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Full Length Research Paper

Bacteriological quality and occurrence of *cryptosporidium* and *giardia* from sources to household water samples of the rural communities of Dire Dawa Administrative Council, Eastern Ethiopia

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In Ethiopia, access to improved water supply and sanitation was estimated at 38% and 12% respectively. This study was conducted to assess the microbiological quality of drinking water sources and water handling practices in rural communities of Dire Dawa Administrative Council (Adada, Legedini and Legebira PA). The water samples were the presence of Cryptosporidium oocysts and Giardia cysts. Water analysis demonstrated microbiological water quality analysis. The average counts of TC were in the range of 1.5-133.05CFU/100ml whereas the average counts of FC were found to be 0.34-54CFU/100ml. The mean concentration of Giardia lamblia and Cryptosporidium ranges from 0 to 5.6 and 0 to 6.5, respectively. The fact that, about 83.34% of the water sample was positive for indicator bacteria shown that the three selected PA had risk of contamination in the three selected PAs which show the high risk of microbiological water quality parameters. High concentration of microbiological indicators in all water sources of this study area may demonstrate the presence of pathogenic organisms which constitute a threat to anyone consuming or in contact with these waters. Protection of water sources accompanied by sanitation and hygiene promotion programs can improve the water quality of rural water sources, where disinfection is not feasible.

Key words: Cryptosporidium, fecal colifrom, giardia, total coliform, water analysis, water borne pathogens.

INTRODUCTION

Water is one of the most important compounds that constitute the largest part of life. About 70% of the earth's surface is water and 3% of this is fresh water. So far, out of the 3% fresh water, 99% is found beneath the surface (Jarrett, 1995). The major water sources for use are surface water bodies such as rivers and lakes, and underground sources and pore spaces down the water table (Ring, 2003). Water derived from these sources is not necessarily pure since it contains dissolved inorganic and organic substances, living organisms (viruses, bacteria, parasites, etc). For this reason, water intended for domestic uses should be free from toxic substances and microorganisms that are of health significance (WHO, 2005).

According to WHO (2003), more than 80% of the human diseases in the world are caused by unsafe water supply and due to inadequate environmental sanitation practices. One billion people lack access to safe water, while 2.4 billion people have inadequate sanitation. The latter has an impact on individuals, households, communities and countries. In a situation where there is no clean water and proper sanitation; millions of people would suffer from devastating diseases and millions of children would die due

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to water borne diseases (Hoffman, 2003).

Protection of water sources from contamination is the first line of defense against water borne disease. Because of the essential role water plays in supporting human life, it has great potential for transmitting a wide variety of disease and illnesses if contaminated. Source protection almost consistently is the best method of ensuring safe drinking water (Richards, 1996).

In rural areas and villages of Ethiopia, water for human consumption, drinking, washing (bathing, laundry), for preparation of food etc, is obtained from rivers, streams, shallow wells, springs, lakes, ponds, and rainfall. Unless water is made safe or treated for human consumption, it may be hazardous to health and transmit diseases. The main contaminants of these water sources are from human excreta because of open field defecation practices, animal waste and effluent from sewage system. Thus, the majority of rural communities use water from contaminated or doubtful sources, which expose the people to various water-borne diseases (MWR, FDRE, 2004).

Different types of pathogens can contaminate water, food, air and other environmental media in many different ways. Measuring all of these pathogens routinely for determining presence or absence or acceptable concentration is not possible. This is due to the following reasons: the methods are not available to recover and measure all microbes; the methods are available for only some selected microbes and not applicable for others; they are technically demanding, some methods are slow to produce results and their costs are high and it's impossible to enumerate all pathogenic microorganisms. Therefore, measuring something other than a pathogen that is indicative of contamination predicts the presence of pathogen and estimates human health risks. In addition, these indicators can tell whether the water is safe or not. So by using indicators the water quality can be assessed. The most applicable and recommendable indicator bacteria are fecal coliform and total coliform (Mark, 2006).

The use of indicator organisms, in particular the coliform group, as a means of assessing the potential presence of water-borne pathogens has been of paramount importance in protecting public health. The principle of the detection of selected bacteria that are indicative of either contamination or deterioration of water quality has been the foundation upon which protection of public health from water-borne diseases has been developed (Barrell et al., 2000).

Ethiopia is one of the developing countries where only 52% and 28% of its population have access to safe water and sanitation coverage, respectively (MoWR, 2007). For this reason, 60-80% of the population suffers from water-borne and water-related diseases (MOH, 2007). This burdens the country with enormous financial and social costs to take care of such a huge number of people suffering from these debilitating infections.

Some report showed that water sources and distribution systems of towns and rural communities alike have serious water quality problems. Assessment of bacteriological and physico-chemical qualities of urban source water and tap water distribution systems in Akaki Kalit sub-city of Addis Ababa (Mengestayehu, 2007), Ziway town (Kassahun, 2008), Bahir Dar town (Getnet, 2008), Nazareth (Adama) town (Temesgen, 2009) showed contaminations of water by indicator bacteria such as total coliforms, faecal coliforms and/or faecal streptococci.

Similarly, underground water sources (hand dug wells) from rural areas in Menge District, Benishangul Gumuz region (Mebratu, 2007), and protected springs and hand pumped wells in Werebabo District, South Wello (Atnafu, 2006) indicated that 60-100% of the water samples were positive for total coliforms and faecal coliforms. This shows that the provision of safe water through extraction of water from deep underground and protected water sources from relatively less contaminated rural areas was not even immune from contamination.

All these findings give conclusive evidence that water quality problems are rampant both with small-scale and large-scale water delivery systems in the country. This would pose high health risks to users unless prompt intervention is undertaken. This, therefore, necessitates the evaluation and putting in place of sustainable monitoring system to determine the water quality status of municipal and rural water distribution systems.

As the previous study conducted on the prevalence of parasitic infections among children in Dire Dawa surrounding areas revealed that, safe water supply was not available or sufficient, so people were reverting to unhygienic and unsafe sources of water (Dawit, 2006). There is also improper household water storage and handling practices in all the villages. All the above-mentioned problems can lead to water related diseases if no intervention is made to solve water contamination in most rural areas of the communities (Dawit, 2006).

The World Health Organization Microbiological Guidelines (2004) and Federal Democratic Republic of Ethiopia, Ministry of Water Resources (2002) for drinking water recommend zero total coliform and thermolerant/fecal coliform/100 ml of water and zero concentration of *Giardia* and *Cryptosporidium*.

Therefore, this study was used to evaluate the water quality based on two bacterial indicators of drinking water quality (total coliform, and thermolerant /fecal coliform) and the occurrences *Cryptosporidium* and *Giardia* from different water sources (springs (unprotected and protected), wells (unprotected and protected) and tap water) and the water handling practices among the household in Dire Dawa Administrative Council.

