ORIGINAL ARTICLE

FACTORS AFFECTING DRINKING WATER QUALITY FROM SOURCE TO HOME IN TEHULEDERE WOREDA, NORTHEAST ETHIOPIA

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ABSTRACT

BACK GROUND: ***Water becomes contaminated with faecal material due to inadequate protection of the source, unhygienic practices of the community at the source and poor household handling practices. The objective of this study was to identify the risks associated with the protected source, to determine the water quality of the source and household drinking water and to assess the water handling practices of the community***.
METHODS: ***A cross-sectional study on the quality of protected springs and household drinking water by testing for bacterial contamination was carried out in Tehuledere woreda in January 2002. Data were collected using sanitary survey, interviewing of households and bacteriological analysis of water. The study included five protected springs and 192 selected household users of the springs as sole sources of all purpose water supplies.***
RESULTS: ***It was found that a spring with high sanitary risk score had an inferior quality bacteriological tests (Hitecha spring) while those springs with low sanitary risk score found had excellent quality (Gobeya and Pasomile). Among a total of 192 households, 123(64.1%) washed their hands during collection of water, 141(73.4%) rinsed their collection containers. In addition, 178(92.7%) had cover for their storage vessels and 138 (72.0%) drew water from container by dipping.***
CONCLUSION: ***The findings of this study indicated that spring protection was found to be necessary condition but not a sufficient condition for the provision of safe water supply. Training of local people to look after the water supply system, expansion of hygiene, health education on sanitation could have a notable impact for the provision of safe water supply.*** **[Ethiop J Health Sci 2003; 13(2): 95-106].**

KEY WORDS: Sanitary survey, Faecal coliform, Hygiene, protected spring, Water quality.

INTRODUCTION

Without safe water and sanitation, there is no real development (1-4). If water is a mirror of health, it can also become a source of disease. More than one-third of deaths in developing countries are caused by contaminated drinking water.

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The United Nation Center for Human Settlement estimated that a tenth of every individual's life is lost through water related diseases when sanitation breaks down (5).

At the beginning of 2000, about 1.1 billion people in the world were without access to improved supply of clean water. Africa has the lowest water supply coverage with only 62.0% of the population having access to improved water supply. The continent contains 28.0% of world's population with out access to improved water supply. Ethiopia is one of the ten African countries, which have less than 50.0% water supply coverage, with only 24.0% of the population having access to improved water supply. In Ethiopia the situation is much worse in rural areas where coverage is only 13.0% compared with 77.0% in urban areas. These figures mask a large number of equally shocking health condition (6).

The quality of protected water sources can be deteriorated due to poor site selection, in adequate protection and unhygienic management of facilities (7). The result of sanitary and quality monitoring in a pilot water surveillance study in Yogyarkarata, Jaua demonstrated that 65.0-85.0% of public water supplies; mostly springs became faecally contaminated because of poor site selection, protection and un hygienic management of facilities (7-9). On the other hand, permanent supplies of safe water alone cannot guarantee that the water we drink is safe as well. Water may become unsafe at any point between collection and use (10,11). The results obtained from the study done in northeast Thailand suggested that there was a far greater risk of ingesting faecal coliform bacteria, which have arisen from the cross contaminations occurring with in the household than from the faecal pollution of drinking water sources (12). Un restricted and un hygienic water collection activities, soiled hands and un clean water collection vessels were potential contributors for the contamination of drinking water in Lesotho and else where (13). The highest level of household water contamination found in stored water, since stored water became contaminated when it is touched by un clean fingers during over dipping (13,14).

A number of impact studies have indicated a gap that exist between potential and realized benefits of water supplies in developing countries and have highlighted the vital differences (13). The major findings are that few of the benefits expected from water occur spontaneously supporting the package of inputs and strategy for rural developments

Although a number of water sources have been protected in Tehuledere woreda, the safety, handling practices and magnitude of contamination of water are not yet studied.

The objective of this study was therefore, to assess the efficiency of spring protection, household water handling practices and the magnitude of water contamination in Tehuledere woreda.

MATERIALS AND METHODS

A cross-sectional study was carried out to assess the quality of protected springs, sanitary water handling practices and state of safety from bacteriological contamination of household drinking water during collection, storage and use in Tehuledere woreda during January 2002.

The study was conducted on five protected springs and 192 selected households who were the users of the springs, which were the sole sources of water supply. The protected springs were located at Amumo, Gobeya, Hitecha, Kekewa and Pasomile, localities, which served for 60, 60, 88, 76 and 99 households respectively.

