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Microbiological Quality of Drinking Water Sources and Water Handling Practices among Rural Communities of Dire Dawa Administrative Council

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A B S T R A C T

In Ethiopia, access to improved water supply and sanitation was estimated at 38% and 12% respectively. Three- forth of the health problems of children in Ethiopia are communicable diseases due to polluted water and improper water handling practices. Thus, this study was conducted to assess the level of contamination and the major sources of contaminant in rural communities of Dire Dawa. A total of 90 water samples from five types of water sources were collected and bacteriological water quality parameters were analyzed using the membrane filtration method by the procedures of the American Public Health Association. Water analysis demonstrated that all water sources in the study areas were contaminated with total coliforms, fecal coliform and parasites. 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. In all samples, the TC, FC and FS counts were above the recommended limit of WHO for drinking water quality (1-10CFU/100ml for TC, 0CFU/100ml for FC, 0CFU/100ml FS) whereas about 83.34% of the water samples in the three selected PAs had high risk of microbiological water quality parameters. Fecal coliform - fecal streptococci ratios in all water sources in this study showed that 45.0% indicated enteric contamination from human wastes and 55.0% was from domestic animal wastes. Consequently, 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. Proper and basic sanitation, are of prime importance to deliver safe drinking water in the study site.

Introduction

Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all peoples. According to WHO, more than 80% of diseases in the world are attributed

to unsafe drinking water or to inadequate sanitation practices (WHO, 2003a). Globally, 1.1 billion people rely on unsafe drinking water sources from lakes, rivers, and open wells (WHO, 2000). In Ethiopia drinking water coverage was less than or equal to 21% for the rural, 84% for the urban and 30% for the country level. The per capita per day water consumption ranged from 3 to 20 liters with median of 8.5 liters (Abera and Mohamed, 2005).

In Ethiopia, access to improved water supply and sanitation was estimated at 38% for improved water supply (98% for urban areas and 26% for rural areas) and 12% for improved sanitation (29% in urban areas, 8% in rural areas) (UNICEF and WHO, 2008). Over 60% of the communicable diseases are due to poor environmental health conditions arising from unsafe and inadequate water supply and poor hygienic and sanitation practices. Three fourth of the health problems of children in the country are communicable diseases due to polluted water and improper sanitation (FDRE, MOH, 2006).

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 (FDRE, 2004).

Indicator bacteria are used to evaluate the portability of drinking water because it would be impossible to accurately enumerate all pathogenic organisms that are transmitted by water (Paccker *et al*., 1995). 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).

Detection, differentiation and enumeration of Entrobacteriaceae are of primary importance in the microbiological quality control of water. Indicator bacteria are used to evaluate the potability of drinking water because it would be impossible to accurately enumerate all pathogenic organisms that are transmitted by water (Paccker *et al*., 1995). 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*., 2002). The presence of any coliform organism in drinking water is used as an indicator of fecal contamination since they are the most sensitive indicator bacteria for demonstrating excremental contamination (Paccker *et al*., 1995).

Fecal streptococci are also used as indicators of drinking water

microbiological quality. It has repeatedly been shown that these bacteria have a stronger relationship to diarrheal disease even than *E.coli* and a closer relationship to bacterial indicators of known human fecal origin (FDRE, MoH, 2006).

Bacteriological techniques employed to distinguish between human and animal fecal pollution are a valuable tool in water pollution control programs, because they are useful in tracing the source of pollution of drinking water supplies, and they can help in assessing the overall adequacy of protection rendered to small rural water supplies (Mara and Oragui,1985). Fresh addition of human fecal material can be distinguished from additions of animal feces in environmental waters by the ratio of fecal coliforms to fecal streptococci (FC/FS).

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 revert to unhygienic and unsafe sources of water (Dawit, 2006). People in Dire Dawa rural communities collect polluted water from a contaminated and leaking water supply for drinking and cooking purposes. Many populations of the rural communities use water for different purpose from un-protected sources like; the spring, boreholes, wells for domestic and other purpose. 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 fecal coliform/100 ml of water and zero concentration of *Giardia* and *Cryptosporidium*. Therefore, this study was used to investigate the microbiological quality of drinking water sources and water handling practices at the study area.

