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Bacteriological and Physicochemical Quality of Drinking Water Sources and Household Water Handling Practice Among Rural Communities of Bona District, Sidama Zone-Zouthern, Ethiopia

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Abstract: *Background:* Water quality and the risk to waterborne diseases are critical public health concerns in many developing countries. Today, close to a billion people most living in the developing world do not have access to safe and adequate water supply. *Objective:* The objective of this study was to assess the bacteriological and physicochemical quality of drinking water sources and water handling practices at household level among rural communities in Bona District of Sidama Zone. *Methodology:* A cross-sectional study design was conducted to assess the bacteriological and physicochemical qualities of drinking water at source and to assess water handling practice of households. Data were collected using WHO's sanitary survey checklist and rapid water testing kit to assess bacteriological and physicochemical parameters of water source and questionnaire to assess water handling practice of randomly selected 604 households. *Results:* Majority (86 %) of the protected springs and wells in the study area did not fulfill the WHO's criteria for drinking water quality standards. Water schemes with high sanitary risk scores had high number of E. coli/100 ml of sample water. Majority (73.5%) of the respondents didn't treat their water at household level, 64.4% of the respondents washed their hands before collecting water, 77.5% of the respondents washed their water container regularly and 74.7% had covered for their water collection container. Respondents who can read and write and those who completed at least a secondary education were more likely to safely handle water at home compared to illiterates, AOR=3.0 (95%CI: 1.5,6.04) and AOR=8.5 (95% CI:1.1,65.7), respectively. *Conclusions:* The results of this study indicated that protected water sources used by the community in Bona District were subject to contamination and household water handling practices were poor. It is recommended that concerned bodies, such as NGO's working in WASH projects, Bona district Water and Health Offices need to take appropriate action.

Keywords: Coliform Bacteria, Water Quality, Sanitary Survey

1. Introduction

Background

Water quality is the microbiological, physical and chemical properties of water that determine the fitness for use of a specific water source. Microbiological quality refers to the presence of organisms that cannot be seen by the naked eye, such as protozoa, bacteria and viruses. Many of these microbes are associated with the transmission of infectious water-borne diseases such as gastroenteritis and cholera [1].

Protection of water supplies from contamination is the first line of defense. Source protection is almost invariably the best method of ensuring safe drinking-water and is to be preferred to treating a contaminated water supply to render it suitable for consumption.

It is well known that access to safe water and sanitation are important in reducing disease transmission. Most infectious diseases are caused by pathogenic microorganisms such as bacteria, virus, protozoa and other parasites that cause life threatening conditions in relation to drinking water [4, 5].

The most common and wide spread problem associated with drinking water is contamination, either directly or

indirectly, by human or animal excreta, industrial and other wastes. Household water often becomes contaminated with pathogens of fecal origin during transport and storage due to unhygienic storage and handling practices [11]

Around 94% of the global diarrheal burden and 10% of the total disease burden are due to unsafe drinking water, inadequate sanitation, and poor hygienic practices. Contaminated water serves as a mechanism to transmit communicable diseases such as diarrhea, cholera, dysentery, typhoid and guinea worm infection. WHO, estimates that in 2008 diarrheal disease claimed the lives of 2.5 million people. For children under five, this burden is greater than the combined burden of HIV/AIDS and malaria [12, 13]

Globally, 1.1 billion people rely on unsafe drinking water sources from lakes, rivers and open wells. The majority of these are in Asia and sub-Saharan Africa. Ethiopia is characterized by lower water supply and sanitation coverage it is estimated that 62.7% of the Ethiopian population relies on unimproved water; diseases in Ethiopia are attributed to poor access to clean water and sanitation. The problem is more serious in rural area where the majorities of the people do not have access to potable water and therefore, depend on well, stream and river water for domestic use [16, 17, 18]

In Ethiopia, over 60% of the communicable diseases are due to poor environmental health conditions arising from unsafe and inadequate water supply. Frequent examinations of faecal indicator organisms remain the most sensitive way of assessing the hygienic conditions of water. Fecal coli form have been seen as an indicator of fecal contamination and are commonly used to express microbiological quality of water and as a parameter to estimate disease risk [14].

