Original article

High enteric bacterial contamination of drinking water in Jigjiga city, Eastern Ethiopia

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Abstract

Background: The high prevalence of diarrheal disease among children and infants can be traced due to the use of unsafe water and unhygienic practices. The overall concept adopted for microbiological quality is that no water intended for human consumption shall contain *Escherichia coli* per 100 ml sample.

Objective: The aim of this study was to assess household water handling and hygienic practices and to determine bacteriological quality of drinking water from different sources in Jigjiga city.

Methods: A cross-sectional study was conducted to assess bacteriological quality of drinking water in Jigjiga city from May-August, 2013. Both simple random and convenient sampling techniques were applied to select 238 households to assess water handling and hygienic practices, and 125 water samples to assess bacteriological quality of drinking water respectively. The water samples were collected from household water container, pipeline, water reservoir, '*Beyollie*', and main sources.

Easily isolated bacteria called *coliforms* were used as indicator organisms of human and other animals' fecal contamination status of drinking water. Data were summarized using descriptive and analytical statistics. Chi-square ($\chi 2$) and logistic regression tests were used and $p<0.05$ was considered as cut off value for statistical significance.

Results: Overall, 71.2%(n=89) of water samples were contaminated by one or more bacterial species of *E.coli, Shigella Sp, Salmonella Sp*, and *Vibrio sp*. Particularly, 65(52%), 10(8%), 9(7.2%), and 8(6.4%) were contaminated by *E.coli, Shigella sp, Salmonella sp,* and *Vibrio sp*, respectively. On the other hand, 20% of the households and pipeline water samples had a fecal coliform count of 150 and above. Placement of water drinking utensils had a statistically significant association with illiterate education (p=0.01, AOR=5.47, 95% CI: (1.31, 22.78)) and male household head (p=0.02, AOR=2.11, 95% CI: (1.10, 4.05)).

Conclusions: The majorities of drinking water sources were highly contaminated by *Enterobacteriaceae.* Regular bacteriological water quality control mechanisms need to be in place to ensure bacteriological safety of drinking water.

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Key words: Contamination, drinking water, households, enteric bacteria, Jigjiga.

Introduction

Water safety, adequacy, and accessibility are main characteristics of drinking water supply at household level. Improving access to safe drinking water can result in tangible benefits to human health. Every effort should be made to achieve safe drinking water accessibility to all (1). However, it has not always been safe globally. The most common and widespread health risk associated with drinking water is contamination, either directly or indirectly by human or animal excreta that contain pathogenic microorganisms. Drinking such contaminated water or using it in food preparation may cause different infections (2). Water-related diseases continue to be one of the major health problems globally. An estimated 4 billion cases of diarrhea annually represented 5.7% of the global disease in the year 2000 (3). Approximately three out of five persons in developing countries do not have access to safe drinking water and only about one in four has any kind of sanitary facilities. A review of 28 studies carried out by the World Bank gives the evidence that incidence of certain water borne, and water based and water sanitation associated diseases are related to the quality and quantity of water and sanitation available to users (4).

There exists low level of water supply and sanitation coverage in Sub-Saharan countries, with only 42% and 28%, respectively. Ethiopia is one of the countries in Sub-Saharan region with the worst of all water quality problems (5). The majority of Ethiopians does not have access to safe and reliable sanitation facilities. In addition, majority of the households do not have sufficient understanding of hygienic practices regarding food, water and personal hygiene. As a result, over 75% of the health problems in Ethiopia are due to communicable diseases attributed to unsafe and inadequate water supply, and unhygienic waste management, particularly human excreta (6).

Water can be contaminated with pathogens at the sources, during distribution, transportation, or handling in households or other working places (7). The greatest microbial risks are associated with ingestion of water that is contaminated with human or animal faeces infected with pathogenic bacteria, viruses, protozoa and

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helminthes. Short-term peaks in pathogen concentration in drinking water may increase disease risks considerably and may trigger outbreaks of waterborne disease (1). Many of the organisms that cause serious diseases, such as typhoid fever, cholera and dysentery can be directly associated with drinking polluted water. These disease-causing organisms are difficult to detect in water supplies. Less harmful, easily isolated bacteria called indicator organisms can be used indirectly to detect contamination status of drinking water. Among these indicators are coliform bacteria that live in the intestine of human and other animals and are almost always present, even in healthy persons. The presence of coliforms in water in a threshold level is a warning signal that more dangerous bacteria may be present (8). The overall concept adopted for microbiological quality is that no water intended for human consumption shall contain *E. coli* in 100ml water sample. The presence of 10 *E.coli* count per 100 ml is acceptable that needs regular sanitary checks for un-chlorinated water (9).

