



AFRICAN CENTER OF EXCELLENCE FOR WATER MANAGEMENT

**WATER SAFETY PLANS MANAGING DRINKING WATER QUALITY FOR RURAL
COMMUNITY, DIRRE TIYYARA DISTRICT, EASTERN ETHIOPIA, 2020.**

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PROGRAM: AFRICAN CENTER OF EXCELLENCE FOR WATER MANAGEMENT

SPECIALITY: WATER SUPPLY AND SANITATION

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UNIVERSITY, ETHIOPIA**

OCTOBER, 2020

WATER SAFETY PLANS MANAGING DRINKING WATER QUALITY FOR RURAL
COMMUNITY, DIRRE TIYYARA DISTRICT, EASTERN ETHIOPIA, 2020

A REASEARCH PROPOSAL TO BE SUBMITTED TO THE AFRICAN CENTER OF
EXCELLENCE FOR WATER MANAGEMENT IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS OF DEGREE OF MASTER OF SCIENCE IN WATER SUPPLY AND
SANITATION

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This Thesis is submitted in partial fulfillment of the requirements for MSc African center of Excellency for water management (water supply and sanitation), Addis Ababa University. I solemnly declare that this Thesis has not been submitted to any other institution anywhere for the award of academic degree, diploma, or certificate.

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AKNOWLEDGMENT

First and for most I would like to thank almighty God (“Waaqa”) for is unlimited support and guidance through my life. I would also like to thank ACEWM for providing me the chance to study Master program in Water supply and Sanitation at Addis Ababa University. My gratitude goes to my advisors Dr.Ing kinfe Kassa for his consistent support, crucial guidance, unceasing supervision, constructive comments and encouragement and during my thesis work. Without him the thesis wouldn’t have been successfully accomplished.

My special appreciation goes to thank Haramaya University, College of Health and Medical Science for letting me use their laboratory. I would also like to thank Harari region Water supply and Sewerage Authority, WASCHO of Dirre Tiyyara Woreda, study participants and for facilitating the process of data collection. My heartfelt goes to data collectors, supervisors and laboratory Technicians for their contribution on data collection and coordination activities. My appreciation also extends to ACEWM staff and management for facilitating this course of work. Lastly but not least, I am greatly indebted to all my Family and friends those stand by my side.

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ABBREVIATION

ACEWM	African Center of Excellency for Water Management
CFU	Colony Forming Unit
CI	Confidence Interval
CSA	Central Statistical Agency
EDHS	Ethiopian Demographic and Health Survey
E.COLI	Escherichia Coli
FC	Fecal Coliform
HH	Household
HWT	Household Water Treatment
MFU	Membrane filtration Unit
MoWIE	Ministry of Water Irrigation and Energy
MPN	Most probable number
NTU	Nephelometric Turbidity Units
SPSS	Statistical Package for Social Sciences
SDG	Sustainable development goal
TC	Total Coliform

UNICEF United nation children's fund

WASCHO Water supply, sanitation and hygiene committee

WHO World Health Organization

ABSTRACT

Water is essential for human to survive in life and having access to safe drinking water is a basic human right. However, significant number of population in developing countries especially in rural areas still drink fecally contaminated water. Similarly in Ethiopia one point water supplies are major source of drinking water in rural areas and small community(MoWIE 2015).Thus the development of water safety plans for small systems should focus on the control of microbial quality of drinking water in particular fecal contamination.

The objective of the study was to assess Water Safety Plans Managing Drinking water quality for rural community, Dire Tiyyara District, Eastern Ethiopia September, 2020.

A cross-sectional study design was conducted among 180 households in rural community, Dire Tiyyara District, Eastern Ethiopia. A total of 192 Water samples (12 from different source and 180 from HH) were collected and analyzed by membrane filtration method to identify faecal contamination. In addition sanitary survey was conducted at water source and point of use. In Further Combined result of microbiological and sanitary survey was used to prioritize public health risk for intervention. Statistical analysis was performed using Poisson regression to assess the association between outcome variable and independent variable. Odd Ratios along with 95% Confidence intervals were estimated to measure the strength of the association and identify association bacteriological quality and water treatment, handling and storage, and latrine availability, use and operation at household level/point of use

Out of 12 sources eleven (11) water sources were found to have fecal contamination. In addition level of contamination in one source was very high, and has a major public health impact and need urgent intervention. On the other hand, the average Colony count of TTC of sample (CFU/100ml) at point of use had shown increment at every point from catchment to point of use. Thus, out of the samples analyzed at point of use 91.2% had fecal coliform above permissible level (0 CFU/100ml) for drinking water. Out of this 54.7% of the water sample from point of use had major public health impact and it is clearly priority and need urgent intervention. Furthermore Samples from HH who use water treatment found to be 2 times likely to be contaminated [AOR=1.99; 95% CI (1.89, 2.07)]. Similarly HH with low sanitary risk of water handling and storage were 8.89 less likely to be contaminated compared to household with very high risk [AOR=8.89; 95%CI (8.19, 9.86)] and household with very high sanitary risk of latrine availability, use and operation were 3.86 more likely to be contaminated than low risk [AOR=3.86; 95%CI (3.45, 4.32)].

The study showed fecal contamination of drinking water in rural community of Dirre Tiyyara was significant. As a result, an intervention focusing on improving the quality of drinking should be taken.

Keywords: Bacteriological quality; public health Risk prioritization; WSP, Sanitary survey

1 INTRODUCTION

1.1 BACKGROUND

Water is essential for human to survive in life and having access to safe drinking water is a basic human right. Contaminated drinking water and poor sanitation is related to transmission of water borne disease such as cholera, diarrhea, dysentery, and polio. Drinking water with poor quality is significantly affecting health of the consumers. It was reported that still 2 billion people rely on source of water contaminated with human feces (WHO, 2017).

Quality drinking water is highly dependent on the sanitation condition around source. The water source may get contaminated from open field defecation, animal wastes, agricultural runoff, and run of from residential area. All water sources, especially older water supply system; unprotected hand dug well, spring, and pumped r gravity-fed systems including water supply system are prior to contamination. Particularly cracked, source with no casing and leaking are more vulnerable. This will be cause problem when the contaminated runoff able to enter the water source directly (Haylamicheal, 2012) .Another study also pointed out that drinking water quality relies on the type and level of cleanliness of the storage material and on the safety of the handling practice at point of use(Mekonnet al., 2019).

The most reliable and protective means of consistently assuring the quality of drinking water is through the application of risk management based water safety plans (Davison, 2005). Water safety plans can be based on the results of studies of drinking water quality and sanitary inspection of the drinking water source catchment. Hazardous event that can affect the quality of the water can be assessed through collection of sanitary inspection and water quality data. A barrier put to secure the water safety also analyzed for validation of the protection. Sanitary inspection should be used to analyze the hazardous event assessment (Howard, 2003).

Studies in developing countries highlight the vulnerability of small systems to microbial contamination (Davison, 2005). Similarly in Ethiopia one point water supplies are major source of drinking water in rural areas and small community. In addition community managed water supplies lack regular basis water quality testing and sanitary survey (MoWIE, 2015) . Thus the development

of water safety plans for small systems should focus on the control of microbial quality of drinking water in particular fecal contamination.

1.2 Statement of Problem

In 2015, it is estimated that around 663 million people across the world still have no access to improved water source. And nearly half the population lives in Sub Saharan Africa. This people use unimproved drinking water source including springs, unprotected wells and surface. On the other hand 1.4 billion had no access to drinking water facility at all (WHO/UNICEF, 2015).

In addition WHO report provided that 2 billion people across the world still drink fecally contaminated water. Every year 2.9 billion people are affected by cholera and other water born disease by consuming water contaminated with feces. Annually 82, 9000 deaths were reported due to diarrhea disease (WHO, 2016).

Despite the improvement in the coverage of water and sanitation facilities in Ethiopia Access to safe drinking water supply is the lowest among Sub-Saharan African. According to the WHO/UNICEF report, less than half (41%) of the total population have at least basic drinking water services level, 28% have limited services (more than 30 minutes), 22% have unimproved services, and 9% use surface water as a source of drinking water supply, with 1.32% annual rate of change in basic service(Organization, 2019). The prevalence of diarrhea in Ethiopia is still significant with national figure of 12 % (EDHS, 2016).Nonetheless, the hygiene service level in Ethiopia, is still behind the target for achieving the 2030 sustainable development goal agenda.

Most of Water supply systems in rural Ethiopia are frequently broken and not functioning with poor arrangements for maintenance and repair. With this reason the drinking water source will be exposed to microbiological contamination (Arsano et al., 2010) . A study conducted in 36 rural neighbor of Eastern Ethiopia showed that 78 % of the households (Median E.coli MPN 90 per 100ml) and 81% of those from the control households (median E.coli MPN 90 per 100ml) were contaminated with E.coli.(Mengistie et al, 2013) .Similarly another study conducted in rural Dire Dawa district of Eastern Ethiopia showed that from total 90 samples taken from five water supply sources all of the sample were contaminated with E.coli(Amenu et al., 2013) .

As Dire Tiyyara is part of the rural Ethiopia, it shares the same problem. Therefore this study is intended to analyze safety plan managing drinking water quality from catchment to consumer in rural community of Dire Tiyyara. Dire Tiyyara was studied to identify the possible risk of water

contamination in the water supply system. This enable to know the quality of drinking water at source and point of use and figure out the potential source of contamination in the supply from Catchment to consumer in this specific area. In this regard the study result will be used for appropriate intervention to ensure safety of drinking water quality and could also help as an indicator to meet Sustainable Development Goal of water supply and sanitation.

1.3 OBJECTIVE

1.3.1 General Objective

The general of this study is to assess the Water Safety Plans Managing Drinking water quality for rural community, Dire Tiyyara District, Eastern Ethiopia 2020.

1.3.2 Specific Objective

- To conduct the sanitary risk assessment at source and point of use.

- To analyze the bacteriological and physicochemical quality of drinking water at source and house hold level.

- To identify whether microbiological contamination is occurred at household, at source or both.

1.3.3 Research Question

- ❖ Does the sanitation condition around source have impact on the microbiological quality of drinking water at source?

- ❖ Is the water safe for drinking at source and consumer?

- ❖ Is there any difference in the quality of the drinking water at the Catchment and at the containers of the users?

- ❖ Where does the microbiological contamination occurring? At source, household level or both?

1.4 Significance of the Study

This study output will show whether water supply in rural community of Dirre Tiyyara is fecally contaminated or not, and points out the potential contamination risk in the supply system and indicate risk priority which enable the water supply and sewerage authority and respective institutions to take necessary interventions to solve water quality problems.

1.5 Scope of the Research

This research has focused on the investigation water safety plan managing water quality in rural community of Dirre Tiyyara district. This include sanitary survey of water sources, analysis of the selected physico-chemical and bacteriological parameters as well sanitary survey of water supply source, assessment of water availability, accessibility and sustainability, assessment of water transportation and handling at home that has significant effect on the water quality. The study area will be limited to Dirre Tiyyara Woreda, Eastern Ethiopia.

2 LITERATURE REVIEW

2.1 Water Accessibility, Reliability and sustainability

The accessibility of adequate and safe water is highly related with community health. Hence, water is predominantly essential for life, health and human dignity. Moreover all people have a right to safe and adequate water in addition to community health benefit. Thus a community has to get water in equitable manner for drinking, cooking, personal hygiene, and sanitation. As a result provision of safe and adequate water supply is essential in order to prevent water related disease specially water borne disease like cholera and diarrhea (Organization, 2017)

Accessibility of water both at individual level and community plays a crucial role in reducing chance of fecal contamination of drinking water (Ayalew, 2018). The result from multivariate analysis of (Mekonnen, Mengistie et al. 2019) showed that households which encountered water shortage within the previous month had significantly higher fecal contamination than their counterparts. Moreover, households with water shortage had 18 times higher chance of diarrhea occurrence as compared to households having no water shortage (Ayalew, 2018).

According to the study conducted in rural areas of Ethiopia only 55 of the households have access to protected drinking water in their premises, and more than 84% of the house hold spent more than 50 minute to collect water(Muhammed et al, 2016). In addition More than half (53%) of rural community in Ethiopia travel more than 30 minute for round trip to collect water (EDHS, 2016).

The result from a community-based survey done in Tamale Metropolis, Ghana (2013) among 250 households showed that households that get water from sources found outside their home were 81% less likely to had good water quality than households that get their water in their home by a tap. In addition to this drinking water quality among households that get water after traveling a longer distance were 52% less likely to have a good quality of water than those households that travel a shorter distance (Boateng, 2013).

A survey in Fogera and Mecha district of Amhara in Northwest Ethiopia was done from February to March 2014 revealed that accessibility of water was also associated with bacteriological quality of

drinking water, in which a water samples from households that access drinking water within 30 minutes were 62% less likely to be contaminated by E.coli than households that had access more than 30 minutes (Usman, 2016).

2.2 Water safety plan at source/catchment

MDG has aims to reduce by half the number of world population without access to unimproved sanitation. Accordingly improved sanitation coverage has reached 64% in 2012. Despite this significant progress still 2.5 billion people do not have access to an improved sanitation facilities. Similarly mostly the poor and marginalized lack access to an improved source of drinking water, out of this nearly quarter (173 million) use untreated surface water, and 90 % lives in rural areas (Supply, 2014).

Quality drinking water is highly dependent on the sanitation condition around source. The water source may get contaminated from open field defecation, animal wastes, agricultural runoff, and run of from residential area. All water sources, especially older water supply system, unprotected hand dug well, spring, and pumped r gravity-fed system including water supply system are prior to contamination. Particularly cracked, source with no casing and leaking are more vulnerable. This will be cause problem when the contaminated runoff able to enter the water source directly (Haylamicheal, 2012).