Convenient, non-probability sampling was applied to select the five protected springs, due to limited resource and access to the woreda town, Haik. Where as systematic random sampling was employed for the selection of households. As there was no a reliable estimate on the proportion of household water quality, a 50% proportion which leads to the highest possible sample size was used as recommended by Daniel (15). The estimate was desired to be with 5% margin of error and 95% confidence interval.

Data were collected by employing sanitary surveys, laboratory analysis of water for bacterial contamination and interviewing of the selected population using pre-tested questionnaire. The protection status of the springs, the sanitary practices of the community near the source and other condition of the spring were assessed by using sanitary survey format recommended by WHO. A protected spring was considered as low risk when the sanitary risk score was 0-2/10, as intermediate risk when the sanitary risk score was 3-5/10, as high risk when the sanitary risk score was 6-8/10 and as very high risk when the sanitary risk score was 9-10/10 (16).

The analysis of water for bacterial contamination was conducted on five protected springs and from every 5th systematically selected households. Protected springs were examined through out the data collection period, on-average two days for each spring. Household water samples were taken from collection container, storage vessels and drinking cups. Samples were collected using plastic bottles sterilized with methanol smoke. Water samples from storage vessels were taken by aluminium sample cup. Delagua test kit was used to analyze water samples.

A sample of 100ml was filtered through a sterile membrane filter with a pore size of 0.45μm to retain the indicator bacteria to be counted by using sterile forceps; the membrane filter transferred from the filtration apparatus to a petridish. Which contain absorbent pad soaked with lauryl sulfate tryptose broth. The plates were incubated at temperature of 44 ± 0.5°C for 18-24 hours. The formation of yellow colonies was an indicator for the presence of faecal coliforms. Water sample with 0 faecal coliform count per 100ml was considered of excellent quality (grade A), 1-10 colonies per 100ml is acceptable (grade B), 11-50 colonies per 100ml is unacceptable (grade C), and counts of more than 50 colonies per 100mlwas considered as grossly polluted (grade D) [17].

A total of 192 households were interviewed using structured questionnaire. The questionnaire included variable on water collection, storage and use; and other hygienic practices of the households.

Data from sanitary survey, water analysis and interviewing were entered and processed using Minitab computer package. Chi-square test were employed to test the association between variables.

Verbal consent from the respondents was obtained prior to data collection. The findings of this study were disseminated to the respective institutions so as to take the necessary measures.

RESULTS

Sanitary survey

The sanitary survey results revealed that Amumo and Hitecha springs were graded as having high sanitary risk score (six and seven) respectively. The most significant defects were inadequate protection, unsanitary overflow pipe and cover, absence of surface water diversion ditch and lack of fencing. Kekewa spring also open for surface water contamination, had in sanitary over flow pipe and lacks surface water diversion ditch. The sanitary risk scores was three while Gobeya and Pasomile springs found to have low risk of contamination (0 and 2) sanitary risk score (Table 1).

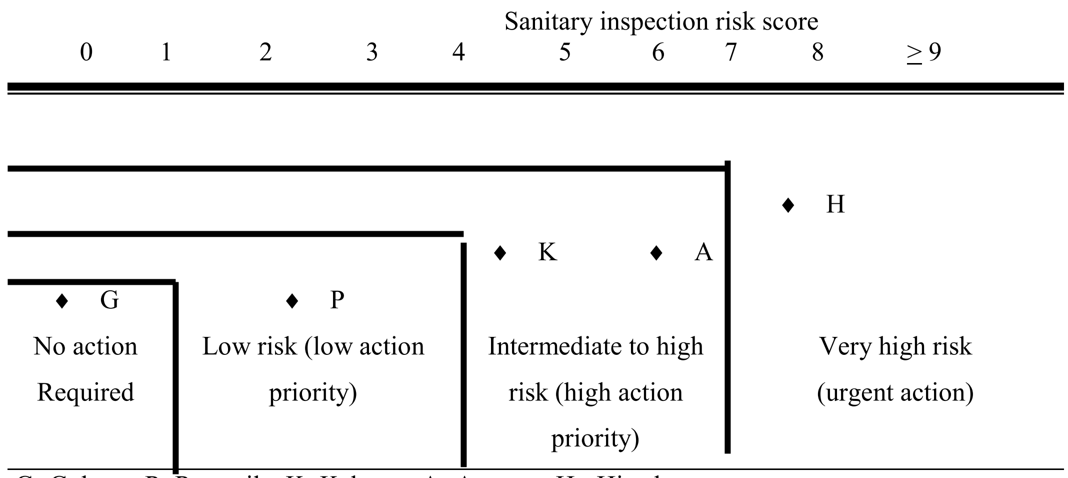
Analysis of water for bacterial contamination

As shown in table 1, the bacteriological analysis of five protected springs were as follows. Out of five springs Gobeya and Pasomile were excellent quality (class A), Amumo and Kekewa were considered acceptable (class B), where as Hitecha spring was of inferior quality and grouped in the unacceptable (class C).