In Bona district, water treatment at source is not regularly done, constructed water schemes has not been regularly maintained, no regular sanitary survey was done, water schemes has not properly fenced this condition can exposed drinking water supply at source for contamination. Handling practice of drinking water at household is also one of the problems of the area, even though water is safe at source it can be contaminated during collection, storage and consumption at household. According to report from Bona district health office diarrhea is the leading ten top diseases this can be directly or indirectly has relation with contaminated drinking water.

Access to safe water alone does not reduce diarrheal diseases significantly. Even if the source is safe water become faecally contaminated during collection, transportation, storage and drawing in the home. Inadequate hygiene practices must be targeted as well when implementing water and sanitation projects, to decrease morbidity and mortality especially in rural area [6]

2. Materials and Methods

Study Design

Community based cross - sectional study design with quantitative approach was conducted.

To assess bacteriological and physicochemical quality of drinking water at sources using sanitary check list and rapid water testing kit. To assess Water handling practice of households of study area by using structural questionnaire.

Study Area

The study was conduct in the SNNPR, Sidama Zone, Bona district, which is located from Addis Ababa at 389 and from regional capital city Hawassa at 114 km, with a total population of 148,201 according to CSA 2007. There are 27 rural and 1 urban kebele in the district. Improved Water coverage in this district is 51%, there are 6 health centers and 1 hospital in the district. The area has cash crop area such as coffee, kahat etc…the main water sources are unprotected spring, protected spring, river, hand dug well, and deep well for drinking, irrigation, cattle watering, washing clothes, and bathing in the district.

Source and Study Population

Source population

For household water handling practices the source populations were all rural community in Bona district. The source population for bacteriological and physico chemical analysis were all protected springs, protected hand dug wells, protected shallow boreholes which were used by the study community.

Study population

Selected rural households found in six selected kebeles of study area were the study population. Protected spring, protected hand dug wells, protected shallow borehole found in selected six sampled kebeles were the study population for bacteriological and physico chemical analysis.

Sample size

To calculate the sample size, the investigator use EPI-INFO version3.5

A single population proportion with the following assumptions is considered to calculate the minimum sample size required:

- Proportion of households who washed water collection container was 27 % (p1=0.27)
- Level of confidence= 95%
- Margin of error = 5%
- Designing effect of 2.0
- n= 302*2.0 =604.

Sampling procedure

In Bona district, there are 27 rural kebeles out of which 8 are open defecation free (ODF) and 19 are practicing open defecation. By using stratification based on open/non-open defecation practices, the investigator sampled 20% of kebeles from each stratum (2 kebeles from 8 ODF kebeles and 4 from 19 kebeles practicing open defecation, a total of 6 kebeles were selected).

All type of protected drinking water sources such as springs, hand dug well, Shallow boreholes that are used by the community for drinking were tested by using rapid water testing kit. To assess the water handling practices of the community, systematic sampling method was used to draw representative sample of households from each village.

Table 1. Numbers of households proportionally selected from each kebele.

S/R	Name of Kebele	No of House hold in each kebele	No of selected household
1	Beshiro Dalo	616	169
2	Beshiro gute	719	81
3	Gowaco	846	95
4	Melgano sede	860	96
5	Warancha	1140	128
6	Melgano kabado	1206	135
Total		5387	604

Eligibility criteria

Inclusion criteria: - Inclusion criteria for taking sample of water for bacteriological and physicochemical testes were all protected spring, protected hand dug well, protected shallow borehole. For assessing the handling practice of drinking water at households; mothers or daughters whose age was more than 15 years of age and who have lived for more than six months in the study area were interviewed.

Exclusion criteria: - Respondents who have lived for less than six months in study area were excluded from the study as responses from these respondents might not reflect the situation in study area.

Study variable

  Dependent variable (Outcome)
  • Water handling practice
  • Number of Fecal coli form per 100ml of water
  Independent variable
  • Socio-demographic conditions
  • educational status
  • Income
  • Age
  • Information on water handling practice
  • Visited by health extension
 Operational definitions

Bacteriological safe water source: - Water which has no faecal coli form bacteria detected in any 100ml of sample.