There was no previous study conducted in this study area regarding to water quality assessment. The study conducted by Dawit (2006) was carried out on the prevalence of parasitic infection among children. Therefore, this study was conducted to initiate and fill the gap related to water quality of the rural communities. The findings of this study will provide baseline information about water quality for stakeholders for further work and intervention.

MATERIALS AND METHODS

Description of the Study Areas

The present study was conducted between February and May, 2011 in three purposively selected Peasant Associations (PA) named Legedini, Adada and Legebira, which are found in Dire-Dawa Administrative Council (Figure 1). The Dire-Dawa town is located in Eastern parts of Ethiopia, which is 508 km away from Addis Ababa, capital city of Ethiopia.

All the three areas receive an average monthly rainfall of 55.71 mm and have bimodal pattern; the big rains occur from July to September, and the small rains from March to April. The monthly average maximum and minimum temperatures are 32.4^{0}C and 19.1^{0}C, respectively and the mean annual relative humidity is 48.2 % (NMSA, 2010). Legedini is located 28 km east of Dire-Dawa City, at 09^{0}37"57'.3 N latitude and 042^{0}02" 44' E longitude and an altitude of 1100-1600m a.s.l. (Figure.1). The area has nine villages with a total population of 4500-5000. Adada is located 18 km east of Dire-Dawa city. Geographically the area is located at 09°32"53'.6 N latitude and 41^{0}56"23'.7 E longitude and an altitude of 1506m a.s.l. The area has 15 villages with a total population of 14,000.Geographically; Legebira is located at 09^{0}31" 23'.4 N latitude and 41^{0}57"16'.5 E longitude with an altitude of 1646m a.s.l. that is at 15km east of Dire-Dawa city. The area has 6 villages with a total population of 2500-3500 (CSA, 2006; NMSA, 2010).

Farmers in this study area are engaged in crop-livestock mixed agriculture and they are not food self-sufficient and most of the time they are dependent on donation from government and other donor organizations (Dawit, 2006). The major crops cultivated by the farmers are maize and sorghum. The livestock owned by the people are mainly camels, cows, donkeys, oxen, goats and sheep. The above mentioned author further reported that in each study sites some people uses water from protected sources such as springs, boreholes, deep and shallow protected well, hand-dug wells, and others use from unprotected water sources such as surface water, river, seepage, unprotected well. The common problems of the three study sites are inadequacy of clean drinking water, lack of water for agricultural and household activities and insufficient sanitary facilities. As a result, waterborne and hygiene related diseases occur frequently (Dawit, 2006).

The Study Design

A cross-sectional survey was conducted to determine the microbiological quality of water sources and to assess the households' water handling practices among the communities in the surrounding areas of Dire Dawa Town. The design also includes laboratory investigation which was carried out by collecting water samples from different sources from February, 2011 to May 2011. The questionnaires survey were done to collect data related to the respondents' socio-demographic characteristics and their water handling practices. The questionnaires were pre-tested in a few selected households living outside of the present study area.

Sample Size

The sample size for the questionnaire survey was determined based on the 5% error term and the 95% confidential interval and P was taken as 0.05. Since there were no previous related studies conducted in the area, 50% was assumed for the proportion of respondents who have good practices households (P). The sample size was calculated using a formula for a single population proportion.

$n = Z^{2} P (1-P)/d^{2}$ Where n= sample size

$n = Z^{2} \alpha/2 (50\%) (1-50\%)/ d^{2}$ P= proportion of households with good water handling practices.

d= margin of sample error

$n = (1.96) (1.96) (0.5) (1-0.5) / (0.0025)$ $Z\alpha/2$=P-value at 95% CI from table

$n = 384$

Questionnaire Survey on Households' Water Handling Practices

Structured questionnaires were prepared by the investigator, which include the basic socio-demographic and the households' knowledge, awareness regarding water handling practices of households in the rural communities of the study area. The questionnaires were then administered to the selected study households at their respective residential places.

A total of 384 questionnaires were administered. The questionnaires were originally developed in English and then translated to local language (Oromiffaa). The Oromiffaa version was later translated back in to English with the help of language professional. All necessary corrections were made for the actual questionnaire.

The questionnaire was pre-tested in few selected household. The pre-test was conducted near the study area which had similar characteristics to the areas where the actual study was carried out. Vague terms, phrases

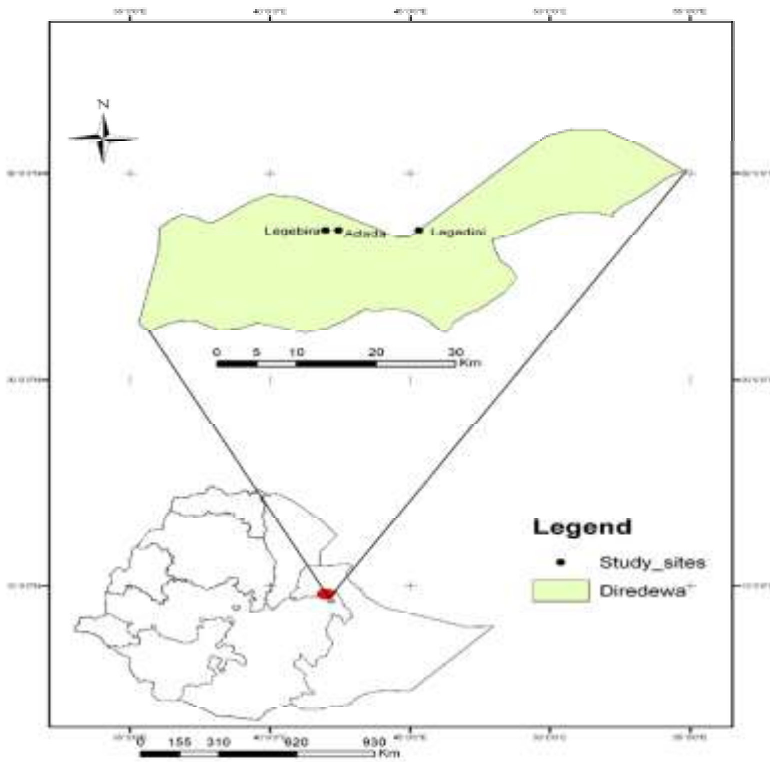

Figure 1. Map of study area showing the location of sampling sites, sources (Dawit, 200.

Table 1. Summary of water sources types and their sanitation condition in the study sites.

Study sites	Study villages	Water sources
	Ajo, Halo, Ido, Ido Bolo, Kora and Konya	Unprotected water sources
Legedini	Selela, Hodo Sere, Kore Chafe and Lalo	Protected water sources
	Awale, Gebro, Afuretu, Hamesa and Gudora	Unprotected water sources
Adada	Huri, Negeye, Berento, Elimo Bajje, Adami, Kulu, Dema and Chore	Protected water sources
Legebira	Bira, Horro, Ware and Rebena	Unprotected water sources
	Shenno and Abdure	Protected water sources

and questions identified during the pre-test were modified and changed. Missing responses like “no response” and “others” were added, and skipping patterns were also corrected.