Table 1. Sanitary condition and bacteriological quality of five protected Springs in Tehuledere woreda, South Wello, January 2002.

Spring site	*Sanitary risk score	Risk of contamination	Faecal coliform count per 100ml	**Category	Quality Remark
Amumo	6	High	2	B	Acceptable
Gobeya	0	Low	0	A	Excellent
Hitecha	7	High	12	C	Unacceptable
Pasomile	2	Low	0	A	Excellent
Kekewa	4	Intermediate	2	B	Acceptable
***Unprotected spring	-	-	157	D	Grossly polluted

* WHO Guidelines for drinking water quality Vol. III 1997
** Chees brough M. Medical Laboratory manual Vol. II. 1984
*** Control



G=Gobeya, P=Pasomile, K=Kekewa, A=Amumo, H =Hitecha

Fig 1. Assessment of priority of remedial action by risk analysis for Protected springs, Tehuledere, January 2002

Water handling practices

In this study, 54.7% of the households were found to collect water in clay pots, 44.7% in Jerricans and the remaining 0.5% collect water using plastic bucket. The majority 178 (92.7%) do have cover for their storage containers, while the remaining 7.3% were with out cover. Drawing of water from storage containers was carried out by dipping in 72.0% and pouring in 28.0% of cases. Most of the households 141(73.4%) rinsed their collection containers and wash their hands 123(64.1%) before water collection (Table 2).

Table 2. Water Handling Practices of Households in Tehuledere, South Wollo, January 2002

Variables	Number	Percent
Types of water collection container		
Clay pots	105	54.7
Jerricans	86	44.8
Bucket	1	0.5
Presence of cover for water storage container		
Yes	178	92.7
No	14	7.3
Hand washing practices before water collection		
Yes	123	64.1
No	69	35.9
Collection container rinsing/washing		
Yes	141	73.4
No	51	26.6
Transfer of water from storage vessel		
Pouring	54	28.0
Dipping	138	72.0
Frequency of water collection		
Every other day	6	3.1
Once per day	57	29.7
Twice a day	104	54.2
More than twice	25	13.0
Duration of water storage at home		
A day and less	129	67.0
More than a day	63	33.0
Type of water storage container		
Clay pot	110	57.3
Jerricans	82	42.7
Placement of water drawing (drinking) utensils		
Tables and/or shelves	51	26.6
Storage cover	24	12.5
Inside the container	12	6.25
Hang on wall	17	8.9
Floor	88	48.8
Latrine availability	15	7.8

Household drinking water quality

Collection: out of 40 water samples examined from collection vessels, 33(82.5) were faecally contaminated, of which 10(25%) were from faecal coliform free sources.

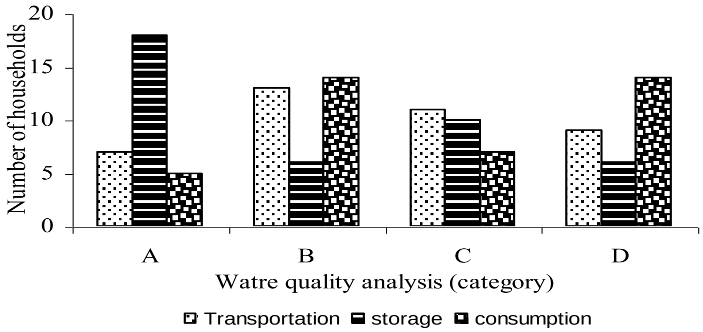


Fig 2. Bacteriological Quality of Drinking Water at the Point of Collection, Storage and use, Tehuledere Woreda, Januar 2002

The study showed that hand washing practices and collection container rinsing found to have positive and statistically significant association with the concentration of faecal coliform count at the point of collection ($P<0.05$). Moreover the use of clay pot for water collection showed a significant reduction on the magnitude of faecal coliform ($P<0.05$) [Table3].