Physico-chemicaly safe water source: - Water free from turbidity, free from Color, water which has recommended amount of PH (6.5-8.5) and Residual chlorine

  Good water handling practices: - households who are practicing at least three of the following practices are considered as good handling practices.
  • Rinsing of collection container before water collection
  • Use of covered and narrow opening material for storage
  • Using pour rather than dipping to transfer water
  • Hand washing before collecting water
  • Treatment of water before drinking
Data collection procedures and quality assurance

Data collection technique for assessment of household water handling practice: the investigator used structured questionnaires for mothers or daughters whose ages were more than 15 years old in the rural communities of the study area. The questionnaire was prepared originally in English and translated into Amharic language and back to English. The reason of using Amharic questionnaire was that almost all of the study community can understand and communicate with

Amharic, and data collectors were from the local community and they were fluent in both Amharic and local language (Sidamigna).

The investigator trained data collectors for two days how to collect data regarding the handling practice of drinking water in rural community. Data collection was conducted in Sep-Oct, 2014. To keep the cleanness and quality of data the investigator monitors the data collector during time of data collection by cross-checking the data in the field. The pre-test was conducted adjacent to the study kebele which had similar characteristics to the areas where the actual study was carried out. Vague terms, phrases and questions identified during the pre-test were modified and changed. Missing responses like "no response" and "others" were added, and skipping patterns were also corrected.

For household water handling practice the data collectors during the pretest and main data collection were the same; but for sanitary survey, Bacteriological and physicochemical data collection the data collectors were the investigator and one Environmental health professional.

Data collection Technique for Sanitary Survey

Sanitary Survey (Source inspections) were carried out by using WHO drinking water survey check list by transect walking and observing around the water source area by trained Environmental health professional and investigator

Data collection technique for bacteriological analysis: Data collection for Bacteriological water sample was collected by the investigator and trained environmental health professional. The procedure was according to WHO guideline of membrane filtration methods [21] using WAGTECH portable water testing kit. The samples from water sources were collected by using sterile plastic bottle after washing the out let pipe for protected spring, hand dug well and shallow bore hall; the steps are according to the procedure of membrane filtration drinking water quality testing.

Data collection technique for physicochemical analysis: Data collection for physico-chemical sample water was collected by the investigator and skilled Environmental health professional. All physicochemical analysis were done onsite by using PH meter for measuring PH of sample water, turbidity tube for measuring turbidity of sample water and chlorine comparator for measuring residual chlorine of sample water.

Data management and Data analysis

The following condition was considered for data management and analysis. For household water handling practice Data collection was checked for completeness, correctness, and consistency by the investigator every day and anything which was unclear corrected and communicated with the data collector. Collected data was entered coded, recorded, edited, and cleaned by investigator in to EPI-ENFO version 3.5 and transformed to SPSS version 20. Univariate (descriptive); bivariate and multivariate analyses of data were conducted using SPSS version 20 statistical software for windows.

For bacteriological water quality test the sample water was taken with sterile plastic bottle with cold box and the testes had done within 6 hr after collecting the sample of water at district Health Office's water testing lab. The physicochemical

water samples were tested at the site of sample collection.

Ethical Consideration

The Ethical clearance was obtained from the Debre Markose University and GAMBY College of Medical Sciences. Permission was obtained from Bona District Water Office and Health Office and from each respective kebele administrations. The purpose of the study was explained to the participating household owners and verbal consent was obtained. Participating house hold owners were assured of the confidentiality of their responses**.** The questionnaire was filled by data collector in separate house hold in each village after the participants were informed about the study; anyone who was not willing to participate in the study have the right to discontinue at any time in the process. Each respondent was assured that the information provided by her/his was kept confidential and used only for the purpose of this study.

3. Results

Socio-demographic characteristics of the respondents

In this study, all the 604 female respondents were interviewed providing an overall response rate of 100%. The mean (±SD) age of the respondents was 27.5 (±7.7) years. The mean monthly household income was 405 birr.