Water Sample Collection

Due to limitation of resources, only three areas, Legedini, Legebira and Adada that are located in DDAC were selected purposively for the present study. Simple random sampling technique was employed to select the Dawa water sampling sites in each study area.

In each study area and water samples were collected from five types of water sources, viz., protected well, unprotected well, protected spring, unprotected spring and tap water. A total of 90 water samples were collected and analyzed during February and May, 2011. 400ml-600ml water samples were collected in sterilized glass bottles that were washed and rinsed thoroughly with nitric acid and distilled water. In each round of sampling, one sample was taken at the center and the other two samples from the two edges of each site. These water samples were

Table. 2. Occurrence of indicator bacteria and mean bacteriological counts (100/ml) of five types of water sources in Dire Dawa communities during February and May 2011.

Study sites	Water sources	Occurrences of indictor bacteria			Mean bacteriological count	
		No. of sample examined	Total coliform	Fecal coliform	Total coliform	Fecal coliform
			Frequency %	Frequency %		
Adada	Unprotected well	6	6(100%)	6(100%)	81.34±8.07^{a}	33.33±8.80^{ba}
	Unprotected spring	6	6(100%)	6(100%)	64.5±8.61^{b}	21.16±6.2^{abc}
	Protected well	6	5(83.34%)	5(83.34%)	67.83±14.00^{ab}	18±7.68^{abc}
	Protected spring	6	5(83.34%)	4(66.67%)	59.17±6.66^{b}	15.34±6.59^{abc}
	household water	6	3(50%)	2(33.34%)	1.5±0.71^{c}	0.34±0.2^{d}
Lagabira	Unprotected well	6	6(100%)	6(100%)	110.34±27.20^{a}	51±11.9^{a}
	Unprotected spring	6	6(100%)	6(100%)	80±17.07^{a}	33.5±6. 73^{ab}
	Protected well	6	6(100%)	5(83.34%)	100±14. 34^{a}	26.5±9.12^{b}
	Protected spring	6	6(100%)	4(66.67%)	79.34±10.11^{a}	29.67±9.15^{ba}
	household water	6	4(66.67%)	3(50%)	5.66±0.61^{c}	1.5±0.2^{d}
Legedini	Unprotected well	6	6(100%)	6(100%)	133.67±21. 25^{a}	45.5±12.00^{ab}
	Unprotected spring	6	6(100%)	6(100%)	99.5±13.72^{ab}	54.83±11.84^{a}
	Protected well	6	6(100%)	6(100%)	120.16±23.73^{ab}	25.83±7.03^{b}
	Protected spring	6	6(100%)	5(83.34%)	90.5±13.79^{ab}	26±9.05^{b}
	household water	6	4(66.67%)	3(50%)	4±0.50^{c}	1±0.36^{d}

N.B. Grade with the same letter is not show significance difference, while grade with different letter show significance difference.

transported to Dire supply and sanitation laboratory for microbiological water quality analysis.

Microbiological Water Analysis Procedures

Bacteriological analysis

The samples were analyzed for total coliform (TC) and faecal coliforms (FC) using the membrane filter technique as outlined by the APHA (1998). This technique involved filtering water through a membrane that retained total coliforms, fecal coliforms; incubating this membrane on a growth promoting medium (lauryl sulphate broth) and then counting the resultant TC and FC units (APHA 1998).

Each water sample was mixed thoroughly by shaking for a total 30 minutes. 100ml of the sample was placed on surface of a sterile membrane filter with pore size 0.450.45μm placed on funnel unit of the membrane filter support assembly. The filtration was facilitated by applying a vacuum pump, and the assembly was rinsed by sterile distilled water (APHA, 1998).

Up on completion of the filtration process, vacuum were disengaged, unlocked and using a sterile forceps funnel were removed and membrane were removed immediately and placed on Membrane Lauryl Sulphate broth with a rolling motion to avoid entrapment of air in Petri dishes. Finally, the cultures were incubated at 37°C for 18 to 24hrs. Up on completion of incubation period, typical coliform colonies (yellow color) were seen on the surface of membrane filter paper. All yellow colonies extending on the membrane were counted as TC with the aid of a magnifying lens and recorded as total coliform (APHA, 1998).

For fecal coliform count, the same procedure was followed and the medium used, but the incubation and temperature was at 44^{0}C for 18-24hrs. Up on completion of the incubation period, yellow colored colonies on the surface of the filter paper were counted as FC. Finally, the total coliform and fecal coliform per 100ml of sample were calculated

Parasitological laboratory examination procedures

In order to undertake parasitological analysis for the presence of protozoan parasites, *Giardia* and *Cryptosporidium* water samples were concentrated according to WHO, (1991). Samples were transferred in to 15ml of centrifuge tube and sedimented at 5000(rpm) on centrifuge ant 4^{0}C for 15minutes. The sediments were preserved at 4^{0}C. The parasitological water quality (occurrence of *Cryptosporidium* oocysts and *Giardia* cysts) analyzed were conducted based on USEPA (USEPA, 2005).

Direct wet smear

Using an applicator (wire loop), a small portion of (2-3cm diameter) of the preserved sediment was taken and mixed with iodine solution on clean slide. The mixed solution was spread over an area of approximately 2cm×1cm and the mixture of sediment and iodine solution was covered with cover slip. Finally, the cyst was examined under the microscope using 10× 40 objectives (WHO, 1995). The cysts and oocyst were identified following the procedure of WHO parasitological laboratory examination (WHO, 1995).

Modified Ziehl (Nelson method)

The drop of sediment was emulsified on clean slide and spread over an area of 2cm ×1cm and allowed the smear to dry and fixed in using absolute methanol for 10 minutes. The slide was flooded with carbol fuchsine for 20 minutes, rinsed in tap water for 20 minutes. It was then decolorized in 5% H_2SO_4 for 30 minutes, rinsed the with tap water for additional 20 minutes and finally, flooded with 0.3%methylene blue. The presence of oocyst was examined under oil immersion objectives lenses (WHO, 1995).

Quality control

The assessment of water handling practices of the households of the community was collected using pre-structured questionnaires. The completed questionnaire was checked every day during data collection for completeness, clarity and consistency. A few selected households living outside the present study area were re-interviewed to check for the consistency of data.

Data Analysis

At the end of this study, the results on microbiological water quality and the households' water handling practices were analyzed and compared against standards set by WHO (2004) and Federal Democratic Republic of Ethiopia, Ministry of Water Resource (FDRE, MoWR, 2002). Analysis of variance (ANOVA) at 5% level of significance was used to compare the quality of water among all sites. The results were analyzed using statistical analysis software (SAS) version 9.0 and SPSS version 12.0.

RESULTS

Bacteriological Quality of Drinking Water Sources

Bacteriological analysis of water samples from the five sources (protected spring, unprotected spring, protected well, unprotected well and household water) in three sites of Dire Dawa Rural Communities showed that all water sources from Adada, Legedini and Legebira PA were positive for total coliforms and faecal coliform in two rounds of triplicate sampling (Table 2).