Because of this, assessing water quality is extensively essential to reduce water borne-diseases, to increase hygienic status of the society and to improve quality life for both rural and urban populations.

The hygiene and sanitation of water sources have been found to be not protected, including traditional hand dug wells and ponds in Ethiopian Somali region in addition to the poor access(10). Shallow wells are typically located within the reach of settlements where the water is often polluted due to dusts and nearby latrines (*authors' observation*) that could be linked to the outbreaks of water-related diseases, including cholera and diarrhea.

To our knowledge, there is no prior study about household water handling, sanitation practice and bacteriological quality of drinking water in the region's metropolitan city of Jigjiga. Therefore, this study was conducted to assess households' water handling, hygienic practices and to determine bacteriological quality of drinking water at different sources including household storage containers, pipeline, water reservoir, '*Beyollie'* and main sources in Jigjiga city.

Methods

Study design, setting, and study period: A cross sectional study was conducted in Jigjiga city during May-August, 2013 to assess households' water handling, hygienic practice and to determine bacteriological quality of drinking water at different sources including household storage containers, pipeline, water reservoir, '*Beyollie'* (local water suppliers), and main sources in Jigjiga city. Jigjiga is located at 625km from the capital city, Addis Ababa. Jigjiga is the capital city of Ethiopian Somali Regional State. The altitude of the city ranges between 1620 to1720meters. Its climate is classified under semi-arid which is characterized by high temperature and low rainfall which causes high evaporation. Mean maximum annual temperature of the city is 19.54^{o}c, while monthly average temperature ranged between 25.24^{o}c in November to 29.39^{o}c in March. According to the estimated population projection, the population is estimated to be 164,321 by 2016.

The existing water supply system of the city was designed in 1975 by a German consultancy for an expected total population of 20,000. There is a higher demand of water supply due to the increased population and effects of climate change. The distribution of water is provided with piped system and on-site sources. Jigjiga city water sources are classified in to two: the modern water supply system which is the ground water i.e. boreholes through pipes and the traditional system sources directly supplied from surface water sources and hand dug wells in the residential areas especially southern part of the city. The city is supplied with 24 functional underground water points. There is one dam in the north eastern direction of the city that is connected to the water line distribution (11). In addition, considerable numbers of people obtain water from local water venders called '*Beyollie*' who dispense water using plastic barrel carried on donkey carts.