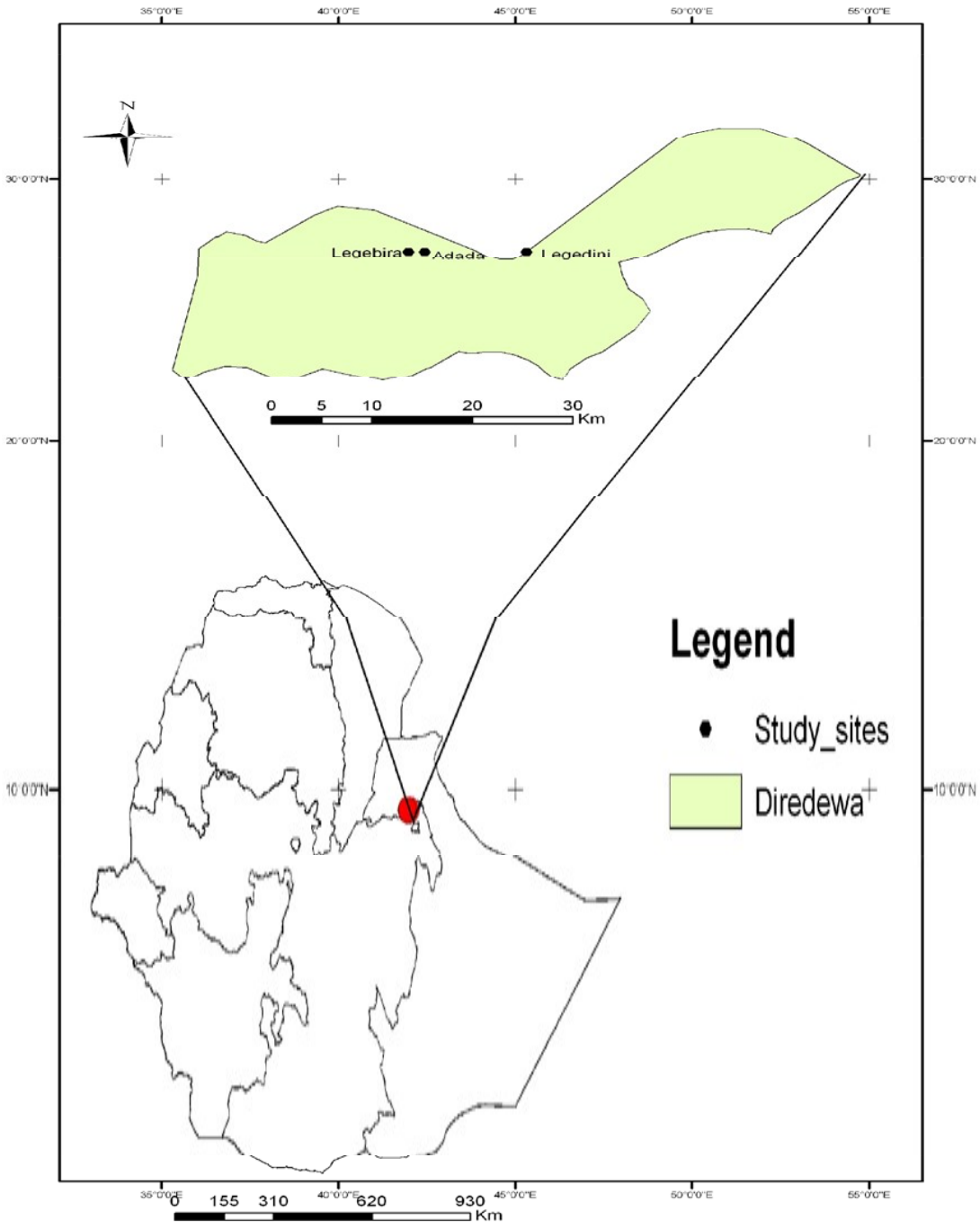
Materials and Methods

The present study was conducted between February and May, 2011 in three purposively selected Peasant Associations (PAs) named Legedini, Adada and Legebira, which are found in Dire-Dawa Administrative Council: (Figure 3.1). The Dire-Dawa town is located in Eastern parts of Ethiopia, which is 508 km away from Addis Ababa, capital city of Ethiopia.