Table 2. *Socio-demographic characteristics of the respondents in Bona District, Sidama Zone SNNPR, Sep 2014.*

Variables	Number	Percent
Age of respondents		
15-24	189	31.3
25-34	265	43.9
35-44	139	23
45-54	11	1.8
Religion of respondents		
Protestants	575	94.9
Catholic	21	3.5
Orthodox	9	1.5
Muslim	1	0.2
Occupation of respondents		
House wife	525	86.9
Merchants	34	5.6
Farmers	20	3.3
Government employee	5	0.8
Others	20	3.3
Educational status		
Illiterate	298	49.3
Read and write	122	20.2
Primary	160	26.5
Secondary and above	24	4
Household income in Birr		
100-500	482	79.8
>500	122	20.2

Table 3. *Sources of drinking water and collection practices in Bona District, Sidama Zone SNNPR, Sep 2014.*

Variable	Number	Percent
Where do you get drinking water?		
Protected spring	527	87.3
Protected well	61	10.1
Unprotected spring	16	2.7
Do pay for the water you used?		
Yes	87	14.4
No	517	85.6
How frequent do you collect water?		
Every day	550	91.1
Every other day	53	8.8
What types of collection container do you use?		
Jerry can	597	98.8
Plastic bucket	7	1.2
Does the water collection container have cover materials?		
Yes	451	74.7
No	153	25.3

Household water handling practices

Table 4. *Household water handling practice in Bona District, Sidama Zone SNNPR, Sep2014.*

Variable	Number	Percent
Do you wash your hands before water collection?		
Yes	389	64.4
No	215	35.6
Do you regularly wash your water containers before water collection?		
Yes	468	77.5
No	136	22.5
Do you treat drinking water in the house?		
Yes	160	26.5
No	444	73.5
Do you cover the containers during storage?		
Yes	439	72.7
No	165	27.3
What methods do you use to with draw water from container?		
Pouring	588	97.4
Dipping	16	2.6
Do the utensils used to draw water from the container have handle?		
Yes	500	82.8
No	104	17.2
Total		
Yes	424	70.2
No	180	29.8

Knowledge and information about household water handling practice

From the 604 respondents, 387(64.1%) had knowledge that water can be contaminated in the house. Of these, 212 (54.8%) said that water can get contaminated by unclean container and 153(39.5%) respondents said that water can get contaminated by uncovered container.

Table 5. Information about household water handling practice in Bona District, Sidama Zone SNNPR, Sep 2014.

Variable	Number	Percent
Have you been visited by HEW in the last 3 months?		
Yes	303	58.2
No	301	49.8
Has the households been graduated as model households?		
Yes	177	29.3
No	427	70.7
During the last 3, month did you receive any information from HEW on safe water handling at home		
Yes	291	48.2
No	313	51.8
During the last 3 month did you receive any information from HEW about home water treatment		
Yes	223	39.1
No	368	60.9

Level of risk of contamination of water sources

Table 6. Levels of risk of contamination of 15 protected springs and 6 protected wells with hand pump in Bona District, Sidama Zone SNNPR, Sep 2014.

WHO Risk Category	Sanitary risk score	Type of water sources			
		Protected spring (15)		Protected well (6)	
		No	%	No	%
No risk	0	-	-	1	17
Low risk	1 -3	5	33	4	66
Intermediate risk	4-6	7	47	1	17
High risk	7-10	3	20	-	-

Bacteriological quality of the studied water sources

Physicochemical quality of the water sources
Turbidity

Turbidity result of the studied water sources revealed that out of 15 protected spring, 2(13%) and out of 6 protected wells,1(17%) had 11-50 NTU and 3(20%) of springs had 5-10 NTU. From 15 protected springs, 10 (67%) and out of 6 protected well 5(83%) had <5NTU.

PH

The study revealed that out of 15 protected springs, 3(20%) had <6 PH, 12(80%) of protected springs and 6(100%) of protected wells had a PH value of 6.5-8.5.

Table 7. Bacteriological quality of drinking water sources in Bona District, Sidama Zone SNNPR, Sep 2014.

WHO recommended Value	E. coli level (CFU/100 ml sample of water)	Risk Category	Type of water sources and their results			
			Protected springs (n=15)		Protected wells (n=6)	
			No	%	No	%
All water intended for drinking should have zero fecal contamination in any 100ml sample	0	in conformity with WHO	-	-	3	50
	1-9.9	Reasonable quality	6	40	2	33
	10-99.9	Polluted	6	40	1	17
	100-1000	Dangerous	3	20	-	-
	>1000	very Dangerous	-	-	-	-

Free Residual Chlorine

Out of the 6 protected wells (100%) had 0.1mg/l free residual chlorine.

