UNICEF, 2008).

2.8 Reasons for Poor Sanitation

2.8.1 Economic Reason

According to Mc Conville, (2018) each day two million children die because of diarrheal disease which its main source is human excreta. Thus, human waste is potentially dangerous material which needs to be managed properly. But there are some factors which may prohibit people from adopting latrine services, of which economic reason is to be listed as the main and the first (Mc Conville,2018). Poor people rely on subsistence income, of their income they prefer to spend on food and goods, then spending it on latrine construction (Elimelech, 2016). Of course, it could be expensive to build a latrine; if people understand having latrine is beneficial, they may not be able and willing to spend high cost on it. Though economic status inhibits people to build their own latrines, on the other hand this shows that, people do not realize the costs they spend on treating diseases cause of unsanitary environment, which the costs for curing might be higher than preventing (Elimelech, 2016). Thus, if people had aware of the consequences of unhealthy environment, the costs to prevent its consequences like diarrheal diseases would be the easiest than treating the diseases. So, investing on latrine is also a means of minimizing expenses of medication comes after unhealthy living environment because of poor sanitation;(Mc conville,2018).

2.8.2 Socio Cultural Reason

There are also socio-cultural reasons why people do not adopt latrine use; dirty and clean can vary from culture to culture". Many people latrines as evil and view dirty places. As a result, people may prefer to defecate away from their houses in the fields which are considered more sanitary. Of course, it might be difficult to change long ingrained behavior dictating defecation practices; without proper support people will revert to old habits.

The practice of open defecation is ritualized and bound in tradition; (Mc conville,2018). Both the economic and socio-cultural reasons for unimproved sanitation do not outweigh the costs of the consequences because of unimproved water and sanitation. In addition to the above reasons the study conducted in three African countries: Zambia, South Africa, and Zimbabwe; illiteracy, lack of strong linkages between sanitation service providing agencies and communities, supply-led approach in providing sanitation service, and lack of effective

communication between the local authorities and the communities are found to be some of the causes for poor sanitation (Manas., 2021).

2.9 Prevalence of Waterborne and Water Related Diseases

Waterborne and water-related diseases pose a significant threat to public health worldwide. Each year, millions of people suffer from illnesses caused by poor water quality and inadequate sanitation, with most of these cases occurring in developing countries (Hetal 2021). Incidents of enteric diseases, such as diarrhea and cholera, are particularly prevalent in these regions, with children in poorer populations being the most vulnerable to these diseases. According to the World Health Organization, approximately two million deaths occur each year because of waterborne diseases, with individuals under the age of 5 being the most affected (Ali ,2020).

Additionally, in urban areas with deficient sewage disposal systems, inadequate housing, and precarious water supply and sanitation infrastructure, the potential for waterborne disease transmission is greatly increased (Zeilhofer, 2017). In sub-Saharan Africa, where a large proportion of the population relies on unsafe drinking water sources, waterborne diseases are a significant cause of morbidity and mortality, especially among children (Birhan, 2022).

In developed countries, waterborne diseases are still a concern. For example, in the United States alone, tens of thousands of cases of waterborne diseases are reported each year, resulting in hospitalizations and deaths (Kincaid, 2022). This highlights the global prevalence of waterborne diseases and emphasizes the need for improved water quality and sanitation measures to reduce the risk of these illnesses.

The prevalence of waterborne and water-related diseases is a global concern, affecting both developed and developing countries (Wei, 2018).

According to various sources, waterborne diseases cause millions of deaths and cases of illnesses every year (Wei, 2018). Waterborne disease is estimated to cause more than 2 .2. million deaths annually and millions of cases of illness, including diarrhea, gastrointestinal diseases, and other systemic illnesses.

CHAPTER THREE

3. MATERIAL AND METHODOLOGY

3.1. Description of the Study Area

Gamachis Woreda is one of the Districts in the Oromia Regional State of Ethiopia. The Gemechis woreda's capital is now known as Kuni. Chiro is 20 km away from. Situated atop a hill, the city experiences a 70% overcast and cold climate. Numerous tiny cities spread out between 20 and 45 miles throughout Gemechis woreda. The main ones are Sogido, Sire, Metadhab, and Degaga. is roughly 17 kilometers south of Chiro, the zone's major town, and 343 miles east of Addis Ababa. Commuting transportation is one of the woreda's main issues. This woreda had a total population of 184,238 according to the 2007(EC) national census, with 93,766 men and 90,472 women; 3,863 people, or 2.1% of the total, lived in urban areas.

The Bureau of Agriculture and Rural Development states that the main sources of income are from agriculture, which includes the cultivation of sweat potatoes, haricot beans, chat, cattle, sheep, and corn, as well as small-scale trading, labor, and carpentry.

Gemechis district is situated at the coordinate between 8° 40'0" and 9° 04'0" N and 4° 50'0" and 41° 12'0" E.