Protection the microbial safety of drinking water is achieved through multiple barriers, from the source to consumer, to prevent the contamination of water by pathogenic microorganism or to reduce the contamination the level not harmful to human health. Safety will be secured if multiple barriers are in place, including source protection, proper site selection and operation of series treatment process and management of distribution system (piped or) to maintain and protect the treated water quality. The preferred strategy is giving primary emphasis on protecting water source or preventing or reducing the load pathogens entering the supply system and reducing reliance on treatment process for removal of pathogens (Organization, 2017).

Effective catchment management has many benefits. By decreasing the contamination of the source water, the amount of treatment required is reduced. This may reduce the production of treatment by-products and minimize operational costs (Organization, 2017) .

In further according to UNICEF/WHO 2015 progress reported that around 663 million people worldwide rely on unimproved drinking water sources, including unprotected wells, springs and surface water. Furthermore it is estimated that 79% of the people living in rural areas using unimproved surface water (2015 Update and MDG Assessment, 2015).

Improved source had less chance of bacteriological contamination while compared with unimproved water source. A systematic review and Meta-analysis conducted in middle and low income countries which includes 319 studies from 1990 to 2013 reporting on 96,737 water samples. According to this study the odds of contamination were 85% less likely among improved sources than unimproved sources. (AOR=0.15[0.10-0.21], P<00001). However, also more than the quarter of the sample from improved sources were contaminated (Bain, 2014).

A cross sectional study conducted in different region (high land, valley and low land) Bolivia provide that piped distribution is accounts 58%, while dug well(home based) and bowser truck accounts 6% and 36% respectively (Rufener, 2010).

A survey in Fogera and Mecha district of Amhara in Northwest Ethiopia was done from February to March 2014 among 454 household samples and the result revealed that water from unprotected sources is 1.9 – 3.6 times more likely to be contaminated than protected sources. In this study accessibility of water was also associated with bacteriological quality of drinking water, in which a water samples from households that access drinking water within 30 minutes were 62% less likely to be contaminated by E.coli than households that had access more than 30 minutes(Usman, 2016).

According to cross sectional study conducted in South west Ethiopia Serbo town (2010) on 18 unprotected wells and 6 protected wells, for all of the water sources there was no regular water source treatment undertaken. Thus 87.5 % of the water from this source has presumptive bacteria count MPN above the permissible limits of drinking water. Analysis of sample from protected well reveals that three of the well had total coliform count more than 10 ml per 100 ml of the water. On the other hand all sample from unprotected well had total coliform count greater than 10 ml per 100 ml, which is not safe for human consumption (Abera et al., 2011).

According to study conducted in Pakistan out of 289 samples collected from different water source, 245 samples were contaminated with coliform bacteria. All most all water bodies 23 from canal

water, 89 from dug wells, 107 from shallow pumps, and 26 from water supply were contaminated(Memon et al., 2011).

2.3 Water Safety Plan at Point Of Use/ Water Handling and Storage

Similarly another study also pointed out the effect the storage might have on drinking water quality since it relies on the type and level of cleanliness of the storage material and on the safety of the handling practice. Accordingly, one hundred eighty three (59.8%) of stored water sample and 18(35.3%) of the source water sample were positive for fecal coliforms. In addition to this, among household water samples, 121(39.5%) had a fecal coliform count above the low risk limit of 10cfu/100ml, 56(18.3%) exceeded the moderate risk limit of 100cfu/100ml. on the contrary, only 11 (21.6) of the source samples had fecal coliform counts over the low risk limit (Mekonnen et al., 2019).

The fecal coliform counts in the stored water samples were significantly higher than the source sample (Copeland, Beers et al. 2009, Mekonnen, Mengistie et al. 2019). In addition (Copeland, Beers et al. 2009) also emphasized the possible contamination of water during storage. From this study among the 231 stored water samples analyzed 70(30.3%) were found positive for E coli from which, the substantial majority (50/70: 71.4%) contained more than 100 CFU/100ml, and fourteen samples (14/231:6.1%) contained more than 1,000 in 100 CFU/100ml.

(Usman, 2016) argued that, stored water quality can be affected by the types of primary water sources. Stored household water from protected sources/wells/springs had lower E coli compared to unprotected water sources/wells/springs. This is also supported by another study (Jagals, Barnard et al. 2013) in which samples from raw spring water had E.coli (76%) compared to raw river water from which 97% of the sample were positive for E.coli. This study also unveiled that the level of E. coli detected increased when the raw water had been transferred in to containers (at storage); detection rate were 89% for spring water and 100% for river water. Similarly according to (Usman, Gerber et al. 2017) , the results from the logistic regression estimates suggested that stored water from surface water is 3.7 times more likely to be contaminated with fecal materials compared to protected wells/ springs. The study also said, water from unprotected sources is 2 to 3.6 times more likely to be contaminated than from protected sources.

2.4 Water Safety at Point Use/Household Water Treatment

House hold water treatment is any of method or technologies used or employee at house hold or pint of use for the purpose of treating water and making safe for consumption. There are a range of house hold water treatment which enables individuals and the community to remove or inactive pathogens from collected water improved or unimproved source. This includes safe storage, chemical disinfection, filtration, solar disinfection, thermal treatment, chemical treatment (iodine, and chlorine), coagulation, precipitation or sedimentation and other (WHO, 2017) .

The Ethiopian demographic health survey (2016) provided that water treatment practice at home is very low. Accordingly only 11.6% of urban and 7.9 % of rural households treat water at home(Survey, 2016). A cross sectional study conducted in Dire Dawa in 2011 only 13% of the population treat water at home(Amenu et al., 2013).In further a community based cross sectional survey conducted in rural Ethiopia (2014) indicates that among house hold who treat water at home, more than 81% use chlorination. However the treatment was not regularly(Usman, 2016) .

According to survey conducted in rural areas of Ethiopia half of the people living in the rural area get drinking water from unimproved source. In addition from surveyed house hold only 8 % of them apply any kind of water treatment at home(Muhammed et al., 2016) .

Various Water treatment like boiling, filtering, or chlorinating water at home has improved the microbiological quality of drinking water(Organization, 2017).An experimental study conducted among 90 households which were taken from 23 water sources conducted in Malawi (2011) provided that the mean bacteria concentrations of the untreated water is 74 CFU/100 ml for E.coli which was much higher than the mean concentration of the treated water at home which was 4.0 CFU/100 ml for E.coli(Kanyerere, 2012) .

2.5 Water safety plan at point of use/latrine availability, use and operation

Sanitation facilities enables break down of faeco-oral disease transmission by preventing (Six, 2018) contamination of water mostly at source and soil contamination. However, sanitation and hygienic practice is also play a significant role in maintaining the quality of drinking water. A cohort (2006) conducted in south Africa and Zimbabwe also reveals that the quality of water

deteriorates at house hold level when its compared to the quality of the same water at Source(Gundry, 2006) .

Moreover the study conducted in Bolivia states that the quality of drinking water deteriorates along the pathway from supply source to the point of use. Accordingly the Median concentration of E.coli showed significant increment from 0 CFU/100 ml (IQR: 0-13) at the source to 8 CFU/100 ml 9IQR:0-550) at the drinking cup in the home (Wilcoxon signed rank test: n=81, z=-3.7, p <0.001(Rufener et al., 2010)

Housing and sanitation facilities of the households were associated with the bacteriological quality of drinking water. Based on a survey done among 562 households in Dolakha and Ramechhap districts of Nepal indicated that the odds of drinking water contamination were 1.6 times higher among households that had shared their house with domestic animals (Six, 2018).

2016 EDHS report indicate one in three household in rural communities do not have access to latrine. Out of this only 2% of the latrine was shared among neighbor.in addition majority 56% of the latrine used was improved (EDHS, 2016).

A cross sectional prospective study was conducted to Assess hygienic and sanitation practice in Bahirdar city 2009.According to this study 67 % of community wash collecting containers daily. On the other hand 88.5% have no access to latrine in their compound. Thus only 25.7% of them practice hand washing with soap after visiting toilet (Tabor et al, 2011).

A survey conducted in rural areas of Ethiopia provided that around 57% of the population practices open Defecation which was much lower than rural sanitation 43% (WHO/UNICEF 2014).

2.1 Conceptual framework

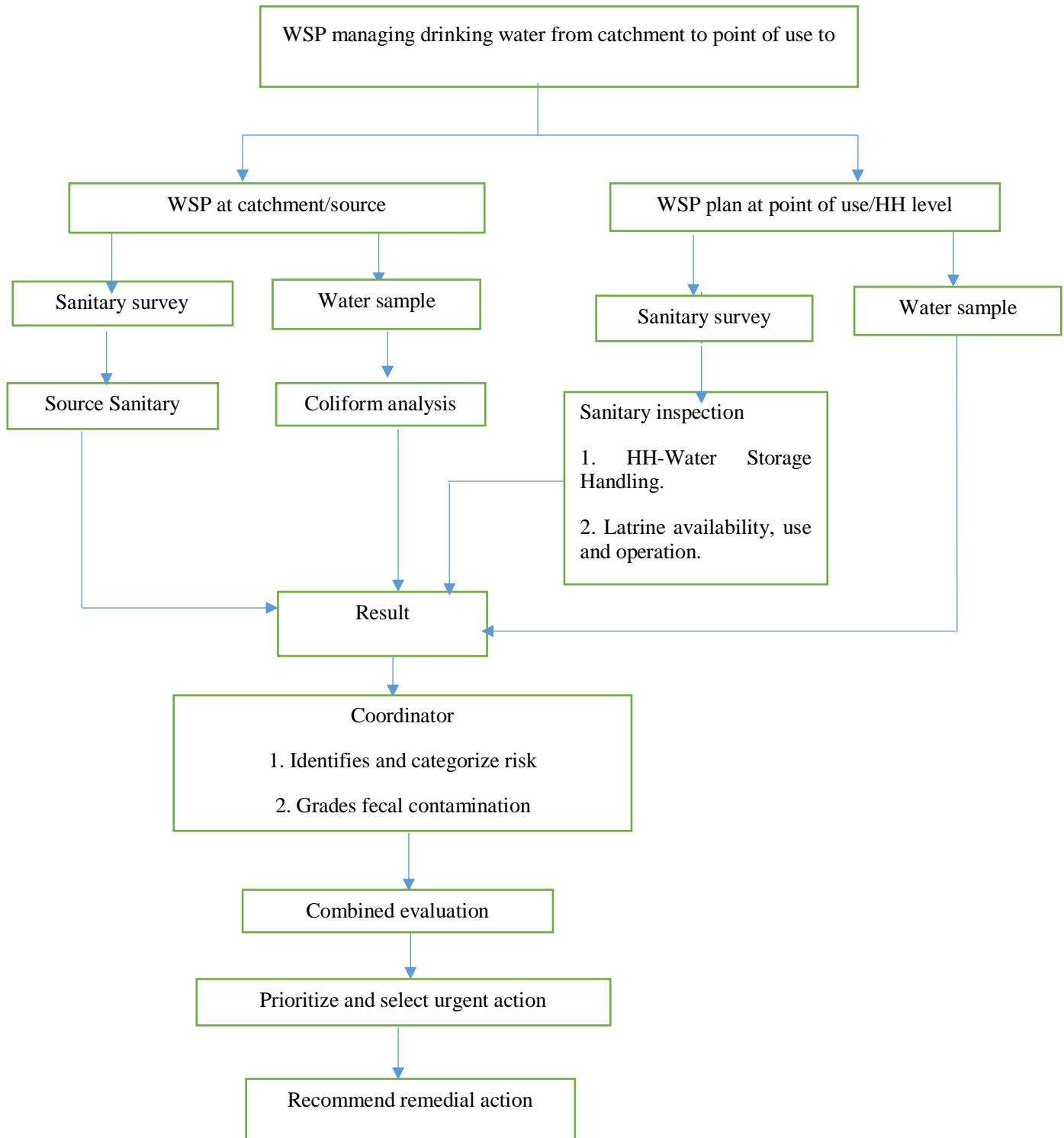


Figure 1 Conceptual framework indicating wsp from catchment to point of use in one point water supply system.