Table 3: Concentration of faecal coliform count from collection vessels by water handling practices of the households in Tehuledere Woreda, January 2002

Variables		Faecal coliform count per 100ml		
		≤ 10	>10	P-value
Hand washing practices	Yes	15	7	
when collecting water	No	5	13	P< 0.05
Collection container rinsing	Yes	15	6	
	No	5	14	P< 0.05
	Clay pot	14	5	
Types of water collection	*Jerricans*	6	15	P< 0.05
		20	20	

Storage: out of 40 water samples examined from storage vessels 22(55.0%) were faecally contaminated, of which 6(15.0%) were samples from faecal coliform free sources (Fig. 2). On the eleven households with varying degree of faecal contamination at point of collection found to have zero faecal coliform at storage vessels.

As depicted in table 4, transfer of water by pouring, relatively longer duration of water storage and placement of water drawing utensils on tables and shelves showed a significant reduction on the concentration of faecal coliform count at the point of storage (P<0.05). Furthermore, water stored in Jerricans found to have significantly better bacteriological quality than water stored in clay pots (P<0.05).

Table 4. Quality of drinking water at the point of storage by water handling practices of the households, Tehuledere Woreda, Soputh Wollo, January 2000

Storage Condition		Faecal coliform count/100ml		
		≤ 10	>10	P-value
Transfer of water from storage vessels	Pouring	17	5	
	Dipping	7	11	P< 0.05
Duration of water storage	More than one day	18	5	
	One day & less	6	11	P< 0.05
Placement of drawing utensils	Table	18	7	
	Floor	6	9	P< 0.05
Types of storage containers	*Jerricans*	17	5	
	Clay pots	7	11	P< 0.05

Consumption: out of the total of 40 water samples examined from drinking utensils only 5(12.5%) were bacteriological safe (category A). Where as the majority 35(87.5%) were faecally contaminated (Fig 2). Out of faecally contaminated samples 12(30.0%) were from faecal coliform free sources.

As depicted in table 5, the concentration of faecal coliform significantly reduced on those households using pouring than dipping (P<0.05). Moreover placement of water drawing utensils on tables showed a significant reduction than putting on floor (P<0.05)

Table 5. Quality of drinking water at the point of consumption by water handling practices of the households Tehuledere woreda, South Wollo, January 2002

Storage Condition		Faecal coliform count/100ml		
		≤ 10	>10	P-value
Water transferred from storage vessels	Pouring	14	6	
	Dipping	5	15	P< 0.05
Placement of drawing utensils	Table	13	5	
	Floor	6	16	P< 0.05

DISCUSSION

The high sanitary risk score of some of the protected springs in Tehuledere woreda is not surprising in view of their protection status and people's hygiene practices near the protected sources. Inadequate protection from the impact of contaminants, unhygienic management of facilities, habit of communal bathing and laundry activities near the sources causes the deterioration of drinking water quality in the study area. A similar study in Tanzania (18) showed that poor community sanitary practices around the source and in the catchment area together with failure in the protection of water sources contributed to the contamination of ground water.

On the other hand, this study demonstrated that adequate protection of water sources could improve their bacteriological quality by effectively preventing faecal coliform from entering water system prior to their delivery point. The bacteriological analysis results of protected springs clearly indicated that a spring with high sanitary risk score had an inferior bacteriological quality (Hitecha spring). And those springs with low sanitary risk score found to have an excellent bacteriological quality Gobeya and Pasomile springs (Table1). Lioyd (19) also indicated the higher hazard scores of protected springs generally correlate well with increasing order of magnitude of faecal contamination.

For the purpose of risk analysis, the faecal coliform count and sanitary survey must be combined (16). In this study Hitecha spring had high sanitary risk score (Seven) and unacceptable quality (category C) and hence urgent action requires to improve its quality. Though both Kekewa and Amumo had acceptable quality, the sanitary survey exhibited the likely hood of contamination. Bacteriological safety at one moment in time may not be a guarantee for safety where as sanitary survey takes account of the previous history of the installation, and future point of risk (16) [Fig 1].

In the present study sanitation was a serious problem only 7.8% of the surveyed households have latrines. The vast majority used back yard or the bush for defecation. This in sanitary practice may contribute to the contamination of protected springs especially to those inadequately protected. Kravitz (13) also found that less than 5.0% surveyed villagers in Lesotho used latrines, as a result the prevalence of water borne diseases especially diarrhoeal diseases were very high.