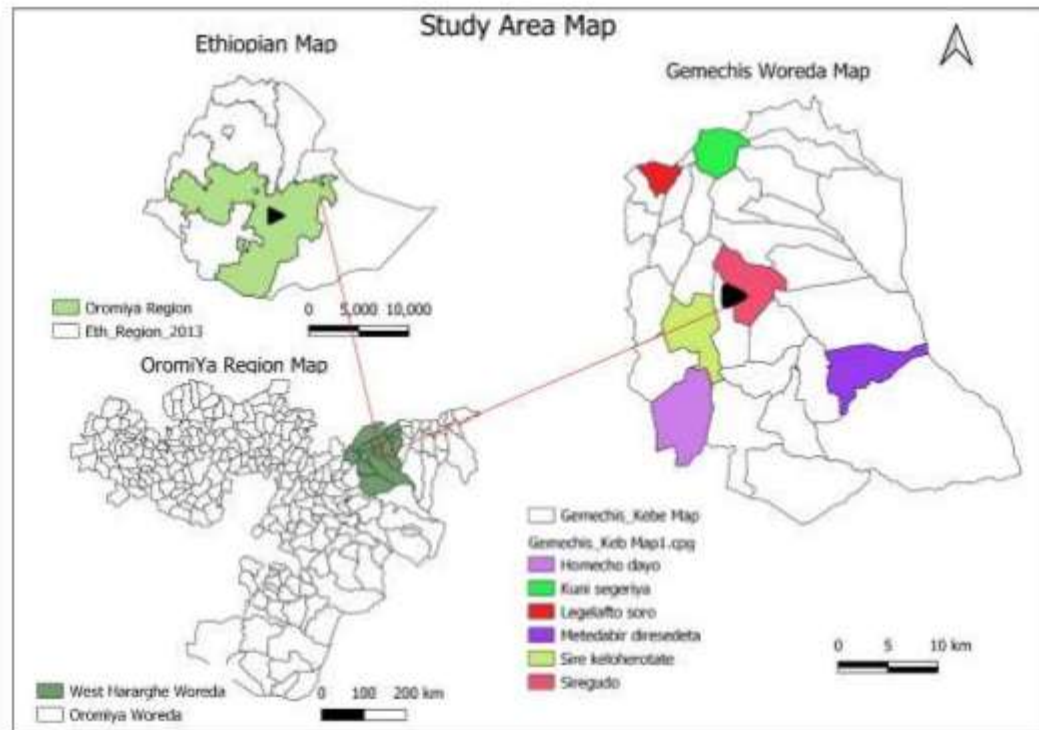


Figure 3. 1:- map of the study area

3.2 Existing drinking water and Sanitation in Gemechis Woreda

According to the Gemechis Woreda Water Resource Office information; most of the drinking water sources comes from HDW fitted with Hand Pump, Shallow well fitted with Hand Pump and Deep well motorized. The adequacy and accessibility of drinking water still 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, deep well, and Shallow well. Most of the communities in study area were used Local ponds as an alternative water source for bathing, washing clothes, livestock drinking. Was significant shortage of safe drinking water that translates into high prevalence of water borne and related diseases and high incidence of Cholera. From the total number of schemes constructed in the Woreda about one third of schemes were not functional due to unavailability of spare parts and deterioration of aesthetic quality of the three waters.

3.3 Sampling Procedure

3.3.1 Study Design and sampling procedures

Between February and May 2023, a bacterial laboratory examination was carried out in specific Gemechis woreda areas, and by May of the same year, a community-based cross-sectional study known as the HHs survey was completed.

From the 35 total rural and one urban kebele in Gemechis woreda, four rural study kebeles were chosen by purposive sampling method to determine the number of selected HHs and water schemes. These kebeles were given priority to be selected as sample kebeles because they had all types of existing water schemes used for sanitary and drinking purposes. Seasonal water scarcity, shortage of water availability, and poor accessibility of water for sanitary and hygiene were also given priority. As a result, Harotate, Kuni Sagariya, Kase Ija, and Walargi Kebeles were the four chosen kebeles.

3.3 Data Collection

3.3.1 Water Samples Collection Procedure

For the study area the 11 water schemes were collected by showed in the fig 3.2: schematic illustration of sampling.

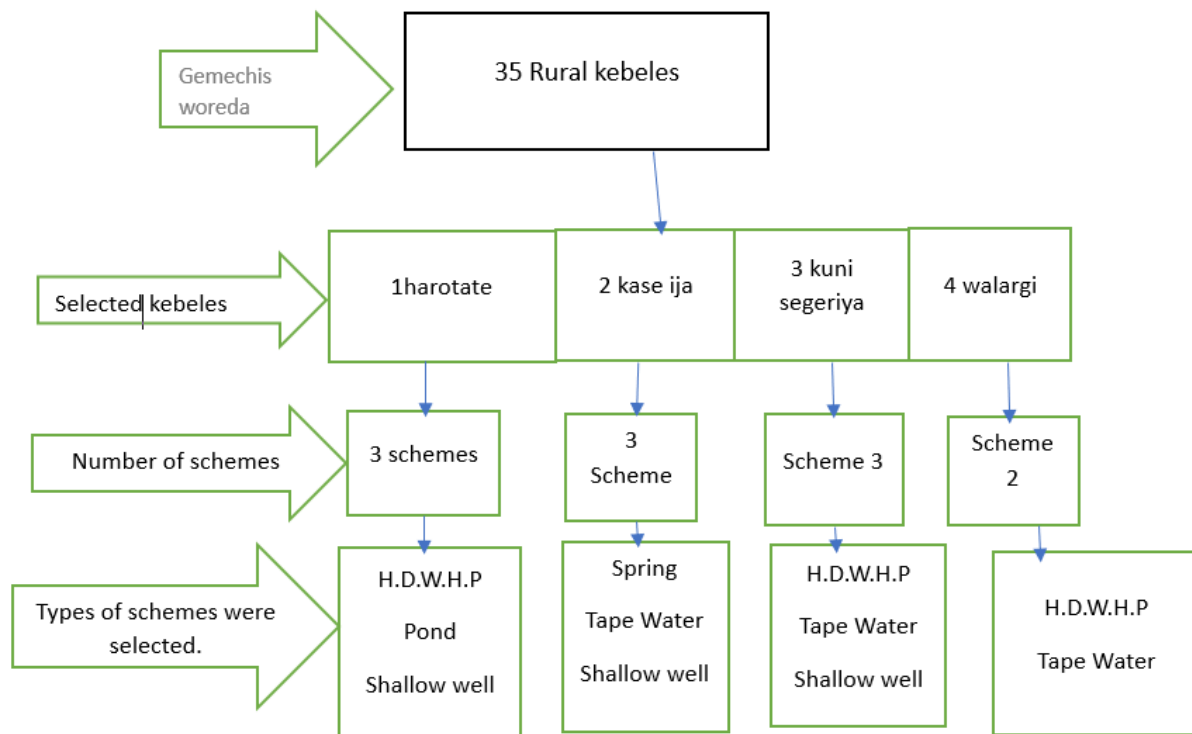


Figure 3. 2: -Schematic illustration of sampling technique.