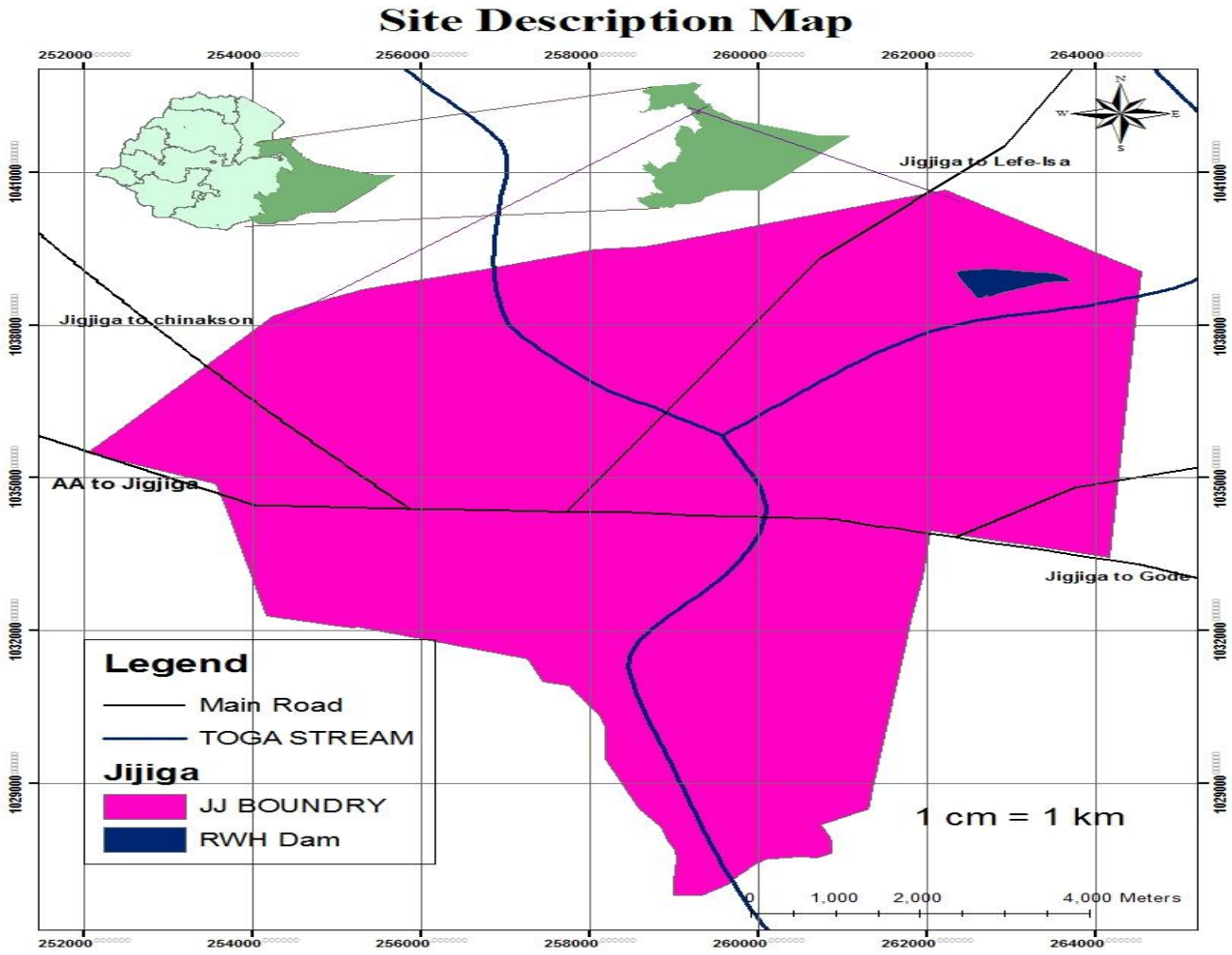

Figure 1: S**tudy area site Description Map, Jigjiga, Ethiopia, 2013**

Sample size and sampling procedures: Sample size is calculated using Open Epi 303 software for frequency in a population (proportion). Assumptions: 95% confidence interval; 80% power; population size (for population correction factor) (N): 100,000; hypothesized % frequency of unsafe water handling practices (P): 82%+/-5; precision level (5%). The total sample size calculated is 227. The final sample size required was 238, considering 5% non-response rate. All kebeles have the same water supply system that six kebeles were randomly selected out of 10 to identify households for the survey. We used a systematic simple random sampling technique to select 238 households after the complete list of households obtained from *kebele* administration offices. Water samples from each households' water storage container (n=60), pipe line (n=30), '*Beyollie*' (n=15), reservoir (n=15) and main sources (n=5) were purposely taken to explore the extent of faecal contamination.

Data collection

Questionnaire survey: A structured interviewer administered questionnaire was used to collect data on socio-demographic variables, water handling and hygienic practices. The questionnaire was first developed in English and translated to Amharic and Somali language (local language). To ensure linguistic validity, another translator translated the Amharic and Somali language version questionnaire back to English. We assessed the difference between the original and translated English versions. If a difference was found in any of the questions, we discussed to draw consensus. Data collectors were BSc holder health professionals who had previous experience on quantitative data collection. Training was given to data collectors to assure quality of data collection. Principal investigator had supervised the sample and data collectors.

Water sample collection techniques: Water sample collection techniques varied according to the type of water sample.

***Pipeline*:** The tap outlet was cleaned using a cloth and allow for maximum flow for two minutes; and then Outlet was sterilized with flame using cigarette lighter. The tap again is allowed to flow for 1-2 minutes at medium flow rate. Using sterile 250ml glass bottle

200ml water was collected and delivered to laboratory within 20-30minutes.

***Home storage containers*:** The water drawing cup was wiped using a clean cotton pad and sterilized with a flame from ignited alcohol-soaked cotton. 200ml of water sample was taken using sterilized 250ml glass bottle.

Main Source: The hydrant valve had opened and bibcock until water runs. Bibcock was shut and allowed at least 1minute and then, opened fully to allow water to flow at least 2minutes. 200ml water was collected aseptically.

***Reservoir Water*:** A sterile bottle was tied on to a rope that was tied with a sterilized stone or heavy piece of metal at its lower tip. The stone is to provide weight for the rope to get into the water. The cap of the bottle was removed and lowered the bottle into the well to a depth of about 1meter and the bottle was raised out and carefully replaced the cap.

***'Beyollie' Water*:** The '*Beyollie'* tanker was initially shacked before sample was drawn. The outlet was sterilized with alcohol-soaked cotton and allowed to flow for 1-2minutes at medium flow rate and then, using sterile 250ml glass bottle 200ml water was collected aseptically.