3 METHODS AND MATERIALS

3.1 Study Area Description

The study was conducted in different villages of Dirre Tiyyara Woreda District located in Harari region, Eastern Ethiopia. The study site is located at 9.3149° N, 42.1968°E latitude and longitude, respectively. Dirre Tiyyara is located at about 530 km Addis Ababa bordered by kombolcha woreda on the North, on the South by Harar city, on the East by Erer woreda and on the West by Haramaya Woreda. The administrative structure of the district is further divided into 6 rural Kebeles. According to the regional health office report on 2017, there were 63,068 (40,904 urban and 22,164 rural) households with the total population of 245,969 from this 120,524 of them are male and 125,444 are female (Harari regional health bureau, 2017). Agriculture is the main livelihood of the community and Chat farm is the major income source in the area (Harari regional Health bureau, 2017)

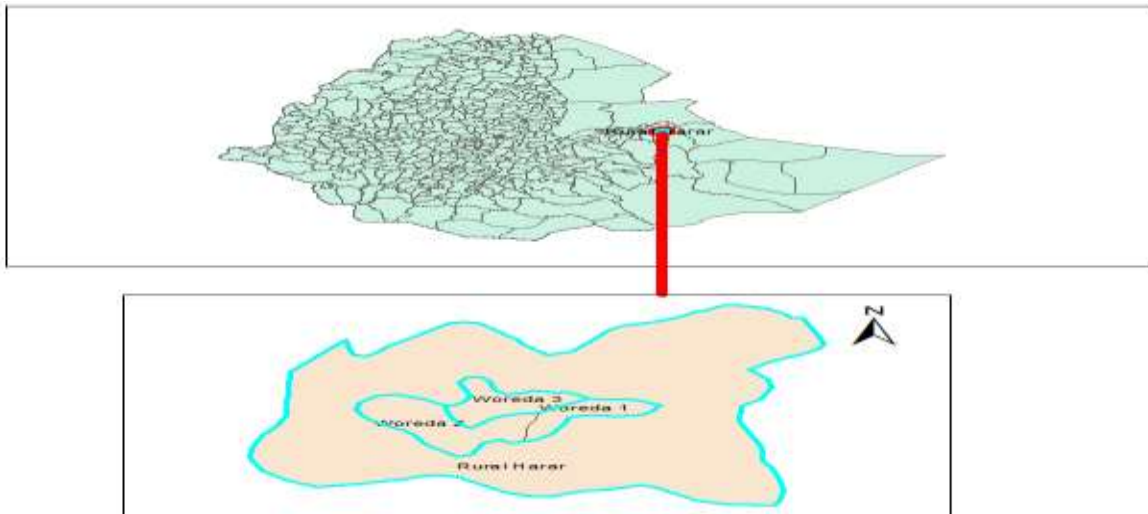


Figure 2 Location map of study area

3.2 Description of the Water Supply of the Area

According to Harari region water supply and sewerage authority, the primary source of drinking water in the region is ground Water. Thus the urban community supply source is from deep wells (bore holes with mechanized pump) from the Dire Jara well field near the town of Dire Dawa, Ifebate in Haramaya and from Erer. On the other hand the main supply source of rural

community is public hand dug well with hand pump and private hand dug well with mechanized pump. (Harari region water and sewerage authority, 2019).

3.3 Study Design

A cross-sectional study design was used to assess water safety plans managing drinking water quality in rural community of Dirre Tiygara, Eastern Ethiopia. Water samples for bacteriological analysis was collected from selected water sources and households. In addition physico-chemical parameters: PH, temperature, turbidity, and residual chlorine were conducted on site. The sanitary survey was undertaken for sanitary risk assessment at source and point use using standard checklist recommended by WHO.

3.4 Sampling procedure

A total of 12 water sources from different six kebeles were included in this study. Accordingly six covered dug well and six boreholes with mechanized pump (private) were selected. In this study the average number of people using one source was 50 households. On the other hand if the number of people using one source is less than 50 households 12 sample from household can be representative for microbial quality (WHO, 2017).Accordingly, 15 households within one kilometer of water source were selected randomly using lottery method to increase the representativeness of the water samples from household. Thus a total of 12 water sources and 180 households were included in this study (WHO, 2017).

3.5 Data Collection Procedure

3.5.1 Household Data Collection Instruments

Data was collected using pretested structured questionnaire from study participants through face to face interview. In addition sanitary inspection was also carried out at household level using standard observational checklist. The questionnaire and check list is attached in appendix .Furthermore the questionnaire was written in English, then translated into Afaan Oromo (local language), and then translated back into English to assure its accuracy. The respondents were primarily women greater than 18 years of age, but in the absence of, women greater than 18 years of age another family member was interviewed.

3.5.2 Water sampling at sources and point of use

The respondents were asked to provide water which they normally use for drinking. Then a 100 mL water sample was collected from the 180 selected households Using 100 ml sterilized polyethylene plastic sample bottle. Similarly, 100 ml of water sample from 12 sources were taken from sources. The water samples were labeled and kept in ice box during transportation. Then all the samples were transported to Haramaya University College of health and medical science laboratory and analyzed within 3 hours sampling for fecal coliform.

3.5.3 Source and House Sanitary Survey

Sanitary Survey (water Source inspections) was carried out on all water sources with WHO drinking water survey check list (WHO, 1997) by observing the point of contamination sources around the water source area by trained Environmental health professional.

Source and HH water contamination risk factor assessment at house level was conducted by using standard check list developed by WHO and adopted by MoWEI. Accordingly a check list with twelve questions was used for identifying and quantifying potential risk for water contamination at source for catchment risk assessment and at point of use contamination risk caused by HH –level water handling and storage and latrine availability, use and operation. Level of contamination was categorized as below depending on the number of score out of total 12 question(MoWIE 2015).

Low risk =0-2; Medium risk =3-5; High risk=6-8; Very high risk=9-12.

3.6 Microbiological Water quality test

Collected water samples were analyzed by the laboratory technician and principal investigator to determine the level of fecal contamination of drinking water at the source and household levels.

Each 100 ml of sample water passed through membrane filtration unit of 0.45 mm pore size and put on petridish having lauryl broth sulphate (LBS) media, then incubated the loaded petri-dish rack at 44 C⁰ for 14 hours. Then, the plates for growth of fecal coliforms were inspected systematically, column by column in the grid. All the yellow colonies irrespective of colony size were counted using a digital colony count. The values recorded as number of fecal (thermo-tolerant) coliforms or CFU per 100 mL of water.

3.7 Physico -chemical quality Analysis

Chlorine residual at direct sources and from household storage containers was tested using the Wagtech potatest Kit. The test allows for assessment of water quality delivered from the water utility to the home and may also help to evaluate changes in water quality at home that occurred as a result of poor hygiene practices or other reasons. Free residual chlorine (FRC) concentrations were measured in all water samples using diethyl-phenylene diamine (DPD) reagents, which are provided in tablet form for convenience and simplicity of use.

One DPD1 tablet will be added into each test tube, then fill the test tube with sample water to the 10 mL mark and shook it vigorously to let the free chlorine react with DPD to produce coloration. The intensity of the pink color is proportional to the free residual Chlorine concentration. The color intensities were measured by comparing against color standards using a Wagtech Comparator. The disk reading represents the free chlorine residual as milligrams per liter.

Turbidity was measured using Wagtech International Turbidity Meter (Wag-WT3020, Halma PLC Company), whereas other Physico-chemical parameters including pH and temperature, were measured in situ using standard instruments (HQ 40d multi parameter meter, HQ 40d, HACH Company)

3.8 Institutional Inspection and Analysis

Checklist containing 11 standard question was used to conduct institutional inspection of water supply system in the study area to identify operation and maintenance situation of relevant functions like defective design, ineffective supervision, inadequate training, inter-sectoral coordination resulting in capacity gaps and absence of clarity of roles, which as a consequence the water supply components fail to operate at optimum efficiency.

3.9 Data Analysis

All collected data was checked for completeness and internal consistency by cross-checking, was coded and double entered into Epi Data 3.1 computer software package and cleaned for inconsistency. For the analysis, the data was reported with frequencies, summary measures, table, and figures. For analysis, the data was exported to STATA Version 14.0. Descriptive

statistics were calculated including means and \pm SD (standard deviations) for continuous variables. In addition combined result of sanitary survey and bacteriological quality was analyzed and the result was reported in the form of table of risk prioritization.

Statistical data analysis was performed using poisson regression model at 95% CI. The modeling strategy involved estimating the crude odds ratio (OR) using bivariate analysis and adjusted odds ratio (AOR) using multivariable analysis. Finally to determine the significant determinant factors of bacteriological quality of drinking water at point of use Poisson regression analysis were employed by selecting only variables that appear with $P \leq 0.01$

3.10 Operational Definitions

A rural water supply system: is a water supply that provide water for drinking and domestic uses; including :(I) a rural system that cover multiple villages, multiple kebeles and /or multiple Woredas managed by the WASHCO/ Board.(II) A single point water sources that serve one or more villages.

Control Sample: 100 ml sterilized distilled water to be analyzed by membrane filtration method for every 10-15 households water sample.

Household water treatment: are any of a range devices or methods employed for the purposes of treating water or remove or inactive microbial pathogens in the home or at the point of use in other setting.

Poor quality of water: Water which has a fecal coliform bacteria detected in any 100ml of the sample

Risk: is the likelihood that a hazardous event/hazard will occur combined with severity of consequences

Sanitary Inspection: is an onsite inspection and evaluation by qualified individuals of all conditions, devices, and practices in the water supply system that poses an actual or potential to the health and well-being of the consumer.

Water safety plan: is a comprehensive risk assessment and risk management approach that encompasses all steps in the water supply system, from catchment to consumer

3.11 Data Quality Control

The data collectors and supervisors was given two days of intensive training by the principal investigator (PI) on the instruments, method of data collection, how to analyze the water sample and ethical issues. A control sample was analyzed for every 10-15 water samples. Aseptic techniques were followed by avoiding any touch to the inside of the sample container or cup with fingers or any other object. To prevent cross-contamination between two consecutive water sample analyses sterilization was used by 99.9% Methanol and waited for 15 minutes(2013). Intensive supervision was done by principal investigator and supervisor and the collected data was checked for completeness, accuracy, and consistency throughout the data collection period. The overall supervision was done by the principal investigator. Double data entry was used to avoid data entry errors.

3.12 Ethical consideration

Prior to data collection process, African center of excellency for water management (ACEWM) wrote an official letter to Harari region water supply and sewerage authority and was able to get consent from the authority. The communities speak Afaan Oromo language, so the questionnaire was translated into Afaan Oromo language. Informed voluntary written and signed consent was obtained from each participant after explaining the purpose and benefits of the study. The data collector was oriented to respect the culture of the people in these communities throughout the data collection process. Confidentiality of the study participants' information was also ensured

3.13 Information Dissemination

The finding of this research will be submitted to African center of excellence for water management (ACEWM), Dirre Tiyyara woreda, Harari region water supply and sewerage authority of and it will also be shared with the nongovernment organization working on water supply and sanitation and other interested bodies. It will be published in international journals.

4 RESULTS AND DISCUSSION

4.1 Socio-demographic status of study participants

91.7% of the respondents were women above 18 age .Out of which (77.2%) of them were married women. nearly half (46.7%) of them did not attend formal education. 98.3% of the respondents were Muslims and the average family size was 6 (Table1).

Table 1.showing socio-demographic status of the study participant in dirre tiyyara woreda, eastern Ethiopia 2020.

No	Variable		Frequency	Percentage (%)
1	Sex of respondent	Male	15	8.3%
		Female	165	91.7%
2	Religion of the respondent	Muslim	177	98.3%
		Orthodox	1	
		Protestant	2	
		Other		
3	Marital status of the respondent	Single	24	13.3%
		Married	139	77.2%
		Divorced	6	3.3%
		Widowed	10	5.5%
4	Occupation	Farmer	131	72.8%
		Merchant	19	10.5%
		Gov't employ	27	15%
		Daily laborer	3	1.7%
5	Educational status of the respondents	Can't read and write	84	46.7%
		Can read and write	31	17.2%
		Attend Elementary school	29	16%
		Attend high school	7	3.9%

	College and above	29	16%
6	Average family size	5.75	

4.2 Water availability, accessibility and reliability

The average service year of the water source was 8 years while the maximum service years were 12 years. On the other hand 96.1% of the respondent responded that the water sources are free of odor and taste.

According to the result of the study the average two ways time taken for fetching water was 20 minutes. On the other hand 8.3% of the community has to walk more than 30 minute to fetch water. In the previous one month 26.7% of the community has experienced water scarcity and the primary reason for the shortage of the drinking water was due to low yield and lack of timely maintenance of the water source (Table 2).

On the other hand study conducted in rural areas of Ethiopia revealed that more than 84% of the house hold spent more than 50 minute to collect water (Usman, 2016).In addition According to (EDHS, 2016) more than half (53%) of rural community travel more than 30 minute for round trip. This indicates that the study community has relatively better basic access to drinking water. The better accessibility in this study is ma be due to availability of private water source in the area. Half (50%) the water source included the survey were private.

Another finding from multivariate analysis (Mekonnen et al., 2019) showed that households which encountered water shortage within the previous month had significantly higher fecal contamination than their counterparts. Furthermore another a community-based survey done in Tamale Metropolis, Ghana (2013) among 250 households showed that households that get water from sources found outside their home were 81% less likely to had good water quality than households that get their water in their home by a tap (Boateng, 2013).Thus collecting water out of premises ma increase the probability of water contamination during transportation.

Collecting water is responsibility and primarily burden of married woman (70%).Similarly (EDHS, 2016) report provided that collecting water is the responsibilities of married women in

rural areas. This indicates collecting water is perceived as a duty of woman in rural areas of Ethiopia.

Table 2 Water availability, accessibility and reliability in Dirre Tiyyara Woreda, Eastern Ethiopia 2020.

Variables	Categories	Frequency	Percentage
Household member who usually collect water	Adult man (> 15 years)	8	4.4%
	Adult woman (> 15 years)	15	8.3%
	Male child (under 15 years)	13	7.25
	Female child (under 15 years)	18	10%
	Married woman	126	70%
Daily water consumption(per capita per day)	Basic accessibility(>20liters/capita/day	77	42.8%
	Not accessible(<20liters/capita/day	103	57.2%
Limit on the amount of water you can fetch?	Yes	101	56.1%
	No	79	43.9%
If yes reason	1 quota	3	3%
	2 low water yield of source	58	57.4%
	3 Long time waiting	44	43.6%
How often is water flowing in your main access	1 Always (7 days /week)	140	77.8%
	2 often (>3 days/ week)	10	5.6%
	3 rarely (<3days/ week)	30	16.7%
Do you pay for water?	Yes	38	21%
	No	142	78.9%
If yes How much?	Per 20 liter	2 birr	

4.3 Water Safety Plan at Source/Catchment

4.3.1 Water Supply Scheme system Description and Institutional capacity characteristics

Ground water was the major source of water supply for drinking; irrigation and domestic use in Dirre Tiyyara. Majority of the drinking water source were located within 1km radius of the community. It was also observed that all water sources were surrounded by farm land/ green vegetation from chat farm land. Furthermore, majority of the water sources (10 sources) lack fencing which allow animal's to get access to the water source. In addition, animal feces were also found within 10 M of water source during sanitary survey of water source.