The results showed that all water samples (100%), from unprotected and protected well sources were positive for total coliform; whereas 83.34% of water of the protected and unprotected spring sources has been total coliform. The least number of total coliform positive water samples of 50% was detected from household water sample (Table 2).

The TC counts were ranging from 1.50±0.71CFU/100ml to 133.67±21.25 CFU/100ml with the lowest and the highest range corresponding to TC counts from samples of Adada household water and Legedini unprotected well, respectively. The fact that Legedini (133.67±21.25 CFU/100ml), Legebira (110.34±27.43CFU/100ml), and

Table 3. The degree of bacteriological contamination from five types of water sources in DDAC, 2011.

Study sites	Water sources	Total coliform CFU/100ml				Thermotolerant/ Fecal coliform CFU/100ml			
		Sanitary infection score				Sanitary infection score			
		0	1-10	11-100	>100	0	1-10	11-100	>100
Adada	Unprotected well	0(0%)	0(0%)	6(100%)	0(0%)	0(0%)	0(0%)	6(100%)	0(0%)
	Unprotected spring	0(0%)	0(0%)	6(100%)	0(0%)	0(0%)	2(33.34%)	4(66.67%)	0(0%)
	Protected well	1(16.67%)	0(0%)	5(83.34%)	0(0%)	1(16.67%)	1(16.67%)	4(66.67%)	0(0%)
	Protected spring	1(16.67%)	0(0%)	5(83.34%)	0(0%)	2(33.34%)	1(16.67%)	1(16.67%)	0(0%)
	household water	3(50%)	3(50%)	0(0%)	0(0%)	4(66.67%)	2(33.34%)	0(0%)	0(0%)
Legebira	Unprotected well	0(0%)	0(0%)	3(50%)	3(50%)	0(0%)	0(0%)	6(100%)	0(0%)
	Unprotected spring	0(0%)	0(0%)	3(50%)	3(50%)	0(0%)	3(50%)	3(50%)	0(0%)
	Protected well	0(0%)	0(0%)	3(50%)	3(50%)	1(16.67%)	0(0%)	5(83.34%)	0(0%)
	Protected spring	0(0%)	0(0%)	4(66.67%)	2(33.34%)	2(33.34%)	0(0%)	4(66.67%)	0(0%)
	household water	0(0%)	6(1000%)	0(0%)	0(0%)	0(0%)	6(1000%)	0(0%)	0(0%)
Legedini	Unprotected well	0(0%)	0(0%)	2(33.34%)	4(66.67%)	0(0%)	1(16.67%)	5(83.34%)	0(0%)
	Unprotected spring	0(0%)	0(0%)	1(16.67%)	5(83.34%)	0(0%)	1(16.67%)	5(83.34%)	0(0%)
	Protected well	0(0%)	0(0%)	3(50%)	3(50%)	0(0%)	0(0%)	6(1000%)	0(0%)
	Protected spring	0(0%)	0(0%)	3(50%)	3(50%)	0(0%)	0(0%)	6(1000%)	0(0%)
	household water	0(0%)	6(1000%)	0(0%)	0(0%)	2(33.34%)	4(66.67%)	0(0%)	0(0%)

Keys: 0CFU/100ml=safe, 1-10CFU/100ml=reasonable quality, 11-100CFU/100ml=polluted and >100CFU/100ml=dangerous (WHO, 2004a, FDRE, WRM, 2002).

Adada (81.34±8.07 CFU/100ml) from unprotected well contained the highest TC counts reflects that there were high human activities (laundering and bathing activities) and unhygienic practices that leads to the contamination of the water sources (Table 2). The patterns of TC counts showed that, the Legedini water sources were more polluted), followed by Legebira water sources whereas Adada water sources were the least compared to others. In this study area, the degree of bacteriological water contamination was very high. The bacteriological counts in most sites were in dangerous range of pollution for drinking specially by TC and TTC/FC (11-100 CFU/100ml). None of the water sources were found to be safe for drinking except the tap water. Moreover, most of water samples taken from spring (unprotected and protected) and well (unprotected and protected) had very high pollution levels categorized under dangerous. While the samples from the household water had lower pollution levels, none of the other samples could be categorized under the very dangerous degree of pollution (Table 3).

From all the study sites, the highest TTC/FC count was recorded from Legedini PAs followed by the lowest counts from Adada PA. The largest TTC/FC count (54CFU/100ml) was recorded from Legedini protected well followed by 51CFU/100ml and 33CFU/100ml from water samples of Legebira and Adada (unprotected well), respectively. Therefore, all water sources except household water samples were polluted by TTC/FC.

DISCUSSION

With regards to thermotolerant (faecal) coliforms, all water samples (100%) were found to contain thermotolerant (faecal) coliforms in the range of 0.34-54 CFU/100ml with significant variation at (p<0.0001) (Annex III). The highest and lowest levels of thermotolerant (faecal) coliforms, i.e., 54 CFU/100ml and 0.34 CFU/100ml, were recorded from Legedini protected well and Adada household water, respectively. The high level of coliform count recorded in this study may be attributed to the high degree of contamination of the water sources due to unhygienic practices around and near water sources.

All samples of the water sources in this study were contaminated with total coliforms. Except the water samples from the household water that had 50% contamination, all the others had 100% contamination with total coliforms. Out of these, 100% of the samples from unprotected well and protected well, 83.34% the sample from unprotected spring and protected spring had unacceptable levels of total coliforms according to the suggested criteria for drinking water sourses (WHO, 2004). Likewise, all water sources were 100% contaminated with thermotolerant (faecal) coliforms, except the sample from tap water, which had only 50% of contamination level.

Similarly, 100% of the samples from unprotected well and protected well, 83.34% from unprotected and protected spring were contaminated by thermotolerant (faecal) coliforms. As the study conducted by Getnet (2008) from Bahir Dar town showed that 100% of the analyzed water samples from the source had a mean total coliform count of 35.5CFU/100ml which is above the acceptable level recommended by WHO (2005). This is much lower than the present study. This difference may be due to the site selection, inadequate protection of water sources and unhygienic practices near the water sources (Richards, 1996).

According to the study conducted by Mengesha in North Gonder ,out of the seventy analyzed protected spring and protected well water samples, 71.43% and 28.6% had levels of total coliform (TC) and faecal coliform /thermotolerant(TTC/FC) count, respectively and the author also further demonstrated that, 50% of the samples had a coliform count of 180 and above /100 ml and the lowest coliform count was 13 coliform /100 ml (Mengesha *et al*., 2004), which was higher than the present study that was 133.65 coliform /100 ml and the lowest total coliform 1.50 coliforms/100ml.