As previously study conducted by Dawit (2008) on the association of the parasitic infection with drinking water sources revealed that farmers in this study area are engaged in crop- livestock mixed agriculture, they are not food self-sufficient and most of the time they are dependent on donation from government and other donor organizations. 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

Figure .3.1. Map of Study Area showing the location of sampling sites



household activities and insufficient sanitary facilities. As a result, waterborne and hygiene related diseases occur frequently (Dawit, 2008).

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 in rural communities in surrounding area of Dire Dawa Town. The laboratory investigation was carried out by collecting water samples from different sources during February, 2011 and 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 present study.

Water Sample Collection

In each study area and sampling site the water samples were collected from five types of water sources, viz., protected well, unprotected well, protected spring, unprotected spring and tap water. That means, a total of three study areas (Legedini, Legebira and Adada), one sampling site was used in each study area; and five types of water sources were used in each study sites. Therefore in two rounds of sampling, triplicate samples of 400-600ml of water were collected from each type of water sources in each study area and sampling site. A total of 90 water samples were collected and analyzed during February and May, 2011. 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 transported to Dire Dawa water supply and sanitation laboratory for microbiological water quality analysis. The water samples were handled aseptically in sterilized glass bottled, labeled and kept in ice box during transportation.

Bacteriological analysis

The membrane filter technique, which involve direct plating for detection and estimation of coliform, effective test for detecting bacteria of the coliform group and it is the best techniques currently available .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 and then counting the resultant TC and FC units (APHA 1998).

An ideal sample volume of water samples were placed on the surface of membrane and drinking water were analyzed by filtering 100ml, or by filtering replicate smaller sample volumes. Using sterile forceps, a sterile membrane filter paper (0.45μm pore sizes, 47mm in diameter, sterile) was placed on the membrane filter support assembly. Funnel unit were placed carefully over the filter support assembly and were locked in place. The sample were mixed systematically by shaking for about 30 minutes and poured in to the funnel assembly then the entire volume of sample were filtered through the membrane-filter by applying vacuum pump. Funnel and membrane-filter assembly were rinsed by sterile dilution 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 prepared culture dishes were incubated for 18 to 24hrs at 37^0C. Up on completion of incubation period, typical coliform colonies (yellow colour) were seen on the surface of membrane filter paper. All yellow colonies extending on the membrane were counted with the aid of a magnifying lens and recorded as total coliform (APHA, 1998).

Following the same procedure of filtration process, membrane filter papers were placed on Membrane lauryl sulphate broth. Finally the prepared culture dish were incubated for 18 to 24 hrs at 44 ^{0} C. Up on completion of the incubation period, yellow colored colonies on the surface of the filter paper were counted.

For isolation of *Entrococcus* and fecal *Streptococcus*, typical colonies from mEntrococcus agar membrane were streaked on the surface of brain-heart infusion agar plate and incubated at 35°C for 24h. A loopful growth from a well-isolated colony on brain-heart infusion agar was transferred to brain-heart infusion broth tube and to each of two clean glass slides. The brain-heart infusion broth was incubated at 35°C for 24h. A freshly prepared 3% hydrogen peroxide was dropped to the smear on a slide and detected.

A loopful of growth from the brain-heart infusion broth was transferred to bile esculin agar (was prepared according to the direction of APHA, 1998) and incubated at 35°C for 48h, and brain-heart infusion broth with 6.5%NaCl and incubated at 35°C for 48h. Typical colonies from Entrococcus agar membrane were streaked, prepared for epiflourescence microscope and seen as diploid and small chain coccid shape cells, which is a typical characteristic of the indicator group (*entrococcus /streptococcus*).

Result and Discussion

Bacteriological Quality of Drinking Water Sources

Bacteriological analysis of water samples from the five sources (protected spring, unprotected spring, protected well, unprotected well and tap water) in three sites of Dire Dawa Rural Communities showed that all samples of water sources from each site (Adada, Legedini and Legebira PAs) were positive for total coliforms and faecal coliform in two rounds of triplicate sampling. Indicator bacteria were encountered in all samples from water sources of the study area. Less frequent of indicators organisms were observed from the tap water (Table 4.1a).