On the other hand all water supply schemes were community managed system. Thus, operation and management is expected to be carried out by WASCHO, as well owner of the water supply scheme (in the case of private well).In further WASCHO were trained on operation, treatment and maintenance of water supply scheme. In addition the WASCHO responded that water source is expected to be disinfected every six month. However, source treatment is not regular.

This result comply with MoWIE report which revealed that majority of the rural areas in Ethiopia rely on one point water supply. In addition it was also indicated that this sources experience frequent breakage and lack timely maintenance, lack regular treatment, lack quality monitoring and sanitation survey(MoWIE, 2015). Another study cross sectional study conducted in South west Ethiopia Serbo town (2010) on 18 unprotected wells and 6 protected wells, revealed that for all of the water sources there was no regular water source treatment undertaken(Abera et al., 2011). This shows that problem faced in rural community water supply common in rural Ethiopia.



Figure 3 Drinking water source in rural community of dirre tiyyara woreda, eastern Ethiopia 2020.

4.3.2 Bacteriological and physicochemical quality of source water

According to the result of the study out of twelve samples taken from different water source only samples from one well with hand pump was free of E.coli (0 CFU/100ml). Whereas, samples from the other eleven (11) sources were encountered for the fecal contamination (Table 3).

A similar study conducted in Dire Dawa district (Amenu et al., 2014) showed that all samples from of the water sources analyzed were contaminated with fecal coliform except the water sample from tap. Another study cross sectional study conducted in South west Ethiopia Serbo town (2010) on 18 unprotected wells and 6 protected wells, revealed that Analysis of sample from protected well reveals that three of the well had total coliform count more than 10 ml per 100 ml of the water This finding has similarity with present study(Abera et al., 2011). The similarity is may be due to vulnerability of rural water supply sources to fecal contamination.

In all water sources turbidity was less than <5NTU .This result comply with the WHO guideline for drinking water. The recorded temperature and PH range of water source was 21.3c⁰-26.2c⁰and 6.81-8.00 respectively. In none of the water sources residual was chlorine was not tested.

Table 3 Bacteriological quality and sanitary survey of water sources in rural community of dirre tiyyara woreda, eastern Ethiopia 2020.

Water source name	Type of water source	owner	TTC count (100ml/CFU)	Source Sanitary risk category
Laga Asangey	Hand dug well with mechanized pump	private	15CFU/100ml	Intermediate risk
Ganda Sukul	Hand dugwell with hand pump	public	08 CFU/100ml	Intermediate risk
Ganda Dirre	Hand dug well with mechanized pump	private	52 CFU/100ml	Intermediate risk
Ganda Abdurrahman	Hand dug well with mechanized pump	private	07 CFU/100ml	Intermediate risk
Laga Fuade	Hand dug well with mechanized pump	private	06 CFU/100ml	Intermediate risk
Laga Ahmed Hassan	Hand dug well with hand pump	public	03 CFU/100ml	Intermediate risk
Abubakar Muti	Hand dug well with mechanized pump	private	19 CFU/100ml	Intermediate risk
Ganda Ashawa	Hand dug well with hand pump	Public	0 CFU/100ml	Low risk
Ganda Assoy	Hand dug well with hand pump	Public	17 CFU/100ml	High risk
Ganda Ibrahim	Hand dug well with hand pump	Public	02 CFU/100ml	Intermediate risk
Ganda Qajeela	Hand dug well with hand pump	Public	117 CFU/100ml	High risk
Ganda Muti	Hand dug well with mechanized pump	private	06 CFU/100ml	Intermediate risk

4.3.3 Sanitary survey and Risk assessment of drinking water source areas

As reported from the result of sanitary survey conducted around the catchment of drinking water out of 12 drinking water sources one covered dug well with hand pump had low risk on microbiological quality of drinking water, four covered dug well with hand pump and 5 borehole with mechanized pump drinking had intermediate risk, and one covered dug well with hand pump and one bore hole with mechanized pump water source had high microbiological risk of source contamination.

Table 4 Risk prioritization for water source in rural community of Dirre Tiyyara Woreda, Eastern Ethiopia 2020.

		Sanitary risk assessment of water source VS bacteriological quality of drinking water at source(risk prioritization)			
		0-2 (low risk)	3-5 (medium risk)	6-8 (high risk)	9-11 (very high risk)
E. Coli	confirmatory	1	1	0	0
	Low	0	6	0	0
	intermediate	0	3	1	0
	High	1	0	0	0

Thus, based on the combined result analysis of sanitary risk assessment of water source and bacteriological quality out of twelve(12) water source assessed and analyzed seven(7) water source had no or minor public health impact, hence is clearly not priority. On the other hand four water sources had moderate public health impact as a result it requires some attention or long term priority. Whereas, one drinking water source had major public health impact and it is clearly priority and need urgent action.

4.4 Water Safety at Point Of Use

4.4.1 Water Safety at Point Of Use /House Hold Water Treatment

It was reported that 33.8% of the community treat the drinking water at house level prior to drinking. Out of this 93.7% add bleach/chlorine for water treatment. However based on the

residual chlorine test conducted on site, residual chlorine was not detected in none of the treated water at house hold.

In this study water treatment at household level prior to drinking was found to be much higher than a cross sectional study conducted in Dire Dawa in 2011 only 13% of the population treat water at home(Amenu et al., 2013). Furthermore the present finding showed discrepancy with the Ethiopian demographic health survey (2016) which provided that water treatment practice at home is only 11.6% of urban and 7.9 % of rural households treat water at home (EDHS, 2016).The difference observed in this study may be due to the site selection or awareness of the community regarding water treatment.

Another community based cross sectional survey conducted in rural Ethiopia (2014) indicates that among house hold who treat water at home, more than 81% use chlorination. This result is has similarity with the current study which indicates chlorination is the most (93.7%) utilized water treatment at household level. However based on the residual chlorine test conducted on site, residual chlorine was not detected in none of the treated water at house hold. This may happen due to improper treatment of water or due to analysis of untreated water sample during the survey.

4.4.2 Water Safety at Point Of Use / Bacteriological and physico-chemical quality of drinking water at point of use.

The result of the survey indicated that from total 180 samples taken at house hold level/point of use only 7.8% of them were free for fecal contamination. On the other hand 91.2% of the samples had fecal coliform above permissible level for drinking water. Regarding public health risk the water contamination was low, intermediate and high for 23.9%, 37.8% and 30.5% of the household respectively (Figure4).

The proportion of households with contaminated drinking water (91.2%) in this study was higher than the finding of (Copeland, Beers et al. 2009) in which only 30.3% of the water samples from the households were found positive for E coli. A possible reason for this difference might be the

type of the water sources and difference in water handling and storage practice at point of use (Usman et al. 2017).

Concerning the bacteriological quality of the drinking water, the average number of E.coli colony counts per 100ml at households was higher than sources at every point (Figure3).

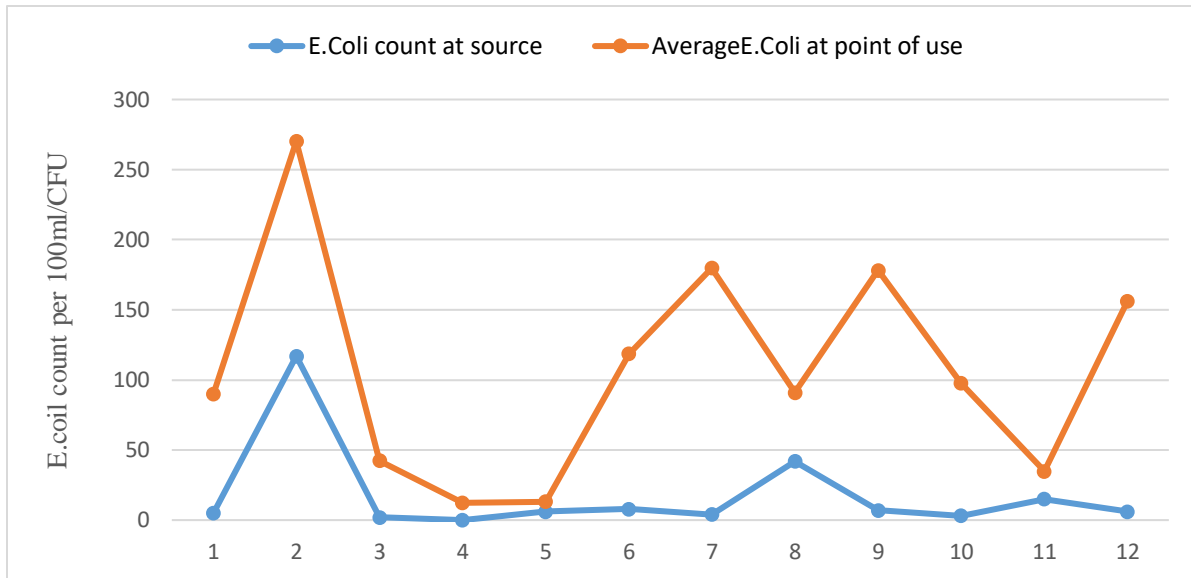


Figure 4 Comparisons of E.coli Count at source and point of use per 100ml/CFU in Dirre Tiyara woreda eastern Ethiopia, 2020.

This finding is also supported by (Copeland et al. 2009, Mekonnen et al., 2019) which emphasized the fecal coliform counts in the stored water samples were significantly higher than the source sample. Moreover the study conducted in Bolivia states that the quality of drinking water deteriorates along the pathway from supply source to the point of use. Accordingly the Median concentration of E.coli showed significant increment from 0 CFU/100 ml (IQR: 0-13) at the source to 8 CFU/100 ml (IQR:0-550) at the drinking cup in the home (Wilcoxon signed rank test: $n=81$, $z=-3.7$, $p < 0.001$) (Rufener et al., 2010). Similarly according to (Usman et al., 2017), the results from the logistic regression estimates suggested that stored water from surface water is 3.7 times more likely to be contaminated with fecal materials compared to protected wells/springs. This clearly indicates microbiological quality of water deteriorates as it goes from source to point of use may be due to transportation, unsanitary handling and storage practice at point of use.

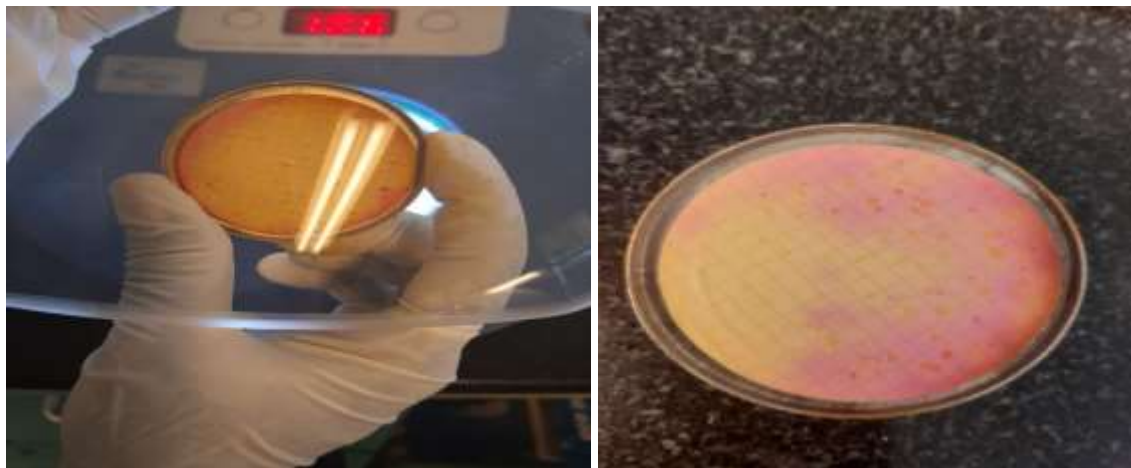


Figure 5 Water sample positive for TTC at point of use in rural community of Dirre Tiyyara Woreda, Eastern Ethiopia 2020.

In all water samples analyzed turbidity was less than <5 NTU which was in line with the WHO recommendation for drinking water. The recorded temperature and pH range of water source was 21.6°C - 26.2°C and 6.73 - 8.23 , respectively. Residual chlorine was not detected in any of the household water containers.

4.4.3 Water Safety Plan at Point Of Use/water handling and storage practice point of use

The result showed that 75.6% of the drinking water containers were found covered with its lids during the survey. On the contrary based on the observation made 26.7% of the inside of storage container not clean. On the other hand Pouring is the most common withdrawal method of drinking water from storage container in the community (Table 4).

Table 5 Point of use water handling and storage practice use in rural community of dirre tiyyara woreda, eastern Ethiopia 2020.