In another study in South Wello, Ethiopia, Atnafu (2006) demonstrated that, 75% of the samples from protected springs were contaminated with total coliforms. This was less than the present study, where all water sources were contaminated with total coliform. In contrast, as the research conducted in Yubdo-Legebatu by Birhanu (2008) indicated that, all the water samples were contaminated by the total coliform in which the highest total colifrom was 1447.47 coliform/100ml and the lowest coliform was 193.8 coliform/100ml and this was also much higher than the present study. This difference may be due to the lack of water sources protection in the case of Yubdo-Legebatu and not in case of Dire Dawa Rural Communities.

In harmony with the present study, results of monitoring six sampling stations in the Geum River in Korea showed average concentrations of total coliforms ranging from 1670 to 8510 CFU/100 ml (Geonha *et al*., 2005). This was higher than the present study and the possible reasons for this variation may be due to the differences in dilution and sources of contaminants, water sources protection and unhygienic practices near the water sources (Richards, 1996).

Alternatively, as the research conducted in Debrezeit town (Desta, 2009) from all water source samples (100%) were contaminated by TC to the range of 1-4 coliform/100ml, but within the acceptable limit of 1-10coliform/100ml set by WHO (1997). In a similar study conducted on rural hand-dug pump well water from South Wello, Atnafu (2006) reported that 50% of the underground wells contain TC counts of 3.3CFU/100ml. This had lower range of total colifrom than present study, but the (100%) of water samples contain total coliform. This indicates that the degree of risk factors for the contamination of water sources in Rural Communities of DDAC is tremendously increasing due to uncontrolled waste disposal and inadequate water treatment around the water sources (Tamiru, 2001).

ANOVA of total coliform concentration among all sources demonstrated that there was a significant difference (p< 0.001) in the average counts of TC between the water sampling sources and sites (Appendix III). Total coliforms in unprotected spring and unprotected well of the Legedini were significantly higher than in all other sources of all sites. Moreover, there is poor sanitation and unhygienic practices near the water sources. In addition drawing water is done using unclean cups and cans, while there is also open access for livestock and wildlife. All these factors might be possible reasons for the high concentrations in total coliforms in this study area. This result was supported by questionnaires survey on households’ water handling practices.

Unprotected wells and unprotected springs demonstrated that 100% of the samples taken from both sources were contaminated by total coliform and fecal coliforms. In addition, analysis of the water samples from the protected spring and wells demonstrated that 100% of the water sources were contaminated by coliform. These results were supported by the research conducted by Mengasha in which analysis of protected springs confirmed that above 71.43%, of the samples had indicator bacteria (Mengesha et al., 2004) this is lower

Table 4. Parasitological analysis of five types of water sources in rural communities Dire Dawa Administrative Council during February and May 2011.

Study Site	Water sources	Number of sample examined	Occurrences of parasites		Mean counts of parasites	
			Giardia	*Cryptosporidium*	*Giardia*	*Cryptosporidium*
			Frequency (%)	Frequency (%)		
Legedini	Unprotected well Unprotected spring Protected well Protected spring household water	6 6 6 6 6	6(100%) 4(66.67%) 3(50%) 3(50%) 0(0%)	5(83.34%) 3(50% 3(50% 2(33.34%) 0(0%)	4.5 ± 0.70^{a} 1.5 ± 0.83^{b} 1.34 ± 0.50^{b} 0.67 ± 0.21^{c} 0 ± 0^{c}	3 ± 0.41^{ab} 6.5 ± 0.64^{a} 6.16 ± 0.60^{a} 5 ± 0.89^{ab} 0.67 ± 0.21^{c}
Legebira	Unprotected well Unprotected spring Protected well Protected spring household water	6 6 6 6 6	6(100%) 6(100%) 4(66.67%) 3(50%) 0(0%)	6(100%) 5(83.34%) 4(66.67%) 3(50% 0(0%)	3.84 ± 1.72^{ab} 3.67 ± 1.96^{ab} 2 ± 1.78^{b} 2.33 ± 2.33^{b} 0 ± 0^{c}	5.5 ± 0.67^{ab} 4.16 ± 2.63^{ab} 2 ± 1.11^{b} 2.34 ± 1.12^{b} 0 ± 0^{c}
Adada	Unprotected well Unprotected spring Protected well Protected spring household water	6 6 6 6 6	6(100%) 5(83.34%) 6(100%) 4(66.67%) 3(50%)	6(100%) 5(83.34%) 5(83.34%) 3(50% 3(50%	3.83 ± 3.43^{ab} 3.67 ± 2.50^{ab} 5.67 ± 2.58^{a} 3.5 ± 1.37^{ab} 0 ± 0^{c}	6.5 ± 1.64^{a} 4.8 ± 28^{ab} 5.16 ± 2.40^{a} 3.33 ± 1.75^{ab} 0.5 ± 0.54^{c}

than the present study conducted in different water sources of Dire Dawa Rural Communities.
The variance analysis of Thermotolerant/fecal coliform concentrations among all sources showed that there was a highly significant difference ($p< 0.001$) in the average counts of TTC/FC among all water sites and sources (Appendix III).

Mean thermotolerant (fecal) coliform levels in Bacteriological contamination of water from various sources is commonly due to the lacks of water treatment, good sanitation, good management of water sources, environmental sanitation etc. In South Australia, Esterman *et al*. (1984) surveyed 100 water samples finding 18% of the water sources with at least one unacceptable bacteriological result, but no significant difference between wells and springs was observed. In all unprotected well of Legebira were significantly higher than in all other sources and sites. Thermotolerant/Fecal coliforms are indicators of fecal contamination. Hence, categorizing the site in terms of risk to human health, the majority, above (66.67% of.

sampled water sources in the study area were at high risk Bacteriological contamination of water from various sources is commonly due to the lacks of water treatment, good sanitation, good management of water sources, environmental sanitation etc. In South Australia, Esterman et al. (1984) surveyed 100 water samples finding 18% of the water sources with at least one unacceptable bacteriological result, but no significant difference between wells and springs was observed. In all cases there was no significance difference between unprotected sources and protected sources in the wells and in spring because, the wells and springs were not properly protected. The spring was not properly covered by stone masonry with one or two boxes and the well was not properly covered by stone masonry (WHO, 1995).

Parasitological Quality of Drinking Water Sources

The parasitological analysis of water sources showed that unprotected and protected water sources (well and springs) were found to be positive for *Giardia* cysts ranging from 50% of water samples of protected well and spring of Legadeni sites to 100% of water samples of unprotected well of Legadeni site and unprotected well and spring of Legebira site, and unprotected and protected well of Adada site.

This indicates that there is no significance difference in prevalence of *Giardia* cysts between unprotected and protected spring. On the contrary, there was a marked difference in distribution of *Giardia* cysts in the household water samples. When all samples were negative, except the water samples from Adada that showed a 50% in tap water. Likewise, the distribution of Cryptosporidium oocyst was found to vary among the different water sources and different sites. Accordingly, a few water samples from sources were found to be 100% of positive compared to the distribution of *Giardia* cysts. The water samples from unprotected well of Legebira and Adada show 100% positive with *Cryptosporidium* oocysts.