The results indicated that all (100%), majority (83.34%) and half (50%) of water samples collected from spring (protected and unprotected), well (protected and unprotected) and tap water sources, were positive for TC, respectively. In addition, enumeration results showed that 66.66% and 33.34% of the unprotected well had TC counts ranging from 11-100 CFU/100ml and above 100 CFU/100ml, respectively (Table 4.1a). The TC count (133.67±21.25 CFU/100ml) was recorded from Legedini unprotected well (Table 4.1a). There was a significant difference among the samples of Adada and the Legedini for TC, but no significant difference was observed between Legedini and Legebira. There was

significant difference among the samples of spring, well and tap water sources where as no significant difference between unprotected and protected water sources for TC and TTC/FC (Table 4.1b).

Total Coliforms (TC)

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 Legedini unprotected well and Adada tap water, respectively. The fact that Legedini (133.67±21.25 CFU/100ml), Legebira (110.34±27.43CFU/100ml), and 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 4.1b). 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.

Thermotolerant/Fecal Coliforms (FC)

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 tap 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. From all the study sites, the highest TTC/FC count was recorded from Legedini PAs followed by the lowest counts from Adada PAs. 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 tap water were polluted by TTC/FC.

All samples of the water sources in this study were contaminated with total coliforms. Except the water samples from the tap 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, 2004a; FDRE, MoH, 2002). 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. A similar 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 protectation 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

Table 4.1a.Bacteriological analysis of five types of water sources in Dire Dawa communities during February and May 2011

Study sites	Water sources	Number of Samples examined	Occurrences of indicators bacteria	
			Total coliform	Fecal colform
			Frequency (%)	Frequency (%)
Adada	Unprotected well	6	6(100%)	6(100%)
	Unprotected spring	6	6(100%)	6(100%)
	Protected well	6	5(83.34%)	5(83.34%)
	Protected spring	6	5(83.34%)	4(66.67%)
	Tap water	6	3(50%)	2(33.34%)
Legebira	Unprotected well	6	6(100%)	6(100%)
	Unprotected spring	6	6(100%)	6(100%)
	Protected well	6	6(100%)	5(83.34%)
	Protected spring	6	6(100%)	4(66.67%)
	Tap water	6	4(66.67%)	3(50%)
Adada	Unprotected well	6	6(100%)	6(100%)
	Unprotected spring	6	6(100%)	6(100%)
	Protected well	6	6(100%)	6(100%)
	Protected spring	6	6(100%)	5(83.34%)
	Tap water	6	44(66.67%)	3(50%)

Table 4.1b.Mean bacteriological count (total Coliform, Thermotolerant/fecal Coliform) of water sources in Dire Dawa rural communities between February 2011 and May 2011 (n =6) (Mean ±SE).

Sites	Sources	Total Coliform	Thermotolerant/Fecal Coliform
Adada	Unprotected well	81.34 ± 8.07^{abc}	33.33 ± 8.80^{ba}
	Unprotected spring	64.5 ± 8.61^{bcd}	21.16 ± 6.2^{abc}
	Protected well	67.83 ± 14.00^{bcd}	18 ± 7.68^{abc}
	Protected spring	59.17 ± 6.66^{bcd}	15.34 ± 6.59^{abc}
Legebira	Unprotected well	110.34 ± 27.20^{ab}	51 ± 11.9^{a}
	Protected well	80 ± 17.07^{abc}	33.5 ± 6.73^{ab}
	Unprotected spring	100 ± 14.34^{b}	26.5 ± 9.12^{b}
	Protected spring	79.34 ± 10.11^{abc}	29.67 ± 9.15^{ba}
Legedini	Unprotected well	133.67 ± 21.25^{a}	45.5 ± 12.00^{ab}
	Protected well	99.5 ± 13.72^{b}	54.83 ± 11.84^{a}
	Unprotected spring	120.16 ± 23.73^{ab}	25.83 ± 7.03^{b}
	Protected spring	90.5 ± 13.79^{bcd}	26 ± 9.05^{b}
	Tap water	4 ± 0.50^{d}	1 ± 0.36^{d}

Table 4.1c.The degree of bacteriological contamination from each study sites and in 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%)
	Tap 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%)
	Tap 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%)
	Tap 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).