All the water samples were taken in an insulated ice box to Ethiopian Somali Public Health and Research Laboratory. Samples were examined within 6hrs of collection according to standard examination methods (12).

Microbial examination of water samples

Detection of Salmonella sp*:* To test for the presence of *Salmonella*, 1ml of each sample was aseptically inoculated into 10ml of lactose broth (LB) and incubated at 37°C for 24h for recovery and proliferation of cells. After the pre-enrichment, 1ml culture was transferred into 10ml of secondary enrichment broth (selenite cystine broth) and incubated at 42°C for 48h. Loopful of culture from Rappaport-Vassiliadis broth was streaked onto Salmonella–Shigella agar, Xylose Lysine Deoxycholate agar and modified Brilliant Green agar followed by incubation at 37°C for 18h. Characteristic non-lactose fermenting colonies were picked, further purified and tested biochemically using Triple Sugar Iron (TSI) agar, Simmon's Citrate agar, Sulfur Indole motility (SIM) medium, Lysine Iron agar, Urea agar, and fermentation tubes of glucose, sucrose and Mannitol (13).

Detection of Shigella sp: To test for the presence of *Shigella sp*, it has been done by the enrichment of water samples on Selenite F broth, followed by isolation of the typical organism on selective medium, Xylose Lysine Deoxycholate Agar (XLD, Oxoid) (14).

***Detection of E.coli*:** For the isolation and identification of *E. coli*, the enriched sample was cultured onto Eosin Methylene Blue Agar (Oxoid) and incubated at 37ºC for 24hrs. Morphologically typical colonies of *E. coli* (at least 4/plate) producing metallic sheen color (a positive test for presence of *E. coli)* were taken into nutrient broth for further identification. Biochemical tests were performed to confirm *E. coli* using Gram staining, Catalase test, Indole, Methyl red, Nitrate reduction, Urease production and various sugar fermentation tests (12, 13).

***Detection of Vibrio sp*:** Isolation and identification of *Vibrio sp* was done by enriching the samples in 1% alkaline peptone water for 6-8hrs followed by isolation on Thiosulphate Citrate Bile salt sucrose agar (TCBS agar, Difco)) medium (14). Six to 12 typical colonies (yellow and 1 to 3mm diameter) were transferred to nutritive soft agar (0.75% agar) and incubated for 24h at 37°C. All colonies were stored at room temperature for further testing (15).

All colonies with different characteristics on M-Endo agar, Xylose Lysine Deoxycholate Agar (XLD) and Thiosulphate Citrate Bile salt sucrose Agar (TCBS) were sub cultured onto Nutrient agar (NA) for purification. Enteric bacteria isolated on respective selective or differential media were identified on the basis of their colony morphological and biochemical properties following standard procedures.

Data quality assurance*:* The quality of data was managed through training data collectors, pre-testing of questionnaire to check its validity, following appropriate sample collection techniques, sample handling, transportation and culturing time of each isolates. Culture media and culturing materials were sterilized sufficiently. Furthermore, positive and negative control tests were done to check the ability of the media to support bacterial growth and environmental contamination of media respectively.

Data Analysis: Data collected from bacteriological water quality analysis and questionnaire survey were entered, cleaned and analyzed by using SPSS (Version 17). Both descriptive and analytical statistical methods were applied. The statistical analysis was done separately for questionnaire survey and bacteriological water quality analysis. Frequency and percentages were computed to describe the relevant variables. In addition, Chi-square ($\chi 2$) and binary logistic regression were applied to test the association between households' water handling and hygienic practices and factors affecting household water handing practice. A p-value < 0.05 was taken as cut-off for statistical significance.

Operational definitions of terms

***Hand Washing*:** The act of cleansing the hands with water or other liquid, with or without the inclusion of soap or other detergent, for the purpose of removing soil or microorganisms.

***'Beyollie'*:** Local water supplier (donkey carts) that fetches water from the sources and distributed to the people in the city.

Reservoir: An artificial pond used for the storage and regulation of water.

Enteric Bacteria: Rod-shaped gram negative bacteria; most occur normally or pathogenically in intestines of humans and other animals.

***Coliform*:** Are bacterial organisms that are present in the environment and in the feces of all warm-blooded animals and humans.

Water Line (pipeline): A type of pipe connection system having a protected and disinfected water source at the initial point of the distribution system.

Safe placement of water drinking utensil: placing water drinking utensil on tables/shelves or hang on wall and the storage container had cover.

Unsafe placement of water drinking utensil: placing water-drinking utensil plainly on the floor or the storage container uncovered.