Primary and secondary data were both employed in the study. Every month, primary data on water quality was gathered by laboratory testing of water samples obtained from four investigated kebeles, representing several various water schemes. To determine the mean outcome of the values, a sample was obtained by replication three times out of the eleven schemes that were chosen.

Trained laboratory professionals collected water samples in glass bottles that had been sanitized from each water source. Standardized methods for collecting drinking water samples were used to gather the samples. Before being analyzed in a lab, the collected water samples were transported in an ice box and maintained at 40 degrees Celsius. Prior to analysis, the necessary lab apparatus and culture media were sterilized. Membrane filtration was chosen over alternative methods because it was readily available, time-saving, and appropriate for testing. Then all obtained water samples were incubated at 44°C (for total coliform) and 37°C (for fecal coliform) for 18-24 hours at west Hararghe zonal health office laboratory.

3.3.1.1 Sample Size Determination

Before the investigation to establish sample, size can start, the researchers must select how much statistical power they are willing to tolerate for the study. The term "effective size" refers to the actual difference detected in a study between groups, or the strength of the connections observed between variables. (WHO, 2016) recommended using a population-based sampling strategy to obtain the bare minimum of samples for drinking water microbiological testing in the water scheme. Thus, we have gathered 33 samples from eleven schemes for Gemechis woreda, which has a population of 184,238. The sample size for this woreda was 28 samples $(184,238/10000) + 10$ plus an additional 5 water samples to address all selected water schemes by three rounds. The total number of samples for water quality was 42, after an additional 9 samples were added for end users.

3.3.2 Respondents Sample Size Determination

$$n' = \frac{z^2 pq}{d^2} \quad n' = z^2 pq d^2 \quad (3.1)$$

$$n = n'1 + n' - 1N \quad (3.2)$$

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

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

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

q = $1 - 0.05$ i.e. (0.95), N = total No of population for each kebele

d = margin of error or degree of accuracy (0.05). Since the population (HHs) of the Kebeles would have been involved in the study are less than 10,000 in number i.e. harotate (878), kuni sagariya (859), kase ija (980) and walargi (782); both equations (3.1 & 3.2) are used to determine sample size required in this study as follow:

$$n' = z^2 pq d^2 \quad n' = \frac{z^2 pq}{d^2} \quad = (1.95)^2 \times (0.05) \times (0.95) / (0.05)^2 = 72.99. \quad \text{Then}$$

$$n = n'1 + n' - 1N$$

$$= 72.99 / (1 + (72.99 - 1) / \text{no of population}) =$$

68, 67, 68 and, 67 HHs

□ Therefore, Sample size required (n) in the study was **270 HHs**.

The total size of respondent of each kebele were determined by using proportionate random sampling method based on household number of the kebele to give equal chance for all household in each sample kebele. as shown in figure 3.3.

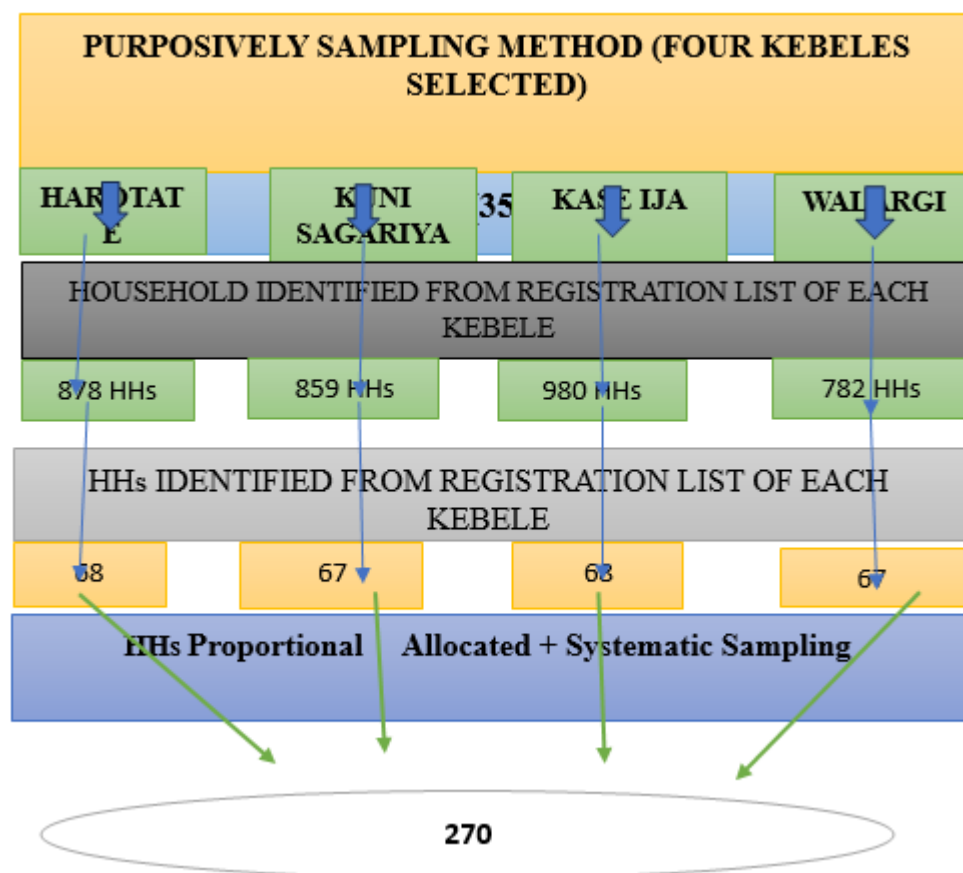


Figure 3. 3:- Diagram indicating how to fix size of respondent households.

3.4 Data Analyze

3.4.1 Bacteriological Analysis

Every medium was ready in accordance with the manufacturer's guidelines. First, Petri plates and test tubes were cleaned. To prepare them for pouring, petri dishes were dried and sterilized at 1800C for one to three hours. The components for each broth and agar media were combined with distilled water. After the mixes in the test tubes and the flask were autoclaved for 15 minutes at 1210C, 15-20ml of the flask's sterilized medium was aseptically poured onto each Petri dish and allowed to harden when the temperature dropped below 600C. To check for potential contamination, the media were finally placed on the table for 24 hours at ambient temperature (APHA, 2018).