Table.4.2a 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	
			Girdia lamblia	*Cryptosporidium*
			Frequency (%)	Frequency (%)
Legedini	Unprotected well	6	6(100%)	5(83.34%)
	Unprotected spring	6	4(66.67%)	3(50%
	Protected well	6	3(50%)	3(50%
	Protected spring	6	3(50%)	2(33.34%)
	Tap water	6	0(0%)	0(0%)
Legebira	Unprotected well	6	6(100%)	6(100%)
	Unprotected spring	6	6(100%)	5(83.34%)
	Protected well	6	4(66.67%)	4(66.67%)
	Protected spring	6	3(50%)	3(50%
	Tap water	6	0(0%)	0(0%)
Adada	Unprotected well	6	6(100%)	6(100%)
	Unprotected spring	6	5(83.34%)	5(83.34%)
	Protected well	6	6(100%)	5(83.34%)
	Protected spring	6	4(66.67%)	3(50%
	Tap water	6	3(50%)	3(50%

Table 4.2b.Mean parasitological count (*Cryptosporidium* and *Girdia lamblia*) of water sources in Dire Dawa rural communities between February 2011 and May 2011 (n =6) (Mean ±SE).

Sites	Sources	*Cryptosporidium*	*Girdia lamblia*
Adada	Unprotected well	3 ± 0.41^{ab}	4.5 ± 0.70^{a}
	Unprotected spring	6.5 ± 0.64^{a}	1.5 ± 0.83^{b}
	Protected well	6.16 ± 0.60^{a}	1.34 ± 0.50^{b}
	Protected spring	5 ± 0.89^{ab}	0.67 ± 0.21^{c}
Legebira	Unprotected well	5.5 ± 0.67^{ab}	3.84 ± 1.72^{ab}
	Protected well	4.16 ± 2.63^{ab}	3.67 ± 1.96^{ab}
	Unprotected spring	2 ± 1.11^{b}	2 ± 1.78^{b}
	Protected spring	2.34 ± 1.12^{b}	2.33 ± 2.33^{b}
Legedini	Unprotected well	6.5 ± 1.64^{a}	3.83 ± 3.43^{ab}
	Protected well	4.8 ± 28^{ab}	3.67 ± 2.50^{ab}
	Unprotected spring	5.16 ± 2.40^{a}	5.67 ± 2.58^{a}
	Protected spring	3.33 ± 1.75^{ab}	3.5 ± 1.37^{ab}
	Tap water	0.5 ± 0.54^{c}	0 ± 0^{c}

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 demonstrated that 75% of the samples from protected springs were contaminated with total coliforms (Atnafu, 2006). This was less than the present study, where all water sources were contaminated with total coliform. 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 Comunities. In contrast, 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 might be differences in dilution and sources of contaminants.

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 .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 site. This result was supported by questionnaires survey on households' water handling practices.

Unprotected wells and 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 and his co-worker in Goder (Mengasha *et al*., 2004). Analysis of protected springs confirmed that 71.43%, of the samples had

indicator bacteria that are lower than the present study (Mengesha *et al*., 2004).

The variance analysis of 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. Mean thermotolerant (fecal) coliform levels in unprotected well of Legebira were significantly higher than in all other sources and sites. 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, 1983).

Parasitological Quality of Drinking Water Sources

From the recapitulate results , above (83.34%) of unprotected wells water sources, (50%-100%) from unprotected springs and protected wells, (33.34%-66.67%) from protected springs and (50%) from tap water were positive both for the presences of *Cryptosporidium* oocysts and *Girdia lamblia* cyst. In addition, as the enumeration results showed , unprotected well and protected well, unprotected spring and protected spring had the parasitic counts ranging from 0cyst/L to10 cyst/L and 0 oocyst/L to 10 oocyst/L, respectively.