Ethical consideration

Ethical clearance was obtained from the Ethical clearance committee of Jigjiga University. Permission was obtained from Jigjiga city administration. Data at the households were collected with full consent of head of the household. The study objectives and benefits of the study and number of anticipated risks were clearly explained to the households and each household was assured that the information provided would be kept confidential and no identifier was used.

Results

Characteristics of Study Subjects: A total of 238 households were interviewed to assess the household water handling and hygienic practices. The male to female ratio was nearly 0.8 to 1 (Table 1).

Majority of the households were using Jerry-cans for home water storage, washing hands before collection, storing water for a day or less, using caps (lids) to cover storage containers and predominantly using pouring technique to transfer water (Table 2).

Socio-demographic factors affecting water-handling practice: Among the variables, only education had a statistically significant association (AOR=5.47, 95% CI of OR= [(1.31, 22.78)]) with placement of water drinking utensils. Illiterate household heads are 5.5 times likely to put water-drinking utensils on unsafe place as compared to college graduates. Similarly, household occupation and placement of water drinking utensils had a statistically significant association (AOR=0.30, 95% CI of OR= [(0.14, 0.67)]). Merchant household heads are 70% less likely to put water drinking utensils on safe place as compared to others household occupation (Table 3).

Table 1: **Socio-demographic characteristics of head of the households interviewed for water handling and hygienic practices in Jigjiga city (n=238), May-August, 2013**

Variables		Frequency	Percent (%)
Gender	Male	107	45
	Female	131	55
Education	Illiterate	89	37.4
	Elementary	74	31.1
	Secondary	48	20.2
	College	27	11.3
Family size	Less than 3	62	26.1
	3 to 5	116	48.7
	More than 5	60	25.2
Occupation	Merchant	76	31.9
	Government employee	63	26.5
	Private employee	26	10.9
	Other	73	30.7
Income	Less than 500	86	36.1
	500-1000	99	41.6
	>1000	53	22.3

Table 2: **Households water handling and hygienic practices in Jigjiga city (n=238), May-August, 2013.**

Attributes		Frequency	Percent (%)
Type of water collection container	Clay pot	3	1.3
	Bucket	8	3.4
	Jerry-cans	218	91.6
	Others	9	3.8
Hand washing before water collection	Yes	148	62.2
	No	90	37.8
Frequency of water collection	Once a day	22	9.24
	Twice a day	100	42.02
	More than twice a day	116	48.74
How long the stored water stay at home?	A day and less	139	58.4
	More than a day	99	41.6
Use of cover for water storage container	Yes	230	96.6
	No	8	3.4
water transfer methods from storage container	Pouring	206	86.6
	Dipping	32	13.4
Water drinking utensils placed at home	Tables/shelves	148	62.2
	storage cover	6	2.5
	Hang on wall	11	4.6
	Floor	37	30.7

Table 3: **Logistic Regression Model of Socio–demographic characteristics of HH heads with water handling and hygienic practices in Jigjiga city (n=238), May-August, 2013.**