Variable	categories	Frequency	Percentage (%)
Drinking water kept in separate container	Yes	131	72.8%
	No	49	27.2%
Water stored in narrow necked container	Yes	150	83.3%
	No	30	16.7%
Water storage covered with its lid	Yes	136	75.6
	No	44	24.4
Inside of water storage container kept clean	Yes	132	73.3%
	No	48	26.7%
Water storage container placed off floor (placed 30cm above floor)	Yes	60	33.3%
	No	120	66.7%
Outside of water storage container kept clean	Yes	153	85%
	No	47	15%
Method of water withdrawal from storage container	Dipping	173	96.1%
	pouring	7	3.9%
Utensil/cup used to draw water is kept clean	Yes	35	19.4%
	No	145	80.6%
Utensil/cup used to draw water from container kept away from floor or stored in the shelf/sling on the shelf on the container	Yes	87	48.3
	No	93	51.7%
How often is the container cleaned	Everyday	98	54.4%

	Every week	51	28.3%
	Every month	24	13.4
	Rarely	7	3.9%
	Never	0	0
How often is utensil/cup is cleaned	Every day	101	56.1%
	Every week	73	40.5
	Every month	6	3.4%
	Rarely never	0	

4.4.4 Water Safety Plan at Point Of Use/ House Hold Sanitation /Latrine Availability, Use and Operation

With regard to latrine availability, 90% of the community use latrine. Out of this 28.3% of them were shared by more than one household. On the other hand only 5.8% of the toilet were improved latrine and 4.6% hygienically used. It was observed that 14.8% of the latrine do not provide privacy and 16% of the latrine do not have adequate height (<1.7cm).it was also observed that 16.7% of the latrine do not have cover and 39.5 % of the latrine had fecal smear on the floor of the latrine out of pit latrine (Figure 2).

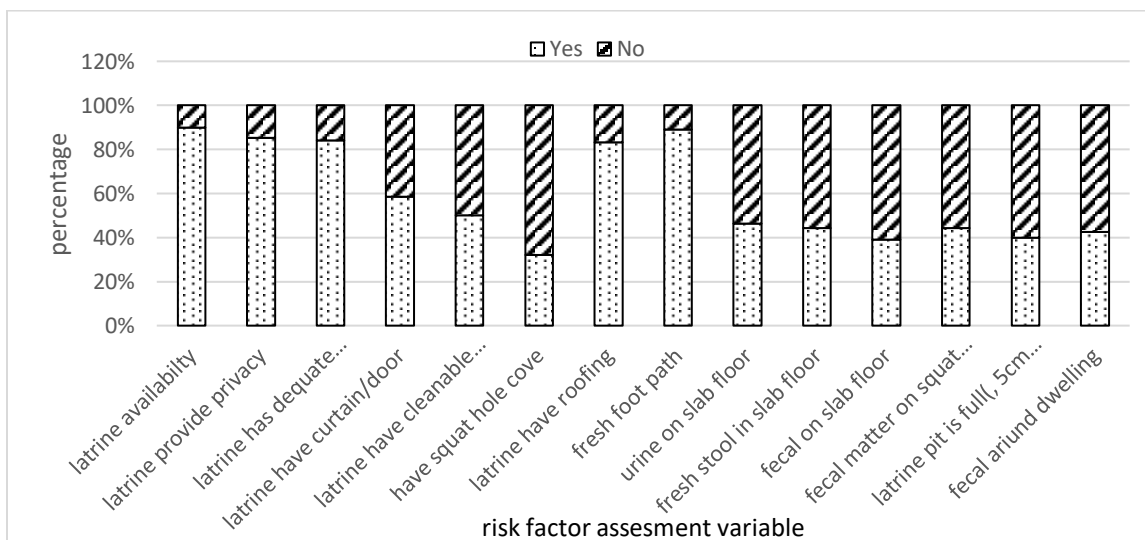


Figure 6 House hold/point of use latrine availability, use and operation practice in rural community of Dirre Tiyyara Woreda, Eastern Ethiopia 2020.

This result has shown discrepancy with 2016 EDHS reports which indicate one in three household in rural communities do not have access to latrine. Out of this only 2% of the latrine was shared among neighbor. In addition majority 56% of the latrine used was improved. Latrine coverage in the study area also found to be much higher when compared to a survey conducted in rural areas of Ethiopia provided that around 43% of the population practice open Defecation in rural area (WHO/UNICEF, 2014).The discrepancy observed is may be due to sample size difference.

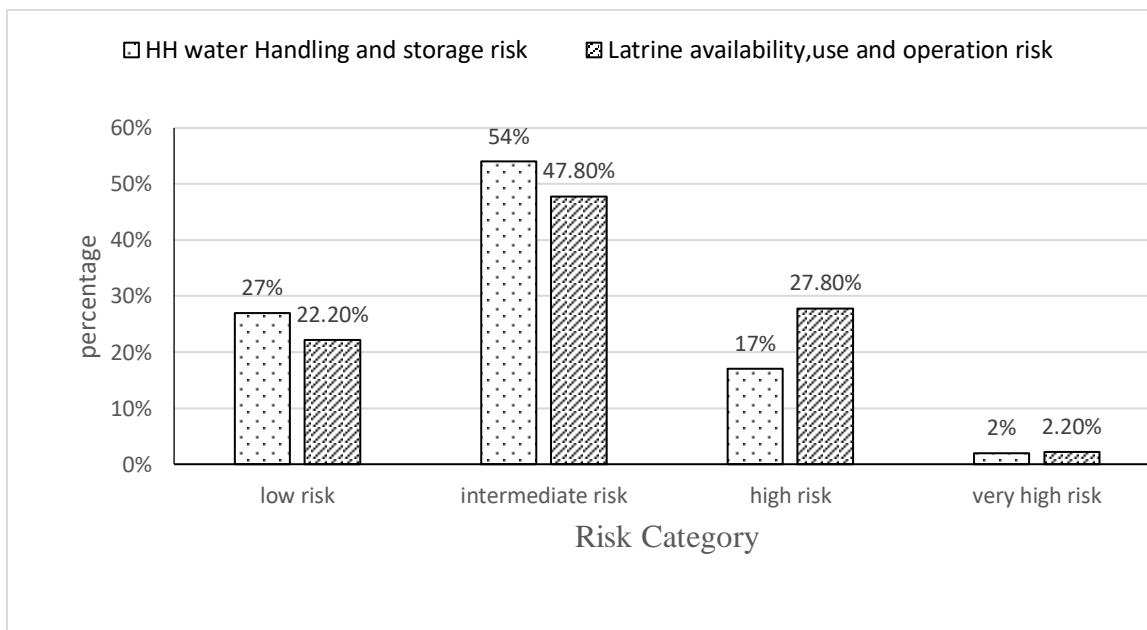


Figure 7 Household level water handling and storage and latrine availability, use and operation risk rating in rural community of dirre tiyyara woreda, eastern Ethiopia 2020.

Table 6 water handling and storage sanitation risk prioritization at household level in rural community of dirre tiyyara woreda, eastern Ethiopia 2020.

		HH water contamination risk factor rating/Vulnerability of drinking water to contamination from water handling at point of use			
		0-2 (low risk)	3-5 (medium risk)	6-8 (high risk)	9-11 (very high risk)
E. Coli	confirmatory	8	5	1	0
	low	24	19	0	0
	intermediate	15	44	8	1
	High	2	30	21	2

Combined result analysis of sanitary risk assessment of water handling and storage at point of use and bacteriological quality water at point of use revealed that 4.4 % of the households comply with WHO and national standards on the contrary 54.7% of them had major public health impact and it is clearly priority and need urgent action. (Fig8).

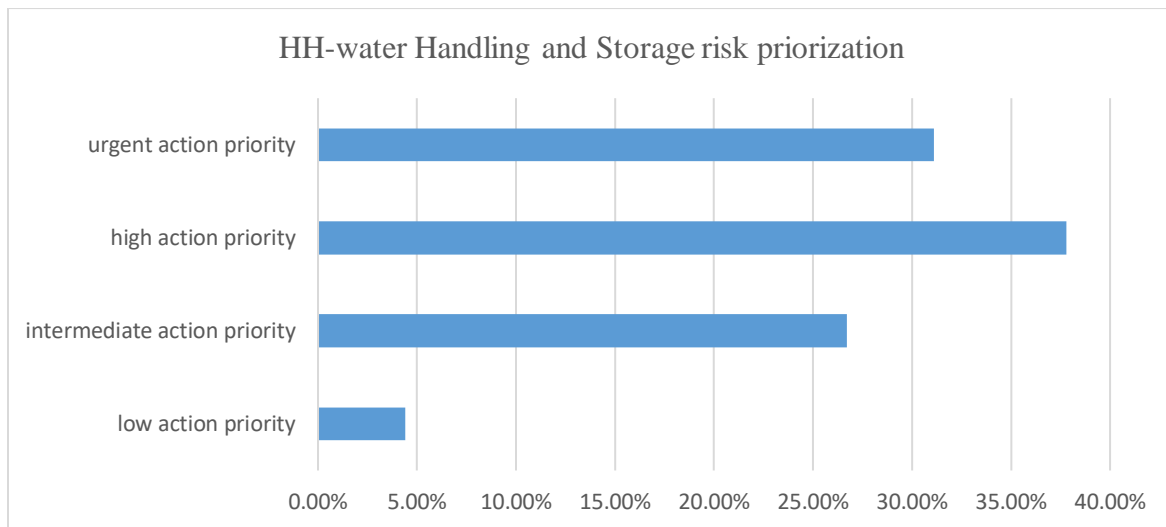


Figure 8 HH level water Handling and storage risk priority in in rural community of Dirre Tiyyara Woreda, Eastern Ethiopia, 2020.

Table 7 Sanitation risk prioritization at house household level in rural *community of Dirre Tiyyara Woreda, Eastern Ethiopia 2020.*

		HH water contamination risk factor rating/Susceptibility of drinking water to contamination from human & animal faces at point of use related to latrine			
		0-2 (low risk)	3-5 (medium risk)	6-8 (high risk)	9-11 (very high risk)
E. Coli	confirmatory	5	7	20	0
	Low	19	22	2	0
	intermediate	14	34	18	2
	high	2	23	28	2

Thus, based on the combined result analysis of sanitary risk assessment of latrine availability, use and operation and bacteriological quality out of total 180 Households 31.6% of the households had major public health impact and it is clearly priority and need urgent action (fig 9).

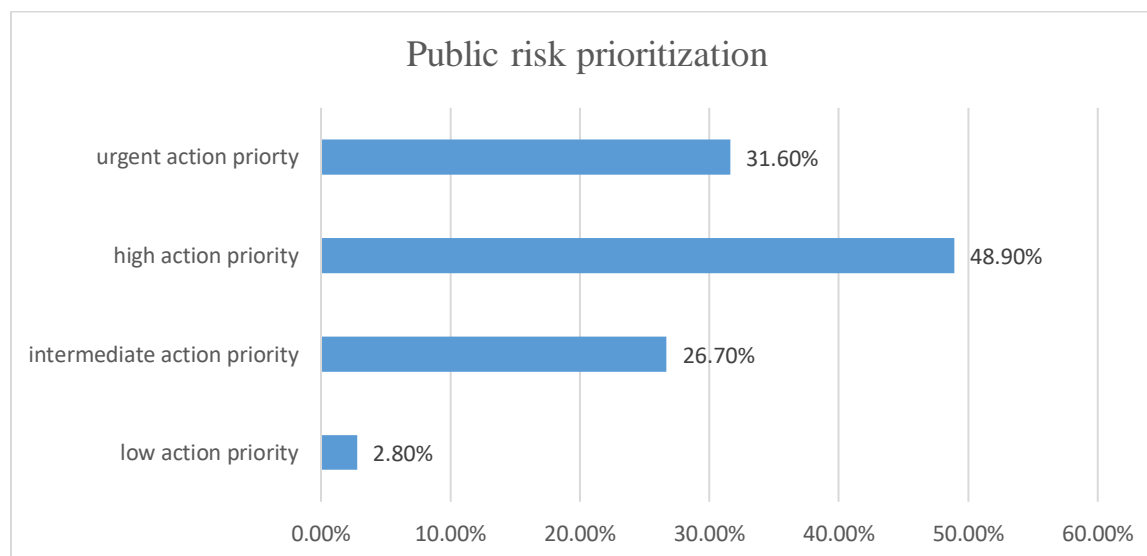


Figure 9 Public health risk prioritization in rural community, dirre tiyyara woreda, eastern Ethiopia, 2020.

4.5 Knowledge On Hand Washing and Water Contamination

95% of the respondent responded that hand washing is mandatory after visiting toilet, before meal, before food preparation and feeding children. Majority 52.2% of the respondent responded that water contamination may occur both at source and point of use. Furthermore the respondents were aware that cleaning water collection storage, hand washing before water collection and water treatment at house hold can prevent water contamination (Table5).

Table 8: Knowledge of the respondents on critical handwashing times and points of water contamination in Dirre Tiyyara woreda eastern Ethiopia, 2020.

Variables	Categories	Frequency	Percentage
Where do you think drinking water contamination occurs	At source	62	34.4%
	In household	24	13.4%
	Both	94	52.2%
Cleansing water collection and storage material prevent water contamination?	Yes	170	94.4%
	No	10	5.6%
washing hands before water collection can prevent water contamination	Yes	171	95%
	No	9	5%
Proper utilization of latrine can prevent water contamination	Yes	171	95%
	No	9	5%
treating water in household can prevent water contamination	Yes	173	96.1%
	No	7	3.9%
washing hands after defecation can prevent water contamination	Yes	175	97.2%
	No	5	2.8%

4.6 Factors affecting bacteriological quality of drinking water at point of use

In bivariate logistic regression analysis water treatment at point of use/household level, Household water handling and storage, and latrine availability, use and operation were associated (p-value< 0.001) with bacteriological quality of drinking water at point of use. Finally in multivariate logistic regression analysis, the variables were found to be statistically significant at 5% level of significance (Table 6).