According to the instructions provided by the manufacturer, every medium was prepared. Test tubes and Petri plates were first cleaned. Petri dishes were dried and sterilized at 1800C for one to three hours to get them ready for pouring. Distilled water was mixed with each broth and agar medium's ingredients. 15-20 ml of the sterilized medium from the flask was aseptically placed onto each Petri dish and left to solidify after the temperature dropped below 600C. This was done after the mixtures in the test tubes and the flask were autoclaved for 15 minutes at 1210C. Finally, the media were left on the table for a full day at room temperature to look for any signs of contamination (APHA, 2018).

EMB Medias were utilized to categorize bacteria according on the characteristics of their colonies. Using the filter membrane technique, the samples' outcomes were examined by counting the colonies per 100 milliliters after the membrane was incubated on a growth-promoting medium. Lastly, the WHO guidelines were compared with the average value of each parameter's results.

3.4.2 Sampling procedure

After donning latex gloves on the hands, a 200 ml sterile plastic bag was utilized to collect the sample directly from the source. After sterilizing the 45µm pore size filter unit with fire and alcohol, the water samples were filtered using the filter unit that included the filter membrane. Bacteria have been grown using M-Coli Blue 24 broth Ampoules as a medium (nutrient). Up

until the material is brought to the camp and utilized in another incubation unit called Pot lab, an ELE Paqualab 25 incubation unit has been used at the site. The latter incubation unit includes two compartments where the Petri dish can be placed and the temperature may be controlled independently to 37 and 44°C. The previous incubation unit only has one temperature adjustment option to grow bacteria: either 37°C or 44°C. Before opening the samples and checking for bacterial growth, they were incubated for a full day.

3.4.3 interpretation

The WHO and National (Ethiopian Drinking Water Standard) norms and guidelines have been compared with the analysis's findings. Protected water sources should normally be devoid of germs that indicate pollution, especially faecal coliform, which indicates contamination from human or animal waste. Selected sample locations for total and faecal coliform have been tested for this investigation. Furthermore, analyses have been conducted on sources and private outlet tap for total and faecal coliform.

3.5 Data Evaluated

Using SPSS software, sanitation practices and facility, challenges, and factors of the study area's sanitation practices were evaluated. Information about hygienic circumstances encompasses hand washing following urine, latrine availability, and latrine management. Age, sex, household size, and income of respondents are examples of socioeconomic statistics. When applicable, tables and graphs were employed to show and discuss the results of each objective. Additionally, utilizing statistics from the Zonal and Warda Health Offices, the prevalence of water-borne and water-related diseases was examined.

3.6 Determination of The Prevalence of Water Borne Diseases

Poor hygiene or exposure to tainted water are the main causes of waterborne and water-related diseases. gather and examine information on the number of cases, the kinds of pathogens, the water sources, and the infection risk factors to ascertain the prevalence of these diseases. Additionally, I have compared the statistics to the size of the population and the anticipated background rates of illness.

3.6.1 Sample size calculation and sampling procedure

To determine the final units of observation, the survey used a random sampling method: seniors (20 years of age and over) and their wives, regardless of age. Choosing rural villages was part of the second phase. households were selected from selected villages in the third stage. The eligible participants in this study are those who are 20-60 years old. The outcome variable (water borne diseases) was binary in nature i.e., water borne diseases coded as no and yes. The variable was generated using the question “has any health professional diagnosed you with diarrhea/gastroenteritis or typhoid or Amoeba in last two years. Additionally, we have gathered data from Gemechis Woreda Health Office.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 Background of the respondent

From a total of 270 household heads interviewed, (66.9%) of them were males and (33.1%) of them were females. The maximum age of respondents was 52 and the minimum age of the respondent was 20. The minimum and maximum household size 3 and 6 members respectively. The occupational situation of the respondents 155 (67.0%) were farmer, 61 (22.4%) warehousewomen, 54 (10.6%) were daily laborer and merchants. (appendix).

4.2 Accessibility of Water Supply

4.2.1 Sources of Drinking Water in the Study Area

The majority of research participants (31.6%) get their drinking water from shallow wells, which the majority of the population in the study area used for various purposes, including drinking. H.D.W.H. P. residents made up the second-highest percentage of the population in the area (29.4%). Public bono (16.0%) is exclusively used for drinking, which is safe for their health and happiness. For drinking and household needs, very few respondents use the nearby pond and natural spring (16.0% and 6.0%, respectively).

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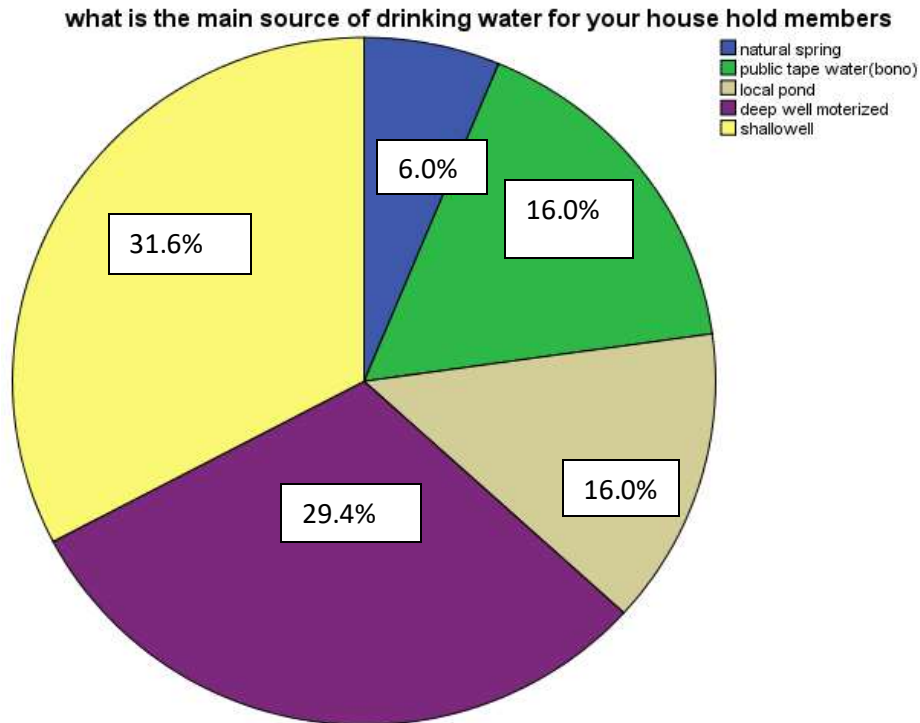