Variables	Water transfer technique				Lid for HH water container				Placement of water drinking utensils			
	Pouring (n (%))	Dipping (n (%))	AOR (95% CI)	P-Value	Yes	No	AOR (95% CI)	P-Value	Safe	Unsafe	AOR (95% CI)	P-Value
GENDER												
Male	90(37.8)	17(7.1)	1.15 (0.48, 2.76)	0.74	103(43.3)	4(1.9)	0.81(0.15,4.16)	0.80	69(29.0)	38(16.0)	2.11 (1.10,4.05)	0.02
female	116(48.7)	15(6.3)	1		127(53.4)	4(1.9)	1		96(40.3)	35(14.7)	1	
EDUCATION				0.08				0.23				0.03
Illiterate	84(35.3)	5(2.1)	0.35 (0.08,1.52)	0.16	86(36.1)	3(1.3)	0.11(0.01,1.29)	0.08	51(21.4)	38(16.0)	5.47(1.31,22.78)	0.01
Elementary	64(26.9)	10(4.2)	0.97 (0.24,3.85)	0.96	73(30.7)	1(0.42)	0.05(0.01,0.99)	0.05	54(22.7)	20(8.4)	2.79 (0.64,12.19)	0.17
Secondary	37(15.5)	11(4.6)	1.72 (0.45,6.54)	0.42	48(20.2)	0(0.0)	0.00 (0.00-)	0.99	36(15.1)	12(5.0)	2.34 (0.52,10.44)	0.26
College	21(8.8)	6(2.5)	1		23(9.7)	4(1.7)	1		24(10.1)	3(1.3)	1	
OCCUPATION				0.09				0.46				0.005
Merchant	68(28.6)	8(3.4)	0.78 (0.24,2.50)	0.68	74(31.1)	2(0.84)	0.54 (0.06,4.59)	0.57	59(24.8)	17(7.1)	0.30 (0.14, 0.67)	0.003
Goven't employee	55(23.1)	8(3.4)	1.38 (0.41,4.57)	0.59	62(26.1)	1(0.4)	0.10 (0.01,1.81)	0.12	50(21.0)	13(5.5)	0.28 (0.12, 0.66)	0.004
Private employee	17(7.1)	9(3.8)	3.8 (1.02,14.23)	0.04	24(10.1)	2(0.84)	0.53 (0.03,7.46)	0.63	18(7.6)	8(3.4)	0.67 (0.22, 2.01)	0.47
Other	66(27.7)	7(2.9)	1		70(29.4)	3(1.3)	1		38(16.0)	35 (14.7)	1	
INCOME				0.45				0.71				0.55
<500	74(31.1)	12(5.0)	1.16(0.35,3.83)	0.79	85(35.7)	1(0.4)	0.40 (0.02,6.46)	0.52	56(23.5)	30(12.6)	1.60 (0.59, 4.34)	0.35
500-1000	89(37.4)	10(4.2)	0.63(0.20,1.89)	0.41	96(40.3)	3(1.3)	1.12 (0.14,8.62)	0.91	66(27.7)	33(13.9)	1.66 (0.65, 4.23)	0.28
>1000	43(18.1)	10(4.2)	1		49(20.6)	4(1.7)	1		43(18.1)	10(4.2)	1	
FAMILY SIZE				0.28				0.67				0.58
<3	54(22.7)	8(3.4)	1		61(35.7)	1(0.4)	1		42(17.6)	20(8.4)	1	
3-5	103(43.3)	13(5.5)	0.64 (0.22,1.82)	0.40	111(46.6)	5(2.1)	2.88(0.27,30.65)	0.37	82(34.5)	34(14.3)	0.77 (0.36, 1.66)	0.51
>5	49(20.6)	11(4.6)	1.38(0.45,4.18)	0.56	58(24.4)	2(0.8)	2.50(0.17,36.67)	0.57	41(17.2)	19(8.0)	1.13 (0.45, 2.81)	0.78

NB: Household (HH) head is wife in married households but either male or female in single leader households

Table 4: **Frequency Occurrence (%) of enteric-bacteria across different source of water samples collected from Jigjiga city (n=125), May-August, 2013.**

Isolated enteric bacteria	Total Isolate No. (%)(n=125)	No. of positive sample (%) per source item				
		Household (n=60)	Pipeline (n=30)	Reservoir (n=15)	'*Beyollie*' (n=15)	Main source (n=5)
E. coli	65(52%)	33(55%)	9(30%)	12(80%)	10(66.7%)	1(20%))
Shigella sp.	10(8%)	2(3.33%)	1(3.33%)	3(20%)	4(26.7%)	0(0.0%))
Salmonella sp.	9(7.2%)	2(3.33%)	1(3.33%)	3(20%)	3(20%)	0(0.0%))
Vibrio sp.	8(6.4%)	2(3.33%)	1(3.33%)	3(20%)	2(13.3%)	0(0.0%)

Bacteriological analysis of water: Generally, 71.2% (n = 89) of all the water samples collected from household storages, pipe water, reservoir water, '*Beyollie'*, and main source were contaminated with single or mixed bacterial species of *E. coli, Shigella sp, salmonella sp,* and *Vibrio sp.* However, all the water samples collected from '*Beyollie*' and reservoir were contaminated (Table 4). About 25(41.7%) households' water, 8(26.7%) pipeline, 11(73.3%) reservoir, 9(60%) '*Beyollie'* water samples had at least two different bacterial groups (Fig 2).