Factors associated with household water handling practice

Table 8. Factors associated with household water handling practices in Bona District, Sidama Zone SNNPR, Sep 2014.

Variables		Water handling practice		COR (95% CI)	AOR (95% CI)
		Good	poor		
Age	15-24	149	40	1.0	1.0
	25-34	218	47	3.14(0.9-10.6)	1.34(0.83-2.18)
	35-44	99	40	3.8(1.1-13.2)*	0.83(0.49-1.42)
	45-54	6	5	2(0.5-7.14	0.35(0.1-1.26)
Educational Status	Illiterate	228	70	1.0	1.0
	Read and write	111	11	3.1(1.58-6.08)*	3.0(1.5-6.04)*
	Primary and above	133	51	.68(.44-1.04)	0.64(.41-1.01)
Income of Household	100-500	385	10	1.0	1.0
	Above 500	176	33	0.68(0.43-1.1)	0.54(.33-.89)*
Households Visited by HEW	Yes	270	33	4.01(2.59-6.19)*	0.24(0.058-1.08)
	No	202	99	1	1
Information on household water handling	Yes	259	32	3.80(2.45-5.88)*	2.68(0.57-12.51)
	No	213	100	1	1

4. Discussions

In the study area most of the respondents, 98.8% used jerry can and 1.2% used plastic bucket to collect and store water. Similar study done in north Gondar indicated that 95.2% of the respondents used jerry can for collecting and storing water [11]. Majority, 74.7% of the collection material had cover and 25.3 % had not cover which is better than the study done in Dire Dawa rural community 37.5% [6] and is less than a study done in Tehulader District north east Ethiopia which was 92.7% [29]. In this study area, 64.4% of the respondents wash their hands before collecting water which is similar to the study done in Tehulader District which was 64.1%.the community of the study area had better water handling practice comparing with Dire Dawa rural community this might be due to information given by health extension workers were good.

In the current study area, 77.5% of the respondents

reportedly wash their water collection material before collecting water which is almost similar with the study done in Tehulader District that reported 73.4%. In Bona District, 73.5% of the respondents did not treat their drinking water at household level showing the same result with the study done in rural community of Dire Dawa where 87% of the respondents did not treat their water at household level. In both Dire Dawa and study area community had low knowledge on household water treatment practice this indicates the information given by health extension worker on household water treatments might be low. The water withdrawal method of the study area show that 97.2% used pouring system and the rest 2.8% used dipping methods. The study in Dire Dawa reported that 93.7% of the respondent used pouring method to draw water which is encouraging for good water handling practice. In this regards both Dire Dawa and study area had good practice it indicted the community had good knowledge on water transfer methods.

The bacteriological analysis results of protected springs clearly indicated that a spring with high sanitary risk score had very high number of fecal coli form per 100ml of water these were Sileshi, Benata and Tariku Springs with 100-185 cfu/100ml of water which were dangerous for health and needs urgent intervention. Spring with intermediate sanitary risk had high fecal coli form per 100ml of water these were Argeta, Sisay, Asfaw, Leda, Dongora and Degefu Springs with 10-99.9 cfu/100ml of sample water which are polluted and needs higher intervention action. Sprigs with low sanitary risk score had low numbers of fecal coli form which are 1-9.9 cfu/100ml of water sample which were reasonable quality and needs low intervention action these springs were Sejo, Chefe, Bodicha, Sasamolanka, Danfile and Bizelk Springs. Similar study done in Tehulader District indicate that spring with high sanitary risk score had an inferior bacteriological quality and those springs with low sanitary risk score found to have an excellent bacteriological quality[19].This was due Inadequate protection from the contaminants, unhygienic management of facilities, lack of fencing, lack of proper diversion ditch, habit of communal bathing and laundry activities near the sources causes the deterioration of drinking water quality in the study area. It implies that water with high sanitary risk had high chance of contamination with fecal coli forms.