Table 9 Bivariate and multi variable analysis of bacteriological quality of water sample at Point of Use related to HH-level water treatment, water handling storage and latrine availability, use and operation.

variables	Categories	Crude IRR(95%,CI)	Adjusted ratio (95%,CI)	odd P Value
Treatment at point of use	Yes	1	1	<0.001
	No	3.44(3.30, 3.59)	1.99(1.89, 2.07)	<0.001
HH_water handling and storage	Low risk	1	1	<0.001
	Intermediate risk	3.36(3.14, 3.59)	1.83(1.70, 1.96)	<0.001
	High risk	9.7(9.1, 10.4)	3.60(3.33, 3.89)	<0.001
	Very high risk	17.34(15.9, 18.9)	8.89(8.19, 9.86)	<0.001
Latrine availability, use and operation	Low risk	1	1	<0.001
	Intermediate risk	0.95(0.80, 1.03)	2.69(2.49, 2.89)	<0.001
	High risk	2.07(2.03, 2.15)	4.26(2.49, 2.89)	<0.001
	Very high risk	6(1.65, 1.87)	3.86(3.45, 4.32)	<0.001

Various water treatment like boiling, filtering, or chlorinating water at home has improved the microbiological quality of drinking water(WHO,2013). This statement goes with the present study which revealed that, the odd ratio of the household who don't practice household water treatment were two times more likely to be contaminated than those whose use water treatment at house hold level,[AOR=1.99; 95% CI (1.89, 2.07)](table 6).Similarly, another experimental study conducted among 90 households which were taken from 23 water sources conducted in Malawi (2011) provided that the mean bacteria concentrations of the untreated water is 74 CFU/100 ml for E.coli which was much higher than the mean concentration of the treated water at home which was 4.0 CFU/100 ml for E.coli(Thokozani et al., 2016).Furthermore effective and consistent utilization of HWTS was able to reduce disease by 61% of diarrheal disease which is mainly caused consuming faecally contaminated water (WHO, 2016) is finding indicates that proper HWTS is effective in maintaining and improving bacteriological quality of drinking water.

In addition water handling and storage was also significant factor affecting the quality of drinking water at point of use. Accordingly the odds of household drinking water contamination in the house hold with intermediate risk were 1.83 more likely to be contaminated than the house with low risk category regarding water handling and storage at point of use [AOR=1.83; 95%CI (1.70, 1.96)].The house hold with high risk category risk were found to be 3.60 more likely to be contaminated than the house with low risk category respect to water handling and storage at point of use[AOR=3.60; 95%CI (3.33, 3.89)].furthermore the house hold which found to have low risk water handling and storage were 8.89 less likely to be contaminated compared to household with very high risk [AOR=8.89; 95%CI (8.19, 9.86)] (Table 6).

In multivariate regression analysis latrine availability, use and operation were also found to be another significant factor affecting the microbiological quality of drinking water at point of use. Consequently the odd ratio of drinking water quality of house hold with intermediate risk regarding to latrine availability, use and operation were 2.69 more likely to be contaminated than low risk households[AOR=2.69; 95%CI (2.49, 2.89)]. On the other hand Drinking water sample from households low risk were 4.26 less likely to be contaminated compared to the households with high risk [AOR=4.26; 95%CI (3.69, 4.58)].In addition the households with very high risk

were 3.86 more likely to be contaminated than the house hold with low risk of contamination [AOR=3.86; 95%CI (3.45, 4.32)] (Table 6).

The discrepancy observed on microbiological water quality between source and point of use may be related to the fact sanitary risk from water handling and storage, and latrine availability, use and operation. Combined result analysis of sanitary risk assessment of water handling and storage at point of use and bacteriological quality water at point of use revealed that 4.4 % of the households were compliant with WHO and national standards and 37.3% of the had low impact and they are clearly not priority. On the other hand 67.6% had moderate impact and requires or long term remedial action plan.54.7% of them had major public health impact and it is clearly priority and need urgent action.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Out of twelve Water sources analyzed for microbial contamination eleven sources were found to be faecally contaminated. In addition Source Sanitary risk assessment also revealed that the water sources were vulnerable for faecal contamination risk from surrounding environment. Great discrepancy was observed in microbiological quality of water from source to point of use. Thus all samples (100ml/CFU) at point of use had shown increment in TTC count. Water handling and storage, water treatment and latrine availability, use, and functionality (sanitation facility) has found to be a potential risk and associated with faecal contamination of drinking water at point of use. Finally the safety of drinking water could be achieved good catchment management (source protection, timely maintenance and treatment) safe handling and storage practice, and availability and safe utilization of sanitation service.

5.2 Recommendation

Based on the finding of this study, the following recommendations were made:

- ✓ Dirre Tiyyara Woreda and Harari Region water supply and sewerage authority
 - Bacterial counts in almost all source and majority of the household have exceeded permissible level of water for drinking and urgent action should be taken to ensure the water quality.
 - Concerned sector Dirre Tiyyara Woreda , Harari Region water supply and sewerage authority and Should strengthen WASCHO in the district and give training on catchment management, operation and maintenance and treatment of water source
 - Where quality of water is at source immediate action such fencing, maintenance and disinfection should considered and continuous monitoring

of bacteriological analysis should be undertaken to determine whether it is safe for drinking.

- At point of use where there is high public health risk emergency precautions such chlorine tablets, filtration and boiling should be applied for immediate disinfection at household level and then carry out bacteriological analysis to determine whether it is safe for drinking.
- Providing Health education programs on water safety plans including safe water handling and storage ,point of use water treatment and sanitation, hygienic practices so as to improve water safety of the rural community,
- To ensure the sustainability of drinking water quality in the area community should actively participate in the water supply project planning and implementation.

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Appendices

Appendix I: Participant Information sheet and Informed Voluntary Consent for respondent

(English Version) My name is _____. I am working as data collector for the study

being conducted in this community by Gutema Mulatu who is studying his Master's degree at African Center of Excellency at Addis Ababa University. I kindly request you to lend me your attention to explain you about the study and being selected as the study participant.

The study title: Water safety plan Managing Drinking Water from catchment to consumer, Dirre Tiyyara, Eastern Ethiopia.

Purpose of the study: The findings of this study can be of a paramount importance for Harari Region water supply and Sewerage Authority and Harari region health office to plan intervention programs to improve the drinking water quality. Moreover, the aim of this study is to write a thesis as a partial requirement for the fulfillment of a Master's program in Water Supply and Sanitation Management for the principal investigator.

Procedure and duration: I will be interviewing you using questionnaire to provide me with pertinent data that is helpful for the study. There are --- questions to answer where I will fill the questionnaire by interviewing you and drinking water sample will be analyzed by membrane filtration. The interview and water sample analysis will take about 30 minutes, so I kindly request you to spare me this time for the interview.

Risks and benefits: The risk of being participated in this study is minimal, but only taking few minutes from your time. There would not be any direct payment for participating in this study. However, the findings from this research may reveal important information for Harari region Water Supply and Sewerage Authority, Harari Region Health Office and government planners.

Confidentiality: The data you will provide us will be confidential. There will be no information that will identify you in particular. The findings of the study will be general for the study population and will not reflect anything particular of individual person. The questionnaire will be coded to exclude showing names. No reference will be made in oral or written reports that could link participants to the research.

Rights: Participation in this study is voluntary. You have the right to declare to participate or not

in this study. If you decide to participate, you have the right to withdraw from the study at any time and this will not label you for any loss of benefit, which you otherwise are entitled. You do not have to answer any question that you do not want to answer.

Contact address: If there, are any questions or enquires any time about the study or the procedures, please contact: Gutema Mulatu:

Mobile number (+251)-915-913313

Email Address: gutumule@gmail.com

Institutional Health Research Ethics Review Committee: -----

P.O.Box: -----

Declaration of informed voluntary consent:

I have read/was read to me the participant information sheet. I have clearly understood the purpose of the research, the procedures, the risks and benefits, issues to confidentiality, the rights of participating and contact address for any queries. I have been given the opportunity to ask questions for things that may have been unclear. I was informed that I have the right to stop the study at any time or not to answer any question that I do not want. Therefore, I declare my voluntary consent to participate in this study with my initials (signature) as indicated below. Name and signature of the participant: _____ Signature of data collector: _____

Date: _____

WS10	If yes How?	1 Metered 2 fixed 3 buy	If 1,2- >WS12
WS11	How much do you pay? (for only those who buy water)	_____ per 20L jerry can _____ per week	

Household Water, Sanitation and Hygiene Practice

General Information

1. Source of Water _____
 2. Does the water source is improved? Yes No
 3. Does the Household use any type of Household Water Treatment methods of means? Yes No
- | | | |
|---|------------------------|----------------------------|
| If yes to the above question, which method have you used? | 1. Boil | 4. Filter with sand |
| | 2. Add bleach/chlorine | 5. Let it stand and settle |
| | 3. Filter with cloth | 6. Other(specify) |
4. If yes please observe and mention _____
 5. Average amount of water collected daily _____ liter
 6. Water containers per household Container with capacity of 20 liter ___ and capacity of 10 liter _____

HH Water Contamination Risk factor Assessment

1. Is drinking water kept in a separate container (ask to be shown this)? Yes No
 2. Is the Water stored in the narrow necked container (<=7.6cm diameter)? Yes No
 3. Is the water storage container covered with its lid? Yes No
 4. Is inside of the water storage container kept clean? Yes No
 5. Is the water storage container placed off floor (>30 CM above the floor)? Yes No
 6. Is outside of the water storage container kept clean? Yes No
 7. Does water taken/drown from the container by pouring? Yes No
 8. Is the utensil/cup used to draw water from the container kept clean? Yes No
 9. Is the utensil/cup used to draw water from container kept away from floor and Stored in the shelf/sling on the neck of the container?
- Total Score Yes _____/9 No _____/9
11. How often is the container cleaned?
I. Everyday____ **II.** Every week____ **III.** Every month____ **IV.** Rarely____ **V.** Never Every
 12. How is the container cleaned?

Over all conclusion Risk rating No 0-2 Low; 3-5 medium; 6-8 high; 9-12 very high

III. Availability, use and operation of Latrine and hand washing facility and domestic hygiene

1. Does the household have latrine? Yes ___ No ___

2.If yes, observe condition and functionality of the latrine and hand washing facility
HH Latrine Observation Checklist
I. Does the latrine have wall that provide privacy? Yes <input type="checkbox"/> No <input type="checkbox"/>
II. Does the latrine have wall have adequate height (>1.7m)? Yes <input type="checkbox"/> No <input type="checkbox"/>
III. Does the latrine have door/curtain? Yes <input type="checkbox"/> No <input type="checkbox"/>
IV. Does the latrine have intact/cleanable floor/slab? Yes <input type="checkbox"/> No <input type="checkbox"/>
V. Does the latrine floor/slab have squat-hole cover? Yes <input type="checkbox"/> No <input type="checkbox"/>
VI. Does the latrine have roofing? Yes <input type="checkbox"/> No <input type="checkbox"/>
Latrine use/functional
I. Is there fresh foot path leading to the latrine? Yes <input type="checkbox"/> No <input type="checkbox"/>
II.Is there splash of urine/water on the floor/slab? Yes <input type="checkbox"/> No <input type="checkbox"/>
III. Is there fresh stool in the latrine pit? Yes <input type="checkbox"/> No <input type="checkbox"/>
Cleanliness (hygiene condition)
I. Is the fecal matter or dirty on the floor of the latrine? Yes <input type="checkbox"/> No <input type="checkbox"/>
II.Is there fecal smear on the squat-hole? Yes <input type="checkbox"/> No <input type="checkbox"/>
Is the latrine pit full (sludge \geq 0.5m from the floor/slab)? Yes <input type="checkbox"/> No <input type="checkbox"/>
IV. Is there stool around the latrine/dwelling house? Yes <input type="checkbox"/> No <input type="checkbox"/>
Knowledge of Hand Washing with soap during critical time(probe for all possible)
When do you consider hand washing with soap is important?
I. After defecation/ visiting toilet _____
II. Before eating _____
III. Before feeding a child _____
IV. Before preparing/handling food_____
After assisting children in defecation/ cleaning bottom _____
Others_____
Cleanness of the house and compound comment on the following
I. Is inside of dwelling house kept clean? Yes <input type="checkbox"/> No <input type="checkbox"/>
II.Is household solid/garbage disposed of in the pit/composted? Yes <input type="checkbox"/> No <input type="checkbox"/>
III. Is household Liquid waste collected and poured/dispensed in soak away pit?
Over all conclusion Risk rating No 0-2 Low; 3-5 medium; 6-8 high; 9-12 very high
Improved latrine: Provide privacy, safety and comfort to the users and interrupt disease transmission. i.e., preclude faeces from water source, soil and flies. • Count YES and add for Q 1+2+3+4+5 and divide for 5 for each household. Then, calculate mean score for total of observed household during risk assessment Latrine use/functionality: if all or either of the three proxy indicator exists is considered the latrine is in use Latrine cleanliness (hygienic use): if the latrine is hygienically kept, proxy indicators Q10, 11, 12 and 13 should not exist. Therefore, • Count NO and add for Q10+11+12+13 and divide by 4 for each household. Then, calculate mean score for total of observed household during risk assessment
HH identification