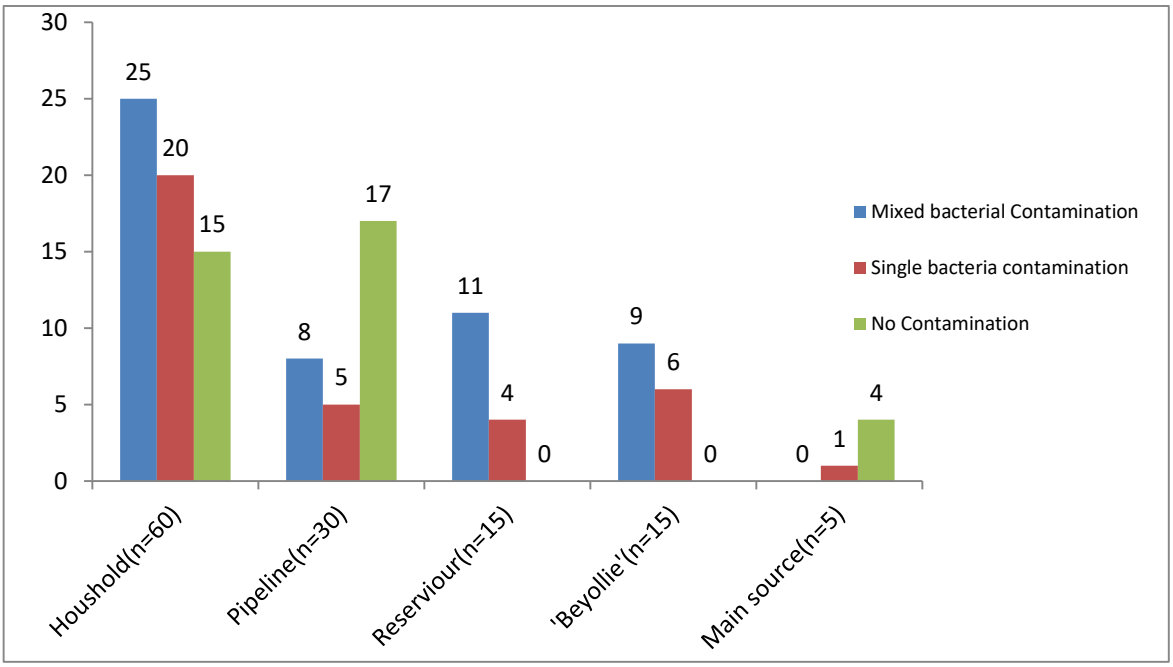

Figure 2: **Mixed bacterial contamination of drinking water samples from different sources in Jigjiga city (n=125), May-August, 2013**

This study demonstrated that 46.7% of the household and pipeline water samples were contaminated by fecal coliforms, especially *E. coli.* Twenty percent of the samples in both cases had a coliform count of 150 and above per100ml. Three samples had a coliform count of less than 10per100 ml and the least coliform count observed was 8 coliform per100 ml. Seventeen (56.7%) of the pipeline samples had zero coliform count per 100 ml, but 16.7% had 50 and above and 13.3% had 1-15 coliforms per 100 ml. *E.coli* was found in 52% of the samples (Table 5).

Table 5: **Bacteriological quality analysis of Households', Pipeline, Reservoir, '*Beyollie*' and main source water samples in Jigjiga city (n=125), May-August, 2013**

Distribution of coliforms	Types of organisms										
	Household water(n=60)		Pipeline (n=30)		Reservoir water(n=15)		'Beyollie' water(n=15)		Main source water(n=5)		No organisms
	E.coli	No *E.coli*	*E.coli*	No *E.coli*	*E.coli*	No *E.coli*	*E.coli*	No *E.coli*	*E.coli*	No *E.coli*	
0	-	15	-	17	-	-	-	-	-	4	36
1-9	2	3	1	1	-	-	-	-	-	-	-
10-15	17	4	3	2	8	1	2	1	1	-	-
>50	14	5	5	1	4	2	8	4	-	-	-
Total	33	27	9	21	12	3	10	5	1	4	36

Discussion

Majority of the households in this study (91.6%) were using Jerry-cans for home water storage. Similarly, a report from Jimma zone revealed that plastic pots are the most favored (86.5 %) material for water storage, making the heat treatment of facilities unlikely(13). The survey from households' water handling and hygienic practices in this study revealed that illiterate household heads and merchants are more likely to put water drinking utensils on unsafe place as compare to college graduates and other HH employees respectively (Table 3).

Faecal pollution of drinking water exposes to a variety of intestinal pathogens. The presence of any coliform bacteria in drinking water is used as an indicator of faecal contamination which in turn is unsafe for drinking (9). However, this study revealed that more than two-third of water samples collected from household storages, pipe water, reservoir water, '*Beyollie'* and main source were contaminated with single or mixed *E.coli*, *Shigella sp*, *Salmonella sp* and Vibrio species. Among these, 7.2% were contaminated by *Salmonella sp;* this is much higher than a finding of 0.89% *salmonella sp* in Iran (15) and a related study in Nigeria by Shittu *et al*.(16) reported that no well water had *Salmonella* and *Shigella*. This might be attributed to poor set up, too old pipelines, and lack of regular supervision and maintenance of the system in Jigjiga city.