Figure 4.1:- source of drinking water in the study area

Among the four kebele chosen for this study, Walargi Kebele was found to have only a hand-dug well, a small pond, and shallow wells in the analyzed area. Unfortunately, the majority of the hand-dug wells in this kebele were not functioning due to structural failures and watercolor issues. Additionally, the residents of this kebele obtain their water from nearby kuni sagariya and kase ija kebeles; neither public nor private tape water is available here. Among research area kuni sagariya kebele had better drinking water source; those were natural spring, Bono, and deep well motorized water sources.

Compared to Walargi Kebele, Harotate and Kase Ija Kebele had slightly better sources of drinking water. They use public tape water sources, shallow wells excavated by hand, and manually dug wells.

The sources of better drinking water are divided into six categories by WHO and UNICEF (2019): protected dug wells, protected springs, boreholes, public standpipes, and piped domestic water connections. Unprotected springs, surface water, and unprotected drilled wells are the sources of unimproved drinking water.

The researcher learned through a house-to-house survey that none of the residents in the neighborhood had access to surface water sources like rivers and lakes or private tap water. Consequently, the researcher conducted an examination and found that the majority of people (64.8%) utilize contaminated water from local ponds, shallow wells, and natural springs; on rare occasions, public water systems malfunction owing to electrical system failure, scheme breakdowns, or inadequate maintenance.

4.3 Amount of Water Consumption in the Study Area Person per Day

The daily water usage of each inhabitant in the research area the amount of water consumed was calculated by dividing the number of family members living in each household by the amount of water that was fetched in a day (measured in liters). According to this study, the quantity of water utilized in different communities varies depending on factors such as family size, water availability, economic standing, and time of year.

The study area's home water usage ranges from 3.63 to 18.7 liters per person per day, with an average of 9.57 ± 3.08 liters per person per day. It was discovered in the study that HHs utilized the least amount of water—3.63 l/c/day—in Kebeles Walargi Kebele. However, Kuni Sagariya Kebele was found to utilize the most water, at around 18.7 l/c/day, as indicated in Table 4.1. The majority of those surveyed in Walargi Kebele stated that "it was very difficult to fetch water because there were few facilities and it was far from the source, so the little water collected was used sparingly".

Table 4. 1: Water used in liters per person per day (Mean $\pm$ SD and Range)

Sample Kebeles	Mean $\pm$ SD (liter)	Range (liter)
Harotate (n = 67)	9.48 ± 2.44	3.625 – 15
Kunisagariya (n = 68)	9.74 ± 2.68	6.25 – 15
Kase ija (n = 68)	8.81 ± 3.52	4.8 – 18
Walargi (n = 67)	10.27 ± 3.63	6.2 – 18.7
Total (n = 270)	9.57 ± 3.08	3.625 – 18.7

n indicates the number of respondents in each kebele |

The likelihood of collecting more water for larger households than for individual households increases with household size. However, when household size increases, the amount of water

consumed per capita decreases due to issues with adequate and accessible water supplies. while considering the resources required to satisfy the demands of a big family, such as water for washing, cooking, and drinking (WHO,20015).

All kebeles combined consumed 9.57 l/c/d on average, which was less than the advised water consumption standard.

4.4 Treatment of Unsafe Water before Consumption

According to this survey, the majority of households in all kebeles cleanse their contaminated drinking water by traditional method for utilizing it. The standard for drinking water is not met by this. These primary treatment techniques were applied to local ponds, shallow dug wells, and natural springs, but not to tape water or natural springs. Filtration and boiling were the primary ways of treatment, according to Kebeles, the study's respondent.

The percentage of respondents that utilized water treatment is displayed in the table below. Of the total respondents, (32.4%) used boiling, (32.0%) used filtration, and (35.7%) did not use any treatment

Table 4. 2: -Treatment of unsafe water

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	by filtration	88	24.2	32.4	32.4
	By boiling.	87	24.0	32.0	64.3
	chlorination	-	-	-	-
	not applicable	97	26.7	35.7	100
	Total	270	74.9	100.0	
Missing	System	00	0.0		
Total		270	100.0		

However, chlorination treatment was used by six month only in tape water at the distribution site by government. The awareness of the household using treatments of unsafe drinking water were very low, so it needs to give awareness to the whole community.

4.5 Sanitation and Hygienic Practice among Household in the Study Area

Nearly eighty-four (83.8%) of household had latrine facility, of which (52.6%) was pit latrine without slab followed by (40.8%) and (6.6%) had pit latrine with slab. (93.0%) had privately owned. Of the household having latrine only 57(21.0%) use latrine for disposal of child feces.

Good hygiene practices (especially handwashing with soap after defecating and before preparing food, and safe disposal of children's faecalis) prevent diarrhea (UNICEF,2008). It has been reported that faecalis that is not properly disposed put household members at risk of diarrhea (Tumwine et al.,2003). Disposal of solid and liquid wastes in open field is a usual activity in the study area. During researcher stay area, observed the people they were disposing different type of wastes in elsewhere.

Table 4. 3 : Sanitation and hygienic practice among households in rural kebeles of study area.