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 tap water of 0±00cyst/L. The mean counts of the *Cryptosporidium* oocyst was highest at Adada unprotected spring and lowest at Legebira tap water but there was no significantly different from Legebira and Adada water sources (Table 4.2a)**.** There was variation on cyst and oocyts count among the different sample with the highest count where recorded from unprotected spring (Table 4.2a)**.**

There was significant difference among the samples of Adada and the Legedini for *Cryptosporidium* oocyst, but no significant difference between Adada and Legebira. There was variation between wells, springs and tap water but there was no much difference between unprotected and protected water sources.

The parasitological counts in most sites were with the range of less polluted (1-10 oocyts/L or cyst/L). Moreover, most of water samples taken from spring (unprotected and protected) and well (unprotected and protected) had moderate pollution levels categorized under low risk or low pollution. While samples from the tap water had lower pollution levels, none of the other samples could be categorized under the very dangerous degree of pollution (Table 4.2c).

Table 4.2c.The degree of parasitological contamination from each study sites and in five types of water sources in DDCA, 2011

Study sites	Water sources	*Cryptosporidium* (oocyts/L)				*Girdia lamblia* (cyst/L)			
		Sanitary infection score				Sanitary infection score			
		0	1-10	11-100	>100	0	1-10	11-100	>100
Adada	Unprotected well	0(0%)	6(100%)	0(0%)	0(0%)	0(0%)	6(100%)	0(0%)	0(0%)
	Unprotected spring	1(16.67%)	5(83.34%)	0(0%)	0(0%)	2(33.34%)	4(66.67%)	0(0%)	0(0%)
	Protected well	2(33.34%)	4(66.67%)	0(0%)	0(0%)	3(50%)	3(50%)	0(0%)	0(0%)
	Protected spring	2(33.34%)	4(66.67%)	0(0%)	0(0%)	2(33.34%)	4(66.67%)	0(0%)	0(0%)
	Tap water	6(100%)	0(0%)	0(0%)	0(0%)	6(100%)	0(0%)	0(0%)	0(0%)
Legebira	Unprotected well	1(16.67%)	5(83.34%)	0(0%)	0(0%)	0(0%)	6(100%)	0(0%)	0(0%)
	Unprotected spring	0(0%)	3(50%)	3(50%)	0(0%)	0(0%)	6(100%)	0(0%)	0(0%)
	Protected well	2(33.34%)	4(66.67%)	0(0%)	0(0%)	2(33.34%)	4(66.67%)	0(0%)	0(0%)
	Protected spring	0(0%)	0(0%)	4(66.67%)	2(33.34%)	2(33.34%)	0(0%)	4(66.67%)	0(0%)
	Tap water	3(50%)	3(50%)	0(0%)	0(0%)	0(0%)	6(1000%)	0(0%)	0(0%)
Legedini	Unprotected well	0(0%)	6(100%)	0(0%)	0(0%)	0(0%)	1(16.67%)	0(83.34%)	0(0%)
	Unprotected spring	0(0%)	6(100%)	0(0%)	0(0%)	0(0%)	1(16.67%)	0(83.34%)	0(0%)
	Protected well	1(16.67%)	5(83.34%)	0(0%)	0(0%)	0(0%)	0(0%)	6(100%)	0(0%)
	Protected spring	0(0%)	0(0%)	6(100%)	0(0%)	0(0%)	1(16.67%)	0(83.34%)	0(0%)
	Tap water	3(50%)	3(50%)	0(0%)	0(0%)	3(50%)	3(50%)	0(0%)	0(0%)

Table 4.3a.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

Table 4.3b.water handling practices related to collection and transportation in rural communities of DDCAC

Questions items	Adada (n=128)		Legebira (n=128)		Legedini (n=128)		Total from all sites
	No.	%	No.	%	No.	%	
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 4.3c.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

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 (tap water) ($p<0.001$). Similarly, as the 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, the samples from well water and underground well water were positive for the presences of *Giardia* cysts and *Cryptosporidium* (Watanabe *et al.*, 2005).

From the total collected samples, 100 % of *Girdia* from both unprotected well and unprotected spring , was detected in unprotected and protected well of the Adada and the *Cryptosporidium* was detected in springs and wells with low percent from the tap water . In contrast to this, *Girdia* was detected in 100% in Legebira springs, 83.34% in wells while the tap water of these sites has no any *Girdia* detected and the *Cryptosporidium* was detected in 100% from both springs and well except the tap water in which there was no detected *cryptosporidium*.