The overall 52% water contamination by *E.coli* in this study was higher than a finding in Gondar on protected springs and protected wells that showed 35.7%, 28.6% of *E.coli* contamination, respectively but similar to 50% on water lines(9). Similarly, our finding is a slightly lower (45.7%) level of household water contamination by thermo-tolerant coliforms revealed in Bahir Dar city(17) but much higher than that of a 7.6% in Iran (15). On the contrary, our finding is lower than 72% *E.coli* contamination rate in Sagamu, Nigeria (18) and 60% in Dhaka, Bangladesh (19).Likewise, the *E. coli* contamination in this study was lower than 83.34% of contamination rate by indicator bacteria in rural communities of Dire Dawa (20).

The difference might arise from variation of the study settings; being rural and urban sites and unprotected well and spring water samples were included in the Dire Dawa study that might increase the contamination rate. In addition, this study reported less *E.coli* prevalence as compared to a finding in Serbo, Jimma, were 23 out of 24 water samples. These were contaminated by fecal coliform, particularly *E.coli*. There was only one water source with excellent type, two with acceptable, nine unacceptable and twelve grossly polluted(21).This difference might be due to source of samples since, 75% of water samples in Serbo study were taken from unprotected well water sources.

All water samples derived from '*Beyollie*' and reservoir water in this study were highly contaminated. This result coincides with study conducted in Sagamu, Nigeria (72%) and (32.5%) of well water were contaminated by *E. coli* and *Salmonella typhi* respectively (17). This might be attributed to lack of cover, exposure to dust, people's tendency to fetch water for toilet services with contaminated toilet articles and lack of proper and regular sanitation of reservoirs.

The pipe water, which was supposed to be protected in this study, was highly polluted (43.3%). This is much higher than a 7.58%, 0.89% and 0.66% contamination rates of *E.coli*, Salmonella *species*, and *Vibrio cholera* respectively reported in Iran(15).This might be attributed to poor set up and lack of regular supervision and maintenance of the system in Jigjiga city. The water supply pipe lines were installed many years before and have not been maintained regularly in this study area.

In the case of ground water, like protected springs, wells and protected water connection systems, it should be possible to achieve very low levels of contamination (12). However, our finding indicates protected water sources were subjected for a high level of faecal contaminations in almost all cases. This indicates that both the main source and the pipelines supposed to be protected are not actually protected and safe. Therefore, the presence of *E. coli*, *Salmonella sp*, or *Vibrio sp* in drinking water is a threat to human health.

Of the total water samples investigated, 6.4% were polluted by *Vibrio sp*. This result is much higher than a finding of 1% in Kathmandu valley, Nepal(22) and 0.66% in Isfahan Iran (14). The isolation of *Vibrio* in water samples indicated that there might be a risk of cholera epidemic. However, there were no declared epidemics of cholera in the city except two cases of cholera among Jigjiga University students detected in the year 2012 (*source: JJU students' clinic*). This might be due to that the *Vibrio* was identified at genus level in our study so that isolates may possess non-pathogenic species. In addition, the community has a practice of taking antibiotics immediately when they get diarrhea without doctors' prescription by purchasing from drug vendors. The commonly used drug is co-trimoxazole. Similarly the 8% isolation rate of *Shigella sp* in this study was higher than a finding of 3.0% in Kathmandu, Nepal (22).

In this study, 71.2% of all water samples were f contaminated by *E. coli* and other entero-bacteria species. This result is in agreement with a finding conducted in Kathmandu valley, Nepal where 92.4% of drinking water samples found to cross the WHO guideline value for drinking water (22). The type of coliform and entero-pathogens detected in this study indicates that there might be higher human involvement in contamination of these water sources and poor sanitation of water supply system. The household water contamination might be highly attributed to low level of hygiene and poor water handling practices. This is supported by a finding from Bahir Dar that reported coliform contamination of household water is associated with poor water handling practice (17). Generally, this study revealed that there is poor sanitation, low level of hygiene, irregular disinfection and poor supervision and maintenance.

Conclusion:

More than two-thirds of water samples from different sources in Jigjiga city were contaminated with coliform or pathogenic enteric bacteria that could be acquired via faecal contamination of drinking water. Contamination may be acquired at different points of the water supply system. The cause, therefore, might be attributed to constructional defects (leakages), poor sanitation, and low level of hygiene awareness, poor supervision, and maintenance and irregular disinfection of drinking water. Accordingly, we strongly recommend proper water treatment at household and main source, maintenance, and regular supervision of supply system and health education to prevent the catastrophic waterborne epidemics by those enteric bacteria. Regular bacteriological quality assessment of all water sources for drinking should be planned and conducted.

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