Code _____							
1. Source of Water _____							
2. Does the water source is improved? Yes <input type="checkbox"/> No <input type="checkbox"/>							
3. Does the Household use any type of Household Water Treatment methods of means? Yes <input type="checkbox"/> No <input type="checkbox"/>							
If yes to the above question, which method have you used?	<table border="0"> <tr> <td>7. Boil</td> <td>10. Filter with sand</td> </tr> <tr> <td>8. Add bleach/chlorine</td> <td>11. Let it stand and settle</td> </tr> <tr> <td>9. Filter with cloth</td> <td>12. Other(specify)</td> </tr> </table>	7. Boil	10. Filter with sand	8. Add bleach/chlorine	11. Let it stand and settle	9. Filter with cloth	12. Other(specify)
7. Boil	10. Filter with sand						
8. Add bleach/chlorine	11. Let it stand and settle						
9. Filter with cloth	12. Other(specify)						
4. If yes please observe and mention _____							
5. Average amount of water collected daily _____ liter							
6. Water containers per household Container with capacity of 20 liter ____ and capacity of 10 liter _____							
HH Water Contamination Risk factor Assessment							
1. Is drinking water kept in a separate container (ask to be shown this)? Yes <input type="checkbox"/> No <input type="checkbox"/>							
2. Is the Water stored in the narrow necked container (<=7.6cm diameter)? Yes <input type="checkbox"/> No <input type="checkbox"/>							
3. Is the water storage container covered with its lid? Yes <input type="checkbox"/> No <input type="checkbox"/>							
4. Is inside of the water storage container kept clean? Yes <input type="checkbox"/> No <input type="checkbox"/>							
5. Is the water storage container placed off floor (>30 CM above the floor)? Yes <input type="checkbox"/> No <input type="checkbox"/>							
6. Is outside of the water storage container kept clean? Yes <input type="checkbox"/> No <input type="checkbox"/>							
7. Does water taken/drown from the container by pouring? Yes <input type="checkbox"/> No <input type="checkbox"/>							
8. Is the utensil/cup used to draw water from the container kept clean? Yes <input type="checkbox"/> No <input type="checkbox"/>							
9. Is the utensil/cup used to draw water from container kept away from floor and							
Stored in the shelf/sling on the neck of the container?							
Total Score Yes _____/9 No _____/9							
11. How often is the container cleaned? I. Everyday____ II. Every week____ III. Every month____ IV. Rarely____ V. Never Every							
12. How is the container cleaned? _____							

Over all conclusion Risk rating No 0-2 Low; 3-5 medium; 6-8 high; 9-12 very high

III. Availability, use and operation of Latrine and hand washing facility and domestic hygiene

.Does the household have latrine? Yes ___ No ___
2.If yes, observe condition and functionality of the latrine and hand washing facility
HH latrine observation checklist
I. Does the latrine have wall that provide privacy? Yes <input type="checkbox"/> No <input type="checkbox"/>
II.Does the latrine have wall have adequate height (>1.7m)? Yes <input type="checkbox"/> No <input type="checkbox"/>
III. Does the latrine have door/curtain? Yes <input type="checkbox"/> No <input type="checkbox"/>
IV. Does the latrine have intact/cleanable floor/slab? Yes <input type="checkbox"/> No <input type="checkbox"/>
V. Does the latrine floor/slab have squat-hole cover? Yes <input type="checkbox"/> No <input type="checkbox"/>
VI. Does the latrine have roofing? Yes <input type="checkbox"/> No <input type="checkbox"/>
Latrine use/functional
I. Is there fresh foot path leading to the latrine? Yes <input type="checkbox"/> No <input type="checkbox"/>
II.Is there splash of urine/water on the floor/slab? Yes <input type="checkbox"/> No <input type="checkbox"/>
III. Is there fresh stool in the latrine pit? Yes <input type="checkbox"/> No <input type="checkbox"/>
Cleanliness (hygiene condition)
I. Is the fecal matter or dirty on the floor of the latrine? Yes <input type="checkbox"/> No <input type="checkbox"/>
II.Is there fecal smear on the squat-hole? Yes <input type="checkbox"/> No <input type="checkbox"/>
Is the latrine pit full (sludge \geq 0.5m from the floor/slab)? Yes <input type="checkbox"/> No <input type="checkbox"/>
IV. Is there stool around the latrine/dwelling house? Yes <input type="checkbox"/> No <input type="checkbox"/>
Knowledge of Hand Washing with soap during critical time(probe for all possible)
When do you consider hand washing with soap is important?
I. After defecation/ visiting toilet _____
II. Before eating
III. Before feeding a child
IV. Before preparing/handling food____
After assisting children in defecation/ cleaning bottom
Others_____
Cleanness of the house and compound comment on the following
Is inside of dwelling house kept clean? Yes <input type="checkbox"/> No <input type="checkbox"/>
II.Is household solid/garbage disposed of in the pit/composted? Yes <input type="checkbox"/> No <input type="checkbox"/>
III. Is household Liquid waste collected and poured/disposed in soak away pit?

Appendix III: Institutional inspection tool

For community managed systems assess the capacity of Water, Sanitation and Hygiene Committee (WASHCO).

1. Is there WASHCO in this village?
2. Does any WASHCO member have skill relevant for operation and maintenance of water supply scheme?
3. Did any WASHCO member take training on water quality management (catchment protection, disinfection and related topic)?
4. Does WASHCO undertake catchment protection?
5. Does WASHCO regularly disinfect the water reservoir?
6. Did any WASHCO member take training on water quality monitoring (biological water quality analysis and sanitary inspection)?
7. Does WASHCO raise money?
8. Do WASHCO members get paid or get other intensive?
9. Do WASHCO have reserve spare parts for future maintenance need?
10. Do women are involved in WASHCO?
11. What was reason for last interruption of water supply?
12. How long did it take for maintenance during last water supply break?

Appendix IV: Participant Information Sheet and Voluntary Consent Form (Afaan Oromo version)

Akkam bultan/ooltan! Maqaan koo _____ jedhama. Anis sassaabduu ragaa qo'annoo ganda keessan irrati barataa digrii lammaffaa Yuniversitii ADDIS ABABA/FINFINNE/ kan tahe Guutama Mulatu geeggeeffamuuti. Isinis garee qo'annoo keenyaa taatanii waan filatamtaniif waa'ee qo'annoo kanaa isii ibsuuf gurra fi qalbii keessan akkanaaf ergifan kabajaan nan gaafadha.

Mata-duree qo'annichaa: qabiyyee qulqullinqa bishaaniif jarmiilee dhukkuba namatti fidanii fi isa waliin walqabatanii wantoota jiranii fi haala bishaanitti fayyadaman bakka madda isaa hanga itti fayyadamanitti kan naannoo Harari, Woredaa Dirre Tiyyara , Itiyoophiyaa, bara 2019/2020tti adeemsifamu.

Kaayyoo qo'annichaa: Argannoon qorannoo kanaa waajjiira bishaani fi qulqullina naannoo Harari kessaa fi waajjira fayyaa naannoo Harari qulqullu bishaanii foyyesudhaf gargaara. Kanaan alattis, kaayyoon qorannoo kanaa, qorataan qo'annoo kanaa digrii lammaffaa (Msc in water supply and sanitation) isaa fudhachuuf uulaagaa isa barbaachisu guuttachuuf isa gargaara.

Iccitii eeguu: Odeeffannoon isin nutti himtan hundi iccitiin qabama. Gaaffiin enyuumma keessan maqaan ibsu hin jiru. Argannoon qo'annaa kanaa hawaasa qo'naanoo kana irratti hirmaatan akka walii galaatti kan ibsu yoo tahu, karaa kamiinuu dhimma nama dhunfaa hin calaqqisiisu. Haala kamiinuu namoota dhunfaa qo'naanoo waliin walqabsiisuuf afaaniiniis tahe barreeffamaan ragaa hin waamsiifnu.

Teessoo Gaaffii yookiin qeeqa qo'annoo kana ilaallatuu kamiifuu, teessoo armaan gadiin gaafachuu fi quunnamuu ni dandeessu.

✓ Qo'ataa muummee: obbo Guutama Mulatu,

lakk. bilbila mobayilii: +251915913313yookiin

E-mayilii, aau.gutema.mulatu@edu.et

Unkaa walii galtee fedhii irratti hundaa'ee: Unkaan walii galtee hirmaattootaa naa dubbifameera/ dubbiseera. Kaayyoo qo'annichaa, deemsiisaa, faayidaa fi midhaa, dhimmi iccitiieeguu, mirgahirmaachuu fi teessoon qo'ataa illee natti himamee jira. Wanta ifa hin taane akkan gaafadhuuf carraan naaf keennamee jira. Akkan yeroo barbaade qo'annicha adda kutee bahuu dandahu yookiin gaaaffii deebisuu hin barbaannee deebisuu hin dirqamnes natti himameera. Kanaafuu, akkan qo'annaa kana irratti feedhii kootiin hirmaadhe mallattoo koo armaan gadiin nan mirkanneessa. Maqaa hirmaattuu _____

Mallattoo hirmaattuu_____.

Mallattoo odeeffannoo sassaabduu_____.

Hub: Waliigalteen kun fuul-dura hirmaataa qo'annoo fi odeeffannoo sassaabduu itti malleettaffamuun, kooppiin isaas hirmaataa/ttu

Galatoomaa!

1. Gaaffi Haala Hawas-dinaagde (sociodemographic)

	Variable		yaada
WSS0001	Saala nama gaaffi kana deebisu	1.dhiira 2.dhala	
WSS0002	Maqaa abbaa Warra	_____	
WSS0003	Amanta nama qorannicharratti Hirmatu	1. Musliima 2. Ortoodoksii 3. Protestaantii 4. Waqeffata 5. Kan Biraa	
WSS0004	Sadarka barnoota olaana kan maatii kana	1.Dubbisuuf Barressuu Kan Hin Dandeenye 2. Dubbisuuf Barressuu Kan Dandahuu 3. Kutaa 1-8 4. Kutaa 9-12 5. Kolleejjii Fi Isaa Ol	
WSS0005	Haala gaa'elaa	1. Hin Fuudhiin/Hin Eerumiin 2. Kan Fuudhe Ykn Heerumte 3. Kan Hiike /Hiikte 4. Kan Irraa Du'e 5. Kan Biraa _____	
WSS0006	Hojiin keessan maali?	1.Daldalaa 2. Qotee bulaa 3. Hojjetaa Mootummaa 4. Kan Hin Qacaramne/Kan Hojii Hin Qabne/Soorama Kan Bahe 5. Dafqaan Bulaa 6. Kan Biraa _____	
WSS0007	baayina maatii mana kana keessa jiraatanii?	Lakk _____	

2. Haala itti fayyadama bishaani (social ecology of water)

WSS0008	Bishaan mana kana keessatti fayyadamtan eessaa argattu?	1.Bishaan Boombaa Mana Biraa 2. Bishaan Boollaa(eelaa) Ooyruu 3. Boombaa kan uummata(public tap) 4. Bishaan Boollaa Eegamu Irraa 5. Laga Burqaa Eegamu Irraa 6. Kan Biraa _____	
WSS0009	Bishaan deemtanii fiduuf dhaquuf galuuf daqiiqaa meeqa fudhata?	Daqiiqaaa _____	
WSS00010	Bishaan kana fiduun itti gaafatamuma eenyutu qaba?	1.Dardara Dhiira 2. Dardara Dhalaa 3. Ijoollee Dhiiraa (Wagaa 15 Gadii) 4. Ijoollee Durbaa (Wagaa 15 Gadii) 5.Haadha warra	
WSS00011	Guyyaan tokko kessaatti biishaan hangam waraabbantani?	Divide it for family size and put ____ L/day/cap	
WSS00012	Guyya tokko kessatti bishaan hanga waraabbachu dandeessan murtahadha	1.eyye 2.lakkii	If no next qs
WSS00013	Deebin eeyye yo tahe sababni isaa maali?	1.Dabaree 2.bishaan heddu hin qabu 3.waraabbachuf yeroo dheera eegna 4.kan biraa	
WSS00014	Bishaan hagamitti argattu	1.yeroo hundaa(torbeetti guyya torba) 2.torbetti guyya sadi 3.darbe darbe(rarerly)guyaa <3 4.torbetti guyya tokko(seasonally)	
WSS00015	Hagamitti bishaan waraabbachu dandeessu	1 all the day(24hrs) 2 most of time (8hrs/day) 3 limited hrs (6hrs) 4 few hrs per day(2 hrs)	
WSS00016	Bishaanif nikafaltanii	1. Eyyee 2. Lakkii	If no skip next q
WSS00017	Deebinke eyyee yoo tahe hagam kaffaltani	_____per/jerican	

3. Haala qulqullina fi qabinsa bishaani sadarka maatitti (Household Water, Sanitation and Hygiene Practice)

Odeeffanno walii galaa

WSS001	Maatiin kun dawaa bishaan ittiin qulqulleessan ni fayyadamaa?	1. Eyyee 2. Lakkii	
WS002	Yoo deebiin kee eyyee tahe malloota bishaan itti qulqulleessan isa kam fayyadamtu?	1. Wuha Agar/bishaan gaarii itti naquu 2. Calaluu 3. Kaa'anii Tursuu 4. Danfisuu 5. Kan Biraa	
WSS003	Guyyaan tokko kessaa nama tokko biishaan hangam fayyadamaa?	_____ litra	
WSS004	Qodaa itti bishaan warrabbatni meeqatu jira	20 litre _____ 10 _____	

4. wantootaa sadarkaa maatitti qulullina bishaan faalu dandahan qorachu (HH Water Contamination Risk factor Assessment)