The study showed that all of the protected spring examined had risks ranging from low to high. From protected well water with hand pump only Urago is under the category of no risk. Two of the well water with hand pump had 4-10cfu/100ml of sample water which is reasonable quality but it needs low intervention. These wells included Godicho and Warancha wells with hand pumps respectively. Dalo Hand dug well had 66 cfu/100ml of sample water which was polluted and needs immediate intervention. Urago, Entelanto and Kabado wells with hand pumps had none coli forms per 100ml of water sample which were compliance with WHO guideline of drinking water quality standards that is zero coli form/100ml of water. The same Study done in north Gonder shows that analysis of protected springs demonstrated that 71.43%, of the samples had all kind of indicator bacteria. Fifty percent of the

positive samples had fecal coli forms, of these 35.7% had E. coli. Fifty percent of protected wells had all kinds of indicator bacteria. Moreover, the same proportion (28.6%) of the samples had both E. coli and fecal coli form (15).

This study demonstrated that adequate protection of water sources could improve their bacteriological quality by effectively preventing faecal coli form from entering water system prior to their delivery point. Source protection almost invariably is the best method of ensuring safe drinking water. However, failure to provide adequate protection, poor site selection, and unhygienic practices of the consumers and deterioration of construction materials may contribute the contamination of water sources and resulting water borne diseases [6, 27]

Study done in India show that all water sources were grossly polluted, the type of coli form exhibited is a fecal type specifically of human origin. The effect, therefore, is attributed to constructional defects, poor sanitation, low level of hygiene education, poor supervision and maintenance and irregular disinfection (28).Turbidity measurement of 15 protected springs, (67%) and six protected well (83%) were <5 NTU which were in compliance with WHO[21]. The PH value of 12(80%) out of 15 protected spring and 6(100%) out of six wells were 6.5-8.5 which were compliance with WHO, the rest 3(20%) of protected springs were <6 which were less than the WHO recommended value.

Regarding to the free residual chlorine none of the water schemes were compliance with WHO Free residual chlorine value 0.2-0.5mg/l, all protected wells, 6(100%) had 0.1 mg/l of free residual chlorine which were less than the recommended value. The absence of free chlorine residual in the distribution system may, in certain circumstances, indicate the possibility of post-treatment contamination [21].

Educational status of the community have significant relationship with household water handling practice, P value <0.05, respondents who have more educational status have good water handling practice. Respondents who have less than five hundred birr income per month have significant relationship with household water handling practice, P value 0.05, respondents who had more income per month practice poor water handling; In this regard it needs more investigation to know the reason. Respondents Visited by health extension worker and getting information on household water handling have significant relationship with house hold water handling practice P value <0.05,those who visited by health extension worker and got information on household water handling have good water handling practice.

This study indicated that the per capital per day conception of water in the study area was 5.2 liter which is less than the minimum water consumption recommended by WHO which is Twenty liter per capita per day and Government of Ethiopian 15 L of safe water per person per day within a 1.5 km rural dwelling radius from the point of source [3, 22]. The same study done in Tehulader district indicate that the mean per capita water consumption in the study area was Seven liter per capita per day [29]

The results of this study indicated that inadequate

protection of water sources, poor community sanitation practices near the source and unhygienic household water handling practices contributes to the deterioration of drinking water quality in the study area.

5. Conclusions

The study results indicated that bacteriological and physicochemical quality of the majority of protected water sources in the study area did not fulfill the criteria of WHO drinking water standards.

The household water handling practices of the area were not good. In this study, educational status, income, visiting by health extension worker and getting information on water handling practice were factor for household water handling practices.

6. Recommendations

We recommend the concerned governments (Bona district water office and health office), NGOs working in the district and communities to take the appropriate measures on all protected water schemes and house hold water handling practice these are, Water sources should be Properly fenced, well water source maintain residual free chlorine at the time of conception, regular monitoring to ensure the standard residual free chlorine, Encouraging households to use household water treatment system.

Acronyms and Abbreviation

AWD:	Acute watery diarrhoea
CFU:	Colony forming Unit
CSA:	Central statics Agency
EDHS:	Ethiopia Demographic and Health Survey
HIV/AIDS:	Human Immune Deficiency Virus/Acquired Immune Deficiency Syndrome
NGO:	Non-Government Organization
NTU:	Nephelometric Turbidity Unit
PH:	Potential Hydrogen
SNNPRS:	South Nation, Nationality and Peoples Regional State
SBH:	Shallow borehole
UAP:	Universal Access Program

Acknowledgements

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