Mean value of *Girdia lamblia* cyst was highest in unprotected well of Adada 5.5±0.670cyst/L, where as the lowest mean observed at the household water of 0.5±0.54cyst/L. The mean counts of the *Cryptosporidium* oocyst was highest at Adada unprotected spring and lowest at Legebira tap water but there was no significance different from Legebira and Adada water sources (Table 5)**.** There was no much variation on cyst and oocyts count among the different water samples but, the highest count was recorded from unprotected spring (Table 5)**.**

There was no much significant difference among the samples of water sources and household water samples for *Cryptosporidium* oocyst. Similarly, there was no variation between wells and springs except the samples from household water and not much difference between unprotected and protected water sources were observed.

In similar with the present study, the research conducted in South Africa revealed that, *Giardia lamblia* and *Cryptosporidium* were detected in all (100%) raw water samples collected from selected catchments (Sigudu et al., 2008). In contrast, *Giardia* cysts was found in (50%) of samples from river water while no *Giardia* and *Cryptosporidium* were reported both in untreated water sources and municipal drinking water (Bakir *et al.*, 2003).

In a study conducted in Norway water sources demonstrated the presence of *Cryptosporidium* in 13.5%, *Giardia* in 9% and both parasites in 2.5% samples were detected (Robertson *et al.*, 2001). According to Nishi *et al.* (2007), 6.66%, 26.66% and 13.33% of *Giardia* and *Cryptosporidium* were found in samples from untreated water sources, respectively. In the same manner as the research reported by Karanis, 81.81% of *Giardia* and *Cryptosporidium* were detected in samples from river water (Karanis *et al.,* 2005). Research conducted by Wallis *et al.* (1996) reported that, 21% of *Giardia* was detected in raw water samples. Once more, this is lower than the present study conducted at Dire Dawa rural communities, in that above 33.34% of water samples were contaminated with *Girdia lamblia* and *Cryptosporidium.*

Parasitological water quality analysis demonstrated that, 100% of water samples were positive with *Cryptosporidium* oocysts and *Girdia lamblia* cyst both from unprotected and protected wells and springs and the least percent was detected at tap water. In addition, the statistical analysis result demonstrated that, there was significant difference between the untreated water sources (unprotected well and unprotected spring) and treated water sources (household water) ($p<0.001$). Similarly, a researched conducted in Addis Ababa drinking water sources demonstrated that there is was a significant difference in concentration of *Giardia* and *Cryptosporidium* between treated and untreated water (Nigus *et al.*, 2008).

Even though ground water has lower possibilities for contamination by cysts or oocysts but it can be contaminated from surface activities through infiltration. For instance ground water (well) is usually free of *Giardia* and *Cryptosporidium* but it can be contaminated occasionally (LeChevallier *et al.*, 1995). Likewise, Karanis *et al.* (2006) demonstrated that, 11.1% of *Giardia lamblia* and 16.7% of *Cryptosporidium* were detected from the well water sources, respectively. Similarly, as the research conducted by Bakir and Watanabe, showed that the samples from well water and underground well water were positive for the presences of *Giardia* cysts and *Cryptosporidium* (Bakir *et al.,* 2002; Watanabe *et al.,* 2005).

Table 5.Socio-demographic characteristics of respondents from Adada, Legebira and legedini February 2011.

Questions items	Adada (n=128)		Legebira(n=128)		Legedini(n=128)		Total respondents from all sites
	No.	%	No.	%	No.	%	
Age of the respondents							
15-24 years	22	17.4	20	15.62	20	15.62	62
25-34 years	53	41	64	50	69	53.90	186
35-44 years	28	21.9	28	21.87	24	18. 75	80
>44 years	24	19.0	16	12.5	16	12.5	56
Gender							
Male	7	5.5	7	5.5	6	4.68	20
Female	121	94.5	121	94.5	122	95.31	364
Religion							
Christian	4	3.12	3	2.34	4	3.12	11
Muslim	124	96.88	125	97.65	124	96.87	373
Educational status							
Illiterate	113	87.04	100	78.12	98	76.56	335
Read and write	13	10.5	23	17.94	10	7.8	33
Elementary	1	0.78	3	2.34	6	4.68	10
Secondary	1	0.78	1	0.78	4	3.12	6
Occupational status							
Farmers	120	93.75	100	78.12	113	88.28	332
Merchant	4	3.12	12	9.37	16	12.5	32
Gov.tal employers	2	1.56	8	6.25	0	0	10
Housewives	2	1.56	8	6.25	0	0	10

According to the study conducted by LeChevallier *et al.* (1995) on ground water sources, the average concentrations of *Girdia lamblia* were within 0.4-6.3 and 0.3-9.8 respectively. This is similar to the present work in that the distribution of *Giardia* and *Cryptosporidium* were with 0.5-4.5 and 0.67-5.67 respectively. The present findings were much lower than the finding of Sigudu *et al.* (2008) that reported the concentration of more than 1,400 oocysts/10 liters and 2,700 cysts/10 liters were detected.

In contrast, the mean concentration of 0.15 oocysts/l and

0.2 cysts/l recorded by Nishi *et al.* (2007). This was lower than the present study. An investigation made by Stoyanovai *et al.* (2006) on drinking water supply contamination with *Giardia* and *Cryptosporidium* in Varna found positive with an average number of 5 cysts or oocyst/liter. These differences may be resulted due to the sources of contaminations, lack of adequate water treatment and unhygienic practices near and around the water sources in this study area. Protection of water sources and treatment of water supplies have greatly reduced the microbial load in water sources (WHO, 2003).

Water Handling Practices of Rural Households

Socio-demographic characteristics of the respondents

From the three study areas, majority of the respondents were women and mostly they were Muslim. Regarding to the occupational status of the respondent all of the respondents were farmers. Concerning their educational standing majority of the respondents were illiterate (did not able to read and write) (Table 5).

Water handling practices related to collection and transportation Adada

Majority of the respondents were found to collect water from tap water which accounted 54(43.87%), 31(24.2%) of them are collect water from the well and 43(32.78%) of them are collect water from the springs. Maximum time required to fetch water was one and half hours and minimum of thirty minutes within above 50m distance. As the result indicated in this study, 90(70.3%) of the households were not aware to protect the water sources before use and 38(29.7%) of the respondents were admitted to protect the water sources before use (Table 6).

The study revealed that the most commonly preferred type of water collection container was Jerrican which accounted 76(59.37%) followed by clay pots 52 (40.63%). From the total respondents, only 48 (37.5%) of the respondents cleaned their containers before collection. In addition, majority of the respondents were not cover the collection container during transportation (Table 6).

As designated in this study, 28(21.88%) of respondents were collect water once a day, 20 (15.5%) of the respondent were collected water three times a day and the remaining 80(62.5.9%) were collected twice a day. Daughters were highly responsible to collect water followed by mothers to fetch water from a source. Among the responsible children, majority of their age was below 10 years (Table 6).