According to the study conducted by LeChevallier *et al.* (1995), the average concentration of *Girdia lamblia* (range 0.4-6.3) and *Cryptosporidium (*range 0.3 - 9.8) were detected. 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.* (2008). 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/liter. These differences may be resulted due to the sources of contaminations, lack of adquated 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).

Contrary to these, there are studies that in which either or both *Giardia* cysts and *Cryptosporidium* were not detected in treated and untreated water sources (Karanis *et al.*, 2002). These differences may be due to lack of proper water treatment, poor site selection, unhygienic practices around water sources. According to the study conducted in Addis Ababa drinking water sources by Nigus and his co-workers, untreated water source and treated water (protected and unprotected) had different concentration of *Giardia* and

Cryptosporidium (Nigus Fikrie *et al.*, 2008).

In agreement with 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.*, in 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). As 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.*

This variation may be due to lack of regularly treatment and protection of water sources in the study area and it had wide possibilities for contamination than that of reservoirs and tap water which they are treated and confined in pipelines. Source water can be easily contaminated by grazing animals, animal farming and run off specially the springs. This analysis can be supported by the study conducted on microbial pollution of major rivers in Greece that indicated human interference and lack of proper pollution monitoring activities are the main factors for the contamination of rivers by *Giardia* and *Cryptosporidium* (Karanis *et al.*, 2005).

In this investigation, the mean average of the *Cryptosporidium* and *Girdia lamblia* were higher at the unprotected well and unprotected spring of the Adada sites and the lowest mean average of the *Cryptosporidium* and *Girdia lamblia* oocysts/cysts were observed at Legedini which was not significantly different from Legebira . The occurrences of *Cryptosporidium* and *Girdia lamblia* oocysts/cysts were in sighted that as there were a significance difference between the sources and the study sites. Therefore, the Adada unprotected well and unprotected spring were more polluted than the tap water while the tap water is less polluted and acceptable as the standard set by WHO water quality guidiles. In related to the sites and the water sources, Adada was more contaminated by *Cryptosporidium* and *Girdia lamblia* oocysts/cysts than the Legedini sites, but not significantly different from the Legebira sites. The Legedini water sources were less polluted by *Cryptosporidium* and *Girdia lamblia* oocysts/cysts in compare to the Adada and Legebira sites.

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 4.3a).

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 4.3b).

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 4.3b).

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 4.3b).

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 4.3b).

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 4.3b).

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 4.3b).

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 9). 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 4.3b).

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, one majority of their age was below 10 years (Table 4.3b).

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 (Table 4.3c).

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 4.3c). 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 4.3c). 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 4.3c). 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 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 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 4.3c). 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 Sirilanka 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). 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 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, 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 Keeve, 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 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 feacal coliform 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.

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 microbiological results from this study shown that most of the microbiological parameters measured (TC, FC, GC and CO) were in harmony with the reference values set out by WHO, (2004) and most of the sources investigated were grossly polluted. A total of 90 water samples were collected and analyzed for total (TC), fecal coliforms (FC), GC (*Girdia lamblia* cysts) and CO (*Cryptosporidium* oocyst). From all sites the Legedini was the most polluted sites by the microbiological water quality and unprotected well was the more contaminated water sources.

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 concerned sectors (Ministry of Health, Ministry of Water Resources, Non Governmental Organizations involved in water and sanitation activities and the beneficiaries) must increase their effort in water sources protection, monitoring and evaluating the existing facilities, including regular check up of its microbiological safety, and undertaking source maintenance if needed
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. Hygiene education should be targeted on women and children, because they are highly involved in most water collection and management activities.
5. The community should actively participate in the implementation of water and sanitation projects from the beginning of its planning to its operation to ensure sustainability and self-reliance.
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.
7. Generally, proper sanitary survey, design and implementation of water and/or sanitation projects; regular disinfections, maintenances and supervisions of water sources; and regular microbiological assessment of all water sources for drinking should be Planned and conducted.

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