WSS005	Qodaa bishaan dhugaatii qofaatti ni qabda(yoo qabatan akka si garsiisaniif gaafadhu)	1. Eyyee 2. Lakkii	
WSS006	Qodaan bishaan dhugaatii itti ol keewwattu afaan isaa dhiphadha((≤ 7.6 cm diameter)?	1. Eyyee 2. Lakkii	
WSS007	Qodaa bishaan itti ol keewwattu liididhan cuqqaltani	1. Eyyee 2. Lakkii	
WSS008	Qodan bishaan itti waraabdu keessi isaa qulqulludha(ilaali)	1. Eyyee 2. Lakkii	
WSS009	Bishaa dhugaati lafarra CM 30 ol buttanni ni keessani?	1. Eyyee 2. Lakkii	
WSS0010	Qodaa bishaan itti warabdani allii(bakken) isaa qulqulludha?	1. Eyyee 2. Lakkii	
WSS0011	Bishaan gaafa dhugdani qalasatti(qodaa itti bishaan dhugan) buustu ?	1. Eyyee 2. Lakkii	
WSS0012	Qodaan bishaan itti dhugdan qulqulludha(ilaali)	1. Eyyee 2. Lakkii	
	Meeshaa itti dhugdan (qalasa) eessa	1.Laffa irraa	

WS0013	keessan?	2. Bakka itti qophaayeeef 3. Bakka bishaan itti keessan	
WS0014	Total Score Yes_____/9 No_____/9		
WSS0016	Qodaa bishaan keessa keessu si a meeqa dhiqxa?	1. Guyyaa Guyyaatti 2. Guyyaa Sadii Booda 3. Torbeetti Al Takka 4. Guyyaa 15 Al Takka 5. Hin Dhiqu Lakki 6. Kan Biraa _____	
WSS0017	Qodaanjerikana) bishaan itti warabbatan qulqulludha(ilaali)		
Over all conclusion Risk rating No 0-2 Low; 3-5 medium; 6-8 high; 9-12 very high			
III. Availability, use and operation of Latrine and hand washing facility and domestic hygiene (haala itti fayyaama mana fincaanifi fi qulqullina dhuunfa)			
WSS01	Mana fincaani ni qabdani?	1. Eyyee 2. Lakkii	
WSS02	Yoo ni qaban tahe qulqullina isaa fi akka itti fayyadaman ilaali_____		
WSS03	Mana fincaanii keessan olla waliin ni fayyadamtuu?	1. Eyyee 2. Lakkii	
Checklist mana fincaani ittin ilaaludhan guutamu(HH Latrine Observation Checklist)			
WSS04	Manni fincaani nama dhoksuu ni dandaha(Didara yln girgidaa kallatti hundan ni qaba?)	1. Eyyee 2. Lakkii	
WSS05	Dheerinni mana fincaani cm 1.7 fi isa ol ni taha	1. Eyyee 2. Lakkii	
WSS06	Manni fincaani balbala ykn maggaraja ni qaba?	1. Eyyee 2. Lakkii	
WSS07	Mana fincaani lafa isaa qulqullessun ni dandahama?	1. Eyyee 2. Lakkii	
WSS08	Boolli mana fincaani qadaada ni qaba?	1. Eyyee 2. Lakkii	
WSS09	Manni fincaanii qorqorro(xaara) ni qaba?	1. Eyyee 2. Lakkii	
WSS010	Itti fayyadama fi qulqullina mana fincaani(Latrine use/functional)		
WSS011			
WSS012	Daandiin gara mana fincaanitti geessu qulqulludha?	1. Eyyee 2. Lakkii	
WSS013	Lafti Mana fincaani fincaan ykn bishaan ni kuusa irra keessatti?	1. Eyyee 2. Lakkii	
Cleanliness (hygiene condition)			

WSS014	Boobban ykn qoshaashan boolla fincaani alaa mana fincaai keessa ni jira?	1. Eyyee 2. Lakkii	
WSS015	Bobbaan boolla mana fincaanitti ni jiraa?	1. Eyyee 2. Lakkii	
WSS016	Boolli mana fincaani guutudha?cm 5 guutuf yoo hafe jechhuudha	1. Eyyee 2. Lakkii	
WSS017	Naannoo mana jireenya boobban ni jira?		
Knowledge of Hand Washing with soap during critical time(probe for all possible)			
WSS1	Harka ofii dhiqachun yeroo kam barbacchisadha jette yaadda	I..mana fincaani booda II.Nyaata dura III.ijoolle nyaachisu dura IV.Nyaata qopheessu ykn dhiheessu dura V.kan biraa	
WSS2	Haala qulqullina ana jireenya(Cleanness of the house and compound comment on the following)		
WSS3	Manni jireenya kessi isaa qulqulludha?	1. Eyyee 2. Lakkii	
WSS4	Kosii(Qushaasha) goggoga mana keessa bahu boolla ykn kompositi gattani	1. Eyyee 2. Lakkii	
WSS5	Qushasha dhangalaha eessatti gattan?	1. Boola keessaattii 2. Mana fincaanii keessaattii 3. Lafa irrattii ganaqudhaan	
WSS6	Mana ittii jirtan keessa beeyladooni ni jiraa? (wajiin galaa)	1. Eyyee 2. Lakkii	
	Over all conclusion Risk rating No 0-2 Low; 3-5 medium; 6-8 high; 9-12 very high		

Beekumsa faalama bishaanii

KAP1	Bishaan dhugaatii eessatti faalama jettee yaadda?	1. Bakka Waraabamutti 2. Mana Keessatti 3. Bakka Lachuu 4. Kan Biraa _____	
KAP2	Meeshaa bishaan keessa kaa'amuu fi itti waraabamu qulqulleessuun faalama bishaanii ittisa jettee yaaddaa?	1. Eyyee 2. Lakkii	
	Bishaan waraabuun dura harka	1. Eyyee 2. Lakkii	

KAP3	dhiqachuu faalama bishaanii ittisa jettee yaaddaa?		
KAP4	Mana fincaanii fayyadamuun booda harka dhiqachuun faalama bishaanii ni ittisa jettee yaaddaa?	1. Eyyee 2. Lakkii	
KAP5	Mana fincaaniitti sirnaan fayyadamuun faalama bishaanii ni hambisa jettaa yaaddaa?	1. Eyyee 2. Lakkii	
KAP6	Mana keessatti bishaan qulqulleessuun faalama bishaanii ni hambisa jettee yaaddaa?	1. Eyyee 2. Lakkii	
KAP7	Baatii sadeen dabree keessaa waa'ee bishaani fi qulqulina bartanii jirtu	1. Eyyee 2. Lakkii	

Institutional inspection tool /Afaan Oromo version/

For community managed systems assess the capacity of Water, Sanitation and Hygiene Committee (WASHCO).

1. Ganda kana keessa WASHCO n ni jira?
2. Miseensi WASCHO ganda kana ogumma suphinsa fi Haaromsu madda bishaani ni qabu?
3. Miseensi WASCHO Haala eegumsa fi qulqullina, daawa bishaniiti naquu irratti leenji gaha ni qabu?
4. WASCHO n ganda kana madda bishaanif eegumsa ni godha?
5. WASCHON ganda kanaa madda bishaanitti yeroo yeroon dawaa ni godha?
6. Ganda kana keessa miseensi WASCHO haala qulqullina bishaani ilaalurratti leenji fudhate ni jira?
7. WASCHO n ganda kana Qarshii suphiinsa bishaanif tahu walitti ni qaba?
8. Miseensi WASCHO kafalti ni argtani?
9. Miseensi WASCHO madda bishaani cabe suphuf meesha suphinsa ni qabani??
10. Dubartoonni WASCHO Keessatti ni Hiraatu/qooda ni fudhatu?
11. Bishaan yeroo darbee rakkinni addan citeef maalinni? What was reason for last interruption of water supply?

Appendix V: Sanitary risk assessment of water sources

Type of facility: Covered dug well with hand – pump

Sampling and laboratory analysis

Name of Kebele _____	Owner ship 1.public 2.private
Village name	Date collected
Water source name	Time collected
Water source code	Time analysis

Result

E. coli _____/100ml	PH _____
Turbidity _____NTU	Temperature _____

Specific diagnostic information for assessment Risk

	Is there a latrine within 10m of the well and hand-pump?	Yes -----1 No -----2
	Is the nearest latrine on higher ground than the hand-pump?	Yes -----1 No -----2
	Is there any other source of pollution (e.g. animal excreta, rubbish) with in 10m of the hand-pump?	Yes -----1 No -----2
	Is the drainage poor, causing stagnant water within 2m of the cement floor of the hand-pump?	Yes -----1 No -----2
	Is there any faulty drainage channel? Is it broken, permitting ponding?	Yes -----1 No -----2
	Is the wall or fencing around the hand-pump inadequate, allowing animals in?	Yes -----1 No -----2
	Is the concrete floor less than 1m wide all around the hand-pump?	Yes -----1 No -----2
	Is there any ponding on the concrete floor around the hand-pump?	Yes -----1 No -----2
	Are there any cracks in the concrete floor around the hand-pump which could permit water to inter the hand-pump?	Yes -----1 No -----2
	Is the hand-pump loss at the point of attachment to the base so that water could enter the casing?	Yes -----1 No -----2
	Is the cover of the well unsanitary? Y/N	Yes -----1 No -----2
	Are the walls of the well inadequately sealed any point for 3m below ground level? Y/N	Yes -----1 No -----2

Total Score of Risks _____/12 Contamination risk score: 9-12=very high; 6-8=high; 3-5=intermediate; 0-2=low

Signature of data collector _____

Sanitary risk assessment of water sources

Type of facility: Borehole with mechanized pumping

I. Sampling and laboratory analysis

Name of Kebele	Ownership 1. Public. 2. Private
Village	Type of water sources _____
Village code	Date Collected _____
Water source name	Time collected _____
Water source code	Time analysis _____

Result

E.coli-----/100ml	Turbidity _____ NTU
Residual chlorine _____ mg/l	PH _____
Total chlorine _____ mg/l	Temp _____

II. Specific diagnostic information for risk assessment

1	Is there a latrine or sewer within 100 m of the pumping mechanism?	Yes-----1 No-----2
2	Is there a latrine within 10 m of the borehole?	Yes-----1 No-----2
3	Is there any source of other pollution within 50 m of the borehole (e.g. animal breeding, cultivation, roads, industry etc.)?	Yes-----1 No-----2
4	Is there an uncapped well within 100 m?	Yes-----1 No-----2
5	Is the drainage channel absent or cracked, broken or in need of cleaning?	Yes-----1 No-----2
6	Can animals come within 50 m of the borehole?	Yes-----1

		No-----2
7	Is the base of the pumping mechanism permeable to water?	Yes-----1 No-----2
8	Is there any stagnant water within 2 m of the pumping mechanism?	Yes-----1 No-----2
9	Is the well seal insanitary?	Yes-----1 No-----2
10	Is the borehole cap cracked?	Yes-----1 No-----2

Total Score of Risks-----/10

Contamination risk score: 9-10 =Very high; 6-8= high; 3-5= intermediate; 0-2= low

Signature of data collector.....

Appendix VI: Laboratory Analysis procedure for identification of Thermotolerant coliform by Membrane filtration method

I. Principle

In contrast to the multiple-tube method, the membrane-filtration method gives a direct count of total coliforms and thermotolerant coliforms present in a given sample of water. The method is based on the filtration of a known volume of water through a membrane filter consisting of a cellulose compound with a uniform pore diameter of 0.45 micro meters the bacteria are retained on the surface of the membrane filter. When the membrane containing the bacteria is incubated in a sterile container at an appropriate temperature with a selective differential culture medium, characteristic colonies of thermotolerant coliforms develop, which can be counted directly.

II.Equipment

- Membrane-filtration apparatus: including an electric or hand-powered vacuum pump, a vacuum flask (e.g. an Erlenmeyer side-arm flask), and a filter support.
- Reusable Petri dishes: made from glass or metal (disposable plastic Petri dishes may also be used).

- Blunt-ended forceps: for picking up membrane filters.
- Reusable (autoclavable) bottles: for culture media (e.g. 25-ml polypropylene bottles)
- A magnifying lens: with 34 or 35 magnification for examining and counting the colonies on the membrane filters
- A boiling bath/pan: if filtration apparatus is to be disinfected in boiling water between analyses.
- Sterile pipettes: 1ml and 10ml.
- A graduated cylinder: 100ml.
- Membrane filters: 47–50mm in diameter, with a pore diameter of 0.45 μ m. singly packed, presterilized membrane filters are very convenient. Unsterilized membrane filters can also be used, however, and should be wrapped in paper packets in convenient numbers (depending on the number of water samples to be tested). These can then be sterilized in the autoclave and dried by rapid exhaustion of the steam.
- Nutrient absorbent pads: filter-paper discs about 1mm thick, with the same diameter as the membrane filters.
- Culture media: different types are available
- Wax pencils: for labelling Petri dishes.

III. Culture media and dilution water

Various media can be used for the examination of coliform organisms by the membrane-filtration method. Of these, lactose Tergitol1 agar, lactose TTC Tergitol1 agar, and membrane lauryl sulfate lactose broth may be used for coliform organisms at 35 or 37°C and for thermotolerant coliform organisms at 44°C or 44.5°C. Membrane faecal coliform (MFC) broth should be used only at 44 or 44.5°C for thermotolerant coliform counts. Although the use of all these media for the detection of presumptive coliform organisms is based on the fermentation of lactose, the characteristic reaction varies with each medium. Although it is possible to prepare

the media from the basic ingredients, this may be impractical in a small laboratory. The use of dehydrated media is therefore recommended. The media can be prepared as a broth and used together with nutrient absorption pads, or as solid agar plates. The broths may be solidified by the addition of 1.2–1.5% agar before boiling.