Characteristics	Frequency	Percent
Availability Of Laterine(N=270)		
Yes	228	84.4%
No	42	15.6%
Types Of Laterine(N=228)		
Pit Laterine With Slab	0	
With Out Slab	110	48.2%
Open Pit	118	51.8%
Ownership Of Laterine (N=228)		
Private	212	92.9%
Shared	16	7.1%
Laterine Utilization (N=228)		
Proper	65	28.5%
Improper	163	71.5%
Disposl System Of Feaces Of Children (N=228)		
Proper	50	21.9%
Improper	178	78.1%
Hand Washings Facilities (N=228)		
Yes	47	20.6%
No	181	
Soap Near To Hand Washing Facilities (N=47)		
Yes	30	63.83%
No	17	36.2%
Hand Washing Practive(N=228)		
Good	44	19.3%
Poor	184	80.7%

4.6 Current Condition of Latrine

According to this survey, of the sample respondents, 228 (84.4%) had a latrine; of these, 141 (62.0%) had a covered latrine with a wall and roof, and 87 (38.0%) had no covered toilet at all. There are 228 respondents who have pit latrines; 61 (26.66%) of them had no cover, 110 (48.33%) had a cover simply, and 57 (25%) had a cover wall and roof.

4.7 Prevalence of Water Born, and Water Related Disease

According to statistics from the woreda and zonal health offices (2011–2014 E.C.), cholera, typhoid, and amoeba are among the water-borne and water-related diseases that commonly occur in the study area. It was frequently out of control because of tainted drinking water, a subpar sewage system, and according to HHs survey results, cholera was the most common

water-borne disease that frequently occurred (58.1%). This indicates that cholera can be contracted through consuming contaminated food or water. If waste and drinking water are not properly treated, this disease can spread quickly. This finding (15.4% typhoid) indicates that people are using contaminated toilets and touching their mouths before washing their hands. Amoeba infections occur in 26.5% of cases when food or water tainted with parasites is consumed.

Table 4. 4: The common water born disease that frequently occur in the study.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cholera	158	43.5	58.1	58.1
	Typhoid	42	11.6	15.4	73.5
	Amoeba	70	19.8	26.5	100.0
	Total	270	74.9	100.0	
Missing	System	00	0		
Total		270	100.0		

4.8. Bacteriological Test Analyses

4.8.1 Fecal Coliform

Fecal coliform in the study area had an average value of 1.18 ± 1.77 cfu/100ml, with a range of 0 to 5 cfu/100ml. Fecal coliform concentrations (5 cfu/100 ml) were highest in the Harotate Kebele from Local Pond. Kebeles in which there was no detectable fecal coliform in the public bono tape water or any other kebele source were contaminated. Every sample in the Walargi Kebeles and Kase Ija has 0% fecal coliform. The average fecal coliform values from the sample Kebeles group were 0.00 cfu/100 ml, 1.5 cfu/100 ml, 3.33 cfu/100 ml, and 0.00 cfu/100 ml from Kase ija, Walargi, Harotate, and Kuni Sagariya Kebele, respectively. The average fecal coliform value in the research area was 1.18 ± 1.17 cfu/100 ml, exceeding the WHO's (2008) acceptable value recommendation.

There are no bacterial issues in Walargi or Kase Ija, two of the four kebele water sources. However, drinking water from either of the two water sources—Kuni sagariya or Harotate—is not recommended. This suggests that the water sources at Kuni Sagariya and Harotate require quick attention.

4.8.2 Total Coliform

Total coliforms have a range of 0 to 74 cfu/100 ml; the table indicates that the average value was 16.54 cfu/100 ml. The Harotate Kebele had the highest total coliform number (74 cfu/100 ml). Kase Ija from a shallow well with a hand pump, Walargi from a shallow well with a hand pump, and public bono tape water are the Kebeles where total coliform was not detected. The average total coliform value in the research area exceeded the WHO's (2018) recommended value for water quality. The majority of the water sources that were contaminated with total coliform, according to the study's findings, were open water sources including a nearby pond and a Shallo well that required a manual pump. In the research Kebeles, there was an increase in total coliform that was linked to soil particles and human waste getting into exposed water sources. The problem was caused by uncontrolled parameters, poor sanitation, and a low level of cleanliness.

As to the WHO (2018) study, it is unlikely for total coliform to re-grow in the distribution system unless there is an adequate supply of bacterial nutrients, the water temperature is higher than 15°C, and there is no leftover free chlorine (WHO, 2003). By keeping the adjacent area clean and closing off the sources from contaminated surface water intrusion, groundwater supplies are safeguarded (UNICEF, 2008).

Table 4.5 : The mean value of Bacteriological water parameter of the study area

Kebele (Water source)	Mean values		WHO?	EPA, USA
	FCF cfu/100ml	Total coliform	Standard (2008)	Standard (2009)
			Fecal coliform	Total coliform
Kase ija	0	8.33	0 cfu/100ml	0 cfu/100ml
Walargi	0	2.00	0 cfu/100ml	0 cfu/100ml
Kuni sagariya	1.5	3.5	0 cfu/100ml	0 cfu/100ml
Harotate	33.33	54.66	0 cfu/100ml	0 cfu/100ml

According to the result of study area, half of the water points has contaminated with Feecal coliform in the study Kebeles. This result indicates that additional chlorine is needed at

sedimentation tank and in the distribution systems to be applied and improving sanitary condition to assure a better quality of drinking water.

4.9 Challenge and Factors of Sanitation Practice in the Study Area

4.9.1 Household Income of the Study Area

A household's average income falls into one of two categories: either 500–1000 (\$29.4%) or 1000–2000 (\$70.6%). This determines the level of sanitation. Economic standing is another element that influences hygienic practices. The population with little income finds it difficult to access handwashing stations, restrooms, and appropriate disposal of dry and fecal waste

Table 4. 6: average income of the household

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	501-1000	80	22.0	29.4	29.4
	1001-2000	190	52.9	70.6	100.0
	Total	270	74.9	100.0	
Missing	System	0	0		
Total		270	100.0		

4.9.2 Socio-Cultural Practice of the Study Area

Hand washing practice at critical time

Hand washing practice at critical time refers to the habit of washing hands with soap and water or other clinging agents at moments when there are likely to be contaminated by germs, such as before eating, after changing diapers, before and after caring for sick person and before preparing food.