In this study, the bacteriological quality of the sources and household drinking water showed prominent differences. Out of 87.5% faecally contaminated household water samples from drinking cups, 30.0% were from safe source. On the other hand 9(22.5%) of the household water samples taken from point of consumption showed a faecal coliform count of even more than the unprotected source (Table 1). Sutton (20) also found that initially coliform free water in rural Zambia were contaminated due to the way in which the water drawn, the method of transport to home and at the storage vessels.

The majority (73.4%) of the households in the study villages wash or rinse their containers when collecting water. This is relatively lower than previous reports (21), in which 86% of the households rinse or wash when collecting water. On the other hand 64.1% of the households wash their hands before water collection. Both collection container rinsing and hand washing practices found to have a positive and statistically significant association with the bacteriological quality of household drinking water from collection vessels ($P<0.05$).

The use of clay pot for water collection showed a reduction on the concentration of faecal coliform than Jerricans (P<0.05). This is probably due to clay pots are easy for washing and rinsing than Jerricans. Furthermore, the re-entrance of sloping or wasting water is very high in Jerricans since they are near to the ground or fetching area.

Drinking water also become contaminated during storage: how the water drawn from storage container, where drawing materials kept and duration of water storage in general have an effect on the bacteriological quality of stored water (21-23).

In this study, the majority (72.0%) of the households use clay pots for home storage while the remaining 28.0% use Jerricans. Water stored in Jerricans found to ha ve significantly better bacteriological quality than water stored in clay pots (P<0.05). Mertens (24) also showed that the proportion of faecal coliform positive water samples were higher with on the use of earthen ware pot than other narrow-necked water containers by preventing hands from entering the water container and contaminating the contents.

In this study, it was found that the majority of the households (72.0%) dipped out rather than poured when taking water from storage container. A study from Zambia (20) showed that 80% of the households dipped out when taking water from the storage jar, which is higher than the present study. Transfer of water out of storage container by pouring showed a significant reduction on the concentration of faecal coliform than dipping (P<0.05). A similar study in Bolivia indicated that 52.0% of the respondents admitted that they had introduced their hands into drinking water stored in the house, which results in the contamination of stored water by their infected fingers (20).

Another determinant factor for the contamination of stored water were placement of water drawing utensils. Only 51(26.6%) of the households put water drawing utensils on tables and shelves while the majority (73.4%) put it on floor, or hang on wall or leave it inside the container. Placement of utensils on tables and shelves showed a significant reduction on the concentration of faecal coliform (P<0.05).

Duration of water storage also had an effect on the bacteriological quality of stored water. Households with relatively longer water storage practices found to have a better water quality (P<0.05). Wood (25) also indicated that the reduction of microorganisms in storage vessels is achieved mainly because microorganisms are likely to settle in the bottom together with particles when water is stored in a container.

The highest proportion of inferior water quality was observed at the point of consumption, since it is the cumulative effect of collection, transportation and storage practices of the households. Transfer of water by pouring and placement of water drawing utensils showed a positive contribution for water quality at this point (P<0.05).

Availability of adequate quantities of water has an impact on domestic hygiene (26). However the mean per capita water consumption in the study area is generally low (Seven liter per capita per day, vis-à-vis the minimum water consumption recommended by WHO of Twenty liter per capita per day). Obviously the overall scarcity of water will have an impact on domestic and personal hygiene, which in turn affects the bacteriological safety of household drinking water.

In conclusion, spring protection found to be a necessary condition, but never be a sufficient condition for the provision of safe water supply. Inadequate protection, 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.

This study demonstrated that adequate protection of water sources improved their bacteriological quality by effectively preventing the entrance of contaminates. Therefore, the concerned sector(s) must increase their efficiency in spring protection, monitor, and evaluate the existing facilities to achieve their objective. Another area that requires the attention of the water sector and the community is the establishment of the water committee or local care takers, who look after the system and maintain leaks and break downs.

In this study, the adoption of water supply facilities, users practices and behavior, personal and domestic hygiene were the most neglected aspect of the soft ware components. Therefore expansion of hygiene education and sanitation found to have paramount importance on the provision of safe water supply. Since women and children are highly involved in most water collection activities, their participation in public health education programme is essential to eliminate unhygienic water collection and promote health behaviors. This approach could have a notable impact in the study area, where a significant proportion of the water collectors had low hygienic awareness and practices.

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