Legebira

As the result from the Legebira site shown that, majority of the respondents were collect water from springs which accounted 56 (43.87%), 41(32%) of them are collect water from the well and 31(24.2%) of them are collect water from the tap water. The maximum time required to fetch water was more than one hour and minimum of 30 minutes.

The majority of the households, 98(76.57%) were not aware to protect the water sources before use, while only 30(23.43%) of the respondents were admitted to protect the water sources before use (Table 6).

The study revealed that the most commonly preferred type of water collection container was Jerrican which accounted 32(25%) followed by clay pots 96 (75%). Only 40 (31. 25%) of the respondents cleaned their containers before collection. Majority did not cover for their collection container during transportation (Table 6). Greater part of respondents, 84(65.62%) of the study subjects were found to collect water twice a day, 24 (18.75%) of the respondent once a day and the remaining 20 (15.5%) collect three times. Daughters were highly responsible to collect water followed by mothers to fetch water from a source. Among the responsible children, one majority of their age was below 10 years (Table 6).

Legedini

Majority of the respondents from the Legedini were compel to collect water from well (especially from unprotected one) which accounted 68 (53.12%), 40(31.22%) of them are collect water from the spring and 20(15.62%) of them are collect water from the tap water. Maximum time required to fetch water was more than one hour and minimum of 30 minutes. As the result of the questionnaires pointed out that, majority of the households were not attentive to protect the water sources before use, while only 20(15.62%) of the respondents were admitted to protect the water sources before use (Table 6).

The study revealed that the most commonly preferred type of water collection container was clay pots which accounted 80 (62.5%) followed by Jerrican 48(37.5%). Only 21 (16. 40%) of the respondents cleaned their containers before collection. Majority did not cover for their collection container during transportation (Table 6). Majority of respondents, 80 (65.62%) of the study subjects were found to collect water twice a day, 20 (15.5%) of the respondent once a day and the remaining 28 (21.9%) collect three times a day. Daughters were highly responsible to collect water followed by mothers to fetch water from a source. Among the responsible children children, one majority of their age was below 10 years

Table 6. Water handling practices related to collection and transportation in rural communities of DDCAC.

Questions items	Adada (n=128) No.	%	Legebira (n=128) No.	%	Legedini (n=128) No.	%	Total from all sites
From where did you water							
spring	43	32.78	56	43.87	40	31.25	140
well	31	24.2	41	32	68	53.12	140
Tap water	54	43.87	31	24.2	20	15.62	104
What is the approximate distance of water sources from your home							
Below 30 min.	20	15.6	-	-	10	7.81	30
31-60 min.	40	31.5	54	42.18	40	31.25	134
More than 60 min.	68	52.9	74	57.81	78	60.93	220
What types of container do you use to collect water from sources							
Clay pot	52	40.62	96	75	80	62.5	156
Jerrican	76	59.37	32	25	48	37.5	228
Do you cover the container while water collection							
Yes	48	37.5	40	37.5	21	16.40	109
No	80	62.5	88	68.75	107	83. 59	275
Do you wash your container							
Yes	48	37.5	40	31. 25	32	25	120
No	80	62.5	88	68.75	96	75	264
How many time do you collect water per day							
Once a day	28	21.9	24	18.75	20	15.5	66
Twice a day	80	62.5	84	65.62	80	65.62	204
Three times a day	20	15.5	20	15.5	28	21.88	64

(Table 6).

Water handling practices related to storage and usage by households Adada

Among the study inhabitants using separate container to store water, 84 (65.62%) the households preferred clay pots and the rest 44 (34.36%) used jerrican and 68 (53.12%) of them were not wash storage containers before re-filling, similarly 70 (54.65%) of households were use separate containers without cover materials. From the total selected households, 80 (62.5%) of the households stored water for a day, 28 (21.88%) for more than a day and 20(15.5%) for less than a day (Table 4.3c). According to the observation during the data collection, the sanitation of the area near the storage containers was poor. In addition the storage container has a possibility of reaching animals (Table7).

Pertaining to the way that the respondents' withdraw water from containers, 100 (78.12%) of the respondents preferred pouring and the remaining 28(21.87%) by dipping. Among those respondent using dipping, cups without handle accounted 70 (54.68%). In addition, 87 (69.3%) of the respondents placing dipping or drinking utensils on the floor, the result was also consistent with the observation that was seen during data collection (Table 7). Majority of the households were not admitted to treat the water sources before collecting.

Legebira

As of the result of survey conducted at Legebira sites, along with the study population using separate container to store water, 78 (54.68%) preferred clay pots and the rest 50 (36.88%) used Jerrcan, and 68 (53.12%) of them were not wash storage containers before re-filling, similarly 88 (68.75%) of the separate containers were without cover materials. Majority, 90 (70.31%) of the households stored water more than a day, 24 (18.75%) for less than a day and 14(10.93%) for more than a days (Table 7). In accordance with the observation during the data collection, the sanitation of the area near the storage containers was poor. Almost all the respondents were not treat water sources before use. In addition the storage container has a possibility of reaching animals.

Concerning the way that the respondents' with-drew water from containers, 68 (53.12 %) preferred pouring and the remaining 60 (46.88%) by dipping. Among those respondent using dipping, cups without handle accounted 88 (68.75%). In addition 98 (76.56%) of the respondents placing dipping or drinking utensils on the floor, the result was also consistent with the observation that was seen during data collection (Table 7). All the respondents were not understood to protect the water sources.

Legedini

At the Legedini site, among the study population using separate container to store water 90 (70.31 %) preferred clay pots and the rest used jerrican, and 78 (62. 5%) of them did not wash storage containers before re-filling, similarly 79 (61.71%) of the separate containers were without handle. Greater part of the respondents, 60 (46.68%) of the households stored water for more than a day, 45 (35.14%) for a day and the rest were for less than a day (Table 7). According to the observation during the data collection, the sanitation of the area near the storage containers was poor .In addition the storage container have a possibility of reaching animals.

In relation to the way that the respondents' with-drew water from containers, 8(6.25) preferred pouring and the remaining 120 (93.75%)) by dipping. Among those respondent using dipping, cups without handle accounted 69 (53.9%). In addition 96 (75%) of the respondents placing dipping or drinking utensils on the floor, the result was also consistent with the observation that was seen during data collection (Table 7). Predominantly, the respondents were not aware to protect the water sources before use.

The results of this study indicated that springs and wells water sources were subjected for the microbiological contamination in all sites and sources. Because community unhygienic practices increase the sanitary risk of the water sources , water sources with high sanitary risk score had

unacceptable water quality (unprotected well and protected well, unprotected spring and protected spring and tap water) from the three sites (Adada, Legedini and Legebira). Specially, the water sources of Legedini, unprotected well and protected well had high unhygienic practices. In contrast, the water sources of Legebira had intermediate risk of sanitary practices and the Adada water sources have less sanitary risk than the left sites.

Study in Srilanka demonstrated that (65%) to (85%) of public water supplies mostly protected springs become microbiologically contaminated (Mertens, 1990).