Table 4. 7 : Hand washing practice at Critical time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	65	17.9	23.9	23.9
	No	205	57.0	76.1	100.0
	Total	270	74.9	100.0	
Missing	System	0	0		

Total	270	100.0
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This study revealed that (76%) of households had no awareness on hand washing practice and that nearly (24%) had awareness on hand washing at critical time. This behavioral and awareness problem leads to challenge for poor sanitation practices.

Table 4. 8 : Disposal system of faeces of children & dry waste

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Properly	57	15.7	21.0	21.0
	Improperly	213	59.2	79.0	100.0
	Total	270	74.9	100.0	
Missing	System	0	0		
Total		270	100.0		

As shown from our SPSS data Nearly (80%) of household their disposal system is improper. This is the major challenge and factor of sanitation practices, as well as improper sewerage of Child faces and dry waste was major causes for out break of water born and water related disease like cholera, typhoid, and amoeba are frequently occurred in the study area.

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Drinking water quality and sanitation practice are crucial factors for public health, especially in rural areas where access to safe water sources and adequate sanitation facilities is often limited. In this study, we assessed the impacts of drinking water quality and sanitation practice on public health in Gemechis woreda of west Hararghe zone, Ethiopia. We collected 42 water samples from different sources and tested them for microbiological parameters. We also conducted a household survey to collect data on water use, sanitation practice, and health status of the residents. We found that the majority of the water sources in the study area were contaminated with fecal & total coliforms, which are exceeding the WHO guideline values. The sanitation practice was poor, with low coverage of latrines and handwashing facilities, and improper disposal of solid and liquid wastes. The poor water quality and sanitation practice were associated with increased prevalence of waterborne and water related diseases such as typhoid, Cholera and Ameba worms among the residents. The results of this study highlight the urgent need for improving the drinking water quality and sanitation practice in Gemechis woreda to protect the public health and prevent the spread of water born and water related diseases.

5.2 RECOMMENDATIONS

As an immediate solution for the existing problems, the responsible authority and the beneficiaries should effectively use the following appropriate recommendations to maintain poor sanitation practices and lack of improper use of sanitation facility, the existing availability and quality of water problem, out break of water born, and water related disease as well as for the challenges & factors of poor sanitation practices respectively.

- ❖ Government and Non-Governmental Organizations should be involved in the construction of additional drinking water sources. In addition, the new source may solve the prominent problems associated with maintenance, design and operational systems of the existing source will be renewed.
- ❖ Using proper drainage and fencing will greatly improve water quality and reduce the risk of water borne diseases.

- ❖ Use of source disinfection mechanisms such as chlorination or point-of-use disinfection mechanisms such as boiling to decrease the bacteriological health hazards.
- ❖ Training should be given to entire community about sanitary, personal hygiene and to protect water fetching material properly.
- ❖ Supporting small-scale water and sanitation projects: small-scale water and sanitation project can be effective in improving sanitation in rural areas. These projects can include the construction of community toilet, the installation of hand washing station, and the promotion of hygiene education.
- ❖ Each household should have access to a latrine at ratio of 1 latrine per 5 persons.
- ❖ Promoting sanitary habit among the community
- ❖ Create balance between water withdrawals and available supply.
- ❖ Rehabilitation of water supply systems.

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APPENDIX I: HOUSEHOLD QUESTIONNAIRES

HOUSEHOLD INTERVIEWS ON the Impact of Drinking Water Quality and Sanitation Practices on Public Health, Case of Gemechis Woreda of West Hararghe Zone, Ethiopia

Introduction

My name is Tigist Gosaye. I am studying water supply and environmental engineering at Adama University. I am doing my master's thesis on the Impact of Drinking Water Quality and Sanitation Practices on Public Health, Case of Gemechis Woreda of West Hararghe Zone, Ethiopia. Therefore, I honestly request your collaboration in filling in these questionnaires in a responsible manner because your truthful response is important for the success of this study. Thus, I appreciate your cooperation in giving your time for the success of this thesis. Note that there is no need to write your name; please indicate their response by putting /x/ mark in the box.

Part I. Background information of the respondent

1. Sex of respondent: [] 1=Female 0=Male
2. Household type 1= Male headed household 2= Female headed household
3. Age of respondent in number -----
4. Highest level of formal education of respondent: []
 - 0=Illiterate
 - 1=Grade 1-4
 - 2=Grade 5-8
 - 3 = Grade 9-10
 - 4= Grade 11-12
 - 5=Vocational/ College/ University
5. Marital status of respondent: []
 - 0=Single /Un married
 - 1=Married
 - 3=Divorced
 - 4=Separated /Widowed
6. Occupational of the respondent
 - 1= Farmer
 - 2= Housewife

3= Daily laborer

4= Merchant

5= Government employee

7. What is your family size in numbers? -----

Part II. Sanitation Practices and facilities of the Study area

Behavior

8. Upon returning from social and economic activities do you wash your hands?

1= Always

2= Sometimes

3= Never

9. Before eating food with your hands, do you wash your hands?

1= Always

2= Sometimes

3= Never

10. Before preparing food, do you wash your hands?

1=Always

2= Sometimes

3=Never

11. When you use a public toilet, do you cover the seat with paper or clean it before use?

1= Always

2= Sometimes

3=Never

12. Do you go without a wash or shower or bath two days in a row?

1=Always

2=Some

3= Never

Hand washing practices

1. Do you always wash your hands with soap and water upon visiting the toilets?

1=Yes

2=Sometimes

3=No

2. Reasons for skipping hand washing at school?

1= Not necessary

2= Too busy

3= Always forget

4=Soap not available

5=Water not available

3. What do you usually use to clean/dry your hands after washing them?

1= Clean towel or paper towel

2=Air

3=Handkerchief

4=Clothes

5=Other

4. Where there is no soap and water what do you do when you visit the toilet?

1= Do nothing

2=Always use hand sanitizer

3=Sometimes use hand sanitizer

4= Use only water

5. On an average day, approximately how many times do you wash your hands?

1=1-3

2=4-6

3=7-10

4= >10

6. When you wash your hands, approximately how long do you wash them for?

1=5-10 seconds

2=15-20 seconds

3= >1 minute

4= No specific length of time

7. Do you own and regularly use hand sanitizers?

1=Yes

2=No

Part III. Prevalence of waterborne and water related diseases.