The higher hazard scores of water sources generally correlate with increasing magnitude of bacterial contamination (Lioud, 1992).

More than half of the respondents were doing laundry and bathing activities near the water sources. A similar study in rural Zambia and in South Wollo Ethiopia showed that poor community sanitary practices around the sources and near the catchment areas together with inadequate protection of water sources increased the sanitary risk scores of the springs and contributed to the microbiological contamination of water sources (Thomas and Cairncross, 2004; Seid *et al*., 2003).

In the present study, the wells and springs water sources were more contaminated than tap water. The reason behind the variation of sanitary risk scores between water sources may be due to its location and other factors (poor site selection, unhygienic practices near the water source, and inadequate treatment). Those sources having high sanitary risk score were found in a densely populated area and the number of households who practiced bathing and laundry activities are increasing near the water sources. The result of sanitary and quality monitoring in a pilot water quality surveillance study in Sirilanka demonstrated water sources become contaminated because of poor site selection, protection and unhygienic management of facilities (Mertens, 1990).

From the total respondents, 66.2% of households used clay pots for household water storage while the remaining 33.8% stored water in Jerrican except in Adada, which was the majority of the respondents use Jerrican both for the collection and storage of the water. Respondents that preferred clay pots were revealed increasing of the risk of

Table 7. Water handling practices related to storage and usage by households from Adada, Legebira and Legedini in February2011.

Question items	Adada (n=128)		Legebira (n=128)		Legedini (n=128)		Total from all sites
	No.	%	No.	%	No.	%	
What type of storage do you use to store water							
Clay pots	84	65.62	78	54.68	90	70.31	252
Jerrican	44	34.36	50	36.88	38	29.68	122
Do you cover of storage container							
Yes	60	46.88	60	46.88	50	39.06	170
No	68	53.12	68	53.12	78	60.93	124
How do you collect water from the storage							
Pouring	100	78.12	68	53.12	8	93.75	176
Dipping	28	21.88	60	46.88	120	6.25	208
What the dipping juck looks like							
With handle	68	53.12	40	31.25	49	38.28	157
Without handle	70	54.68	88	68.75	79	61.71	227
Where did you put the juck							
On a safe place	41	31	30	23.43	32	25	103
On the floor	87	69	98	76.56	96	75	281
For how many days do store water in the container							
For a day	80	62.5	14	10.93	45	35.14	108
More than a day	28	21.88	90	70.03	60	46.68	208
Less a day	20	15.5	24	18.75	23	18.18	68
Which method of water treatment do you							
Chemical	6	4.7	34	26.6	46	32.8	86
Boiling	7	5.5	9	7	-	-	23
Filtration	3	2.3	11	8.6	-	-	14
No treatment	112	87	70	57.8	79	67.2	261

faecal coliforms than those of respondents using jerrican. This current result was harmony with the finding in Bangladesh that revealed that traditional pots increased the load of faecal coliforms (Spira *et al.,* 1980). Similarly, Mertens (1990) and Seid et al. (2003) reported that the water stored in clay pots was shown higher proportion of load of faecal coliform than that of narrow necked container.

As indicated from the result of the survey on water handling practices, (55.5%) of the respondents cleaned their container before transferring water from collection to storage containers and (44.5%) of them were not cleaned the container before water collection which was much lower than a study done in Jimma town 91% (Teklu and Kebede, 1998). Similarly, (52%) of the respondents covered their storage container, which was almost similar with the study conducted in Garmuleta district (60%), and Kidame Gebeya (58%), but much lower when comparing with a study done in South wollo, 92.7% (Seid *et al*., 2003). This difference may be due to inadequate and unhygienic practices related to water handling practices in the present study areas.

The main contribution for household water contaminations

The main contribution for household water contaminations were unrestricted and unhygienic water collection and storage activities such as: selection household containers, lack of cover, ignorance of washing of containers before collection and transferring to storage containers, transfer of water out of storage container by dipping and placement of drinking or water drawing utensils on floor, because of this the fecalcoliform load increases by two fold in household container than sources (Thomas and Cairncross, 2004).

In this study, 85.41% of the respondent dipped out water while 14.59 % of the respondents poured water to collect from the storage container, which is a commendable practice. This was almost higher when comparing with studies conducted in Zambia with 80% and in south Wollo with 72% of the households was dipped out from the container (Seid *et al*., 2003). The reason for these much difference is may be due to the use of narrow naked clay pots and jerrican, which is inconvenient for dipping in the study. Transfer of water out of storage containers by pouring showed statistically significant diminution on the concentration of faecal coliforms than dipping in the study area.

SUMMARY AND CONCLUSION

The microbiological quality of drinking water sources and water handling practices at household level in rural communities of Dire Dawa was conducted at the Dire Dawa Rural Communities water supply and sanitation laboratory.

The bacteriological results from this study were not harmony with the reference values set out by WHO (2004) and they were grossly polluted. Therefore, the bacteriological quality of drinking water sources in rural communities of Dire Dawa (Adada, Legedini and Legebira) did not meet national or international guidelines for drinking water that is set by WHO standard. The overall microbiological count (bacterial and parasitic) and water handling assessment among households indicated that the majority of water sources in rural communities of Dire Dawa (Adada, Legedini and Legebira) could be classified as more polluted, while some were at intermediate risk and very few water points had reasonable quality.

High counts of indicator organisms in all sampled water sources of the study areas suggested the presence of pathogenic organisms that constitute a threat to anyone consuming these water sources. The contamination of these water sources with pathogenic organisms due to the absence of fencing of water sources that could prevent the entrance of animals, livestock grazing nearby water sources, people’s open area defecation, collecting of water with unclean jug, cups, agricultural activities nearby water sources, and lack of regular disinfection of the water reservoir.

RECOMMENDATION

The following recommendations are forwarded in view of the findings of this present study

1. As indicator bacterial counts in all sampled water sites have exceeded the guidelines, set for human use there is clearly an urgent need to develop safe water supplies and basic water handling practices at the household level and disinfect the water sources properly.

2. The positive results of the indicator organisms may indicate that there were improper and poor waste disposal practices and poor dumping of wastes as well as poor sanitation and management of water sources. Therefore, there is a need to manage catchment areas around the water sources.

3. Protection of water sources accompanied by sanitation and hygiene promotion programs can improve the hygiene quality of rural water sources, where disinfection is not feasible.

4. The assessment of water handling practices of the rural communities showed that unhygienic practices around water sources, human activities near water sources like unwise waste disposal and fertilizer application on arms in the well field areas as well as some cracks and leaks might be the causes of positive bacterial counts and increased water contamination. Proper sanitation, management, regular monitoring and maintenance of water sources should be carried out.
5. Regular drinking water quality assessment from the source, reservoirs, distribution systems and pipes should be employed to ensure that the water is safe for human use.

6. Future studies are needed to determine the seasonal variations in the contamination level of the water sources, to quantify pathogen loads in different water sources to develop risk-reducing water quality management systems.

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