8. What is the main type of water supply you are using at the household level (multiple response is possible)?

1=Public tap/ standpipe

2=Tube well/ Borehole

3=Protected dug well

4=Unprotected dug well

5=Protected spring

6=Unprotected spring

7=Tanker truck

8=Surface water (river/dam/lake/pond)

9= Other, please specify: _____

9. Is the individual water supply well maintained?

1= Yes

2= No

10. Is drinking water regularly treated onsite?

1= Yes, always.

2= Yes, sometimes/irregularly.

Please specify how often: _____

3= No, never on-site

4= Not applicable

11. How is drinking water treated on-site?

1= By chemical disinfection (e.g., chlorine)

2= By coarse filtration (e.g., Ceramic filter, sand filter)

3= By membrane filtration (e.g., ultra- or nanofiltration, or reverse osmosis)

4= By boiling

5= Water is never treated on-site

6= Not applicable

12. What is the most common water borne diseases that frequently occur in your community? Multiple response is possible

1= Cholera

2= typhoid

3= amoeba

4= other

13. The age group most affected by water borne diseases in general is(multiple response is possible):

1= Children under one year of age

2= Children under 5 years of age

3= Children 5 – 10 years of age

4= Adult above 15 years of age

14. What do you say about the cause of water borne diseases in your locality?

.....
.....
.....

15. Do you treat water at the household level before drinking?

1= Yes

2= No

16. What are the common methods of water treatment that you are using at household level? would you please mention?

.....
.....
.....
.....

Part IV. Challenges of Sanitation Practices

17. Do you have your own latrine at the household level? 1= Yes 2= No
18. What is the kind of your latrine?
- 1= Pit latrine with slab
2= without slab
3= Open pit
19. If yes to the above question, does your latrine has hand washing facility? 1= Yes, always 2= Yes, sometimes 3= No
20. Were any signs of open defecation observed around in your house? 1= Yes 2= No
21. Were any signs of open defecation observed in the village you are living? 1= Yes 2= No
22. If yes, where are people defecate in the open? Multiple response is possible
- 1= In street gutters,
2= Behind bushes
3=Into open bodies of water.
4= Other, specify
23. Does your household have safe waste disposal place? 1= Yes 2= No
24. What are the waste management mechanisms your household is using?

APPENDIX II:

From a total of 270 households heads interviewed, (66.9%) of them were males and (33.1%) of the were female.

Table A. 1: - Sex of respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	180	64.5	66.9	66.9
	Female	90	31.9	33.1	100.0
	Total	270	96.5	100.0	
Missing	System	0	3.5		
Total		270	100.0		

Table A. 2: - Age of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20.00	1	.4	.4	.4
	25.00	68	24.1	25.0	25.4
	28.00	8	2.8	2.9	28.3
	29.00	25	8.9	9.2	37.5
	32.00	20	7.1	7.4	44.9
	34.00	52	18.4	19.1	64.0
	35.00	3	1.1	1.1	65.1
	42.00	57	20.9	21.7	86.8
	52.00	36	12.8	13.2	100.0
	Total	270	96.5	100.0	
Missing	System	00	0.0		
Total		270	100.0		

The average mean size of household family size was 6.1360 and median of 6.0000 with the minimum and maximum household size 3 and 9 members respectively.

Table A. 3: - family size of respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3.00	6	2.1	2.2	2.2
	4.00	49	17.4	18.0	20.2
	5.00	47	16.7	17.3	37.5
	6.00	70	24.8	25.7	63.2
	7.00	48	15.7	16.4	81.6
	9.00	50	17.7	18.4	100.0
	Total	270	96.5	100.0	
Missing	System	00	0.0		
Total		270	100.0		

The occupational situation of the respondents 155 (55.0%) were farmer and 61(21.6%) were housewife ,13 (4.6%) were daily laborer, 30(10.6%) were merchant and 13 (4.6%) were government employee.

Table A. 4: - Occupation of the respondent level of the respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Farmer	155	55.0	57.0	57.0
	Housewife	61	21.6	22.4	79.4
	daily laborer	13	4.6	4.8	84.2
	Merchant	28	10.6	11.0	95.2
	government employee	13	4.6	4.8	100.0
	Total	270	96.5	100.0	
Missing	System	00	0.0		
Total		270	100.0		

The education level of the respondent was as shown in the table below.

Table A. 5: - Education level of respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Illiterate	87	30.9	32.0	32.0
	grade 1-4	63	22.3	23.2	55.1
	grade 5-8	22	7.8	8.1	63.2
	grade 9-10	65	23.0	23.9	87.1
	grade 11-12	24	9.2	9.6	96.7
	vocational/university/college	9	3.2	3.3	100.0
	Total	270	96.5	100.0	
Missing	System	00	0.0		
Total		270	100.0		

Marital status of the respondent was as shown in the table below.

Table A. 6 : - Marital status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	18	6.4	6.6	6.6
	Married	145	51.4	53.3	59.9
	Divorced	41	14.5	15.1	75.0
	Separated	68	24.1	25.0	100.0
	Total	270	96.5	100.0	
Missing	System	00	0.0		
Total		270	100.0		

Household type of respondents was as shown in the table below.

Table A. 7 :- Household type of respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male headed household	191	67.7	70.2	70.2
	female headed household	81	28.7	29.8	100.0
	Total	272	96.5	100.0	
Missing	System	0	0.0		
Total		270	100.0		