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Original Research

Assessment of the Bacteriological Quality of Drinking Water Sources in Nekemte Town, Western Ethiopia

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Abstract

The quality of potable water and treatment of water borne diseases are critical public health issues. Bacterial contamination of drinking water sources is the most common health risk. As water is the most important public need it has to be investigated for its quality regularly, which is crucial for the prevention and control of water borne diseases.Hence this study was aimed to assess the bacteriological contamination of drinking water sources among tap waters, springs and well water in Nekemte Town, January to March 2015. A cross-sectional study on drinking water quality in Nekemte town was conducted by using the membrane filtration technique. A total of 32 springs used for drinking purpose, 2 private and 2 public stand pipes, two reservoirs and 1 well water from each of the six sub cities were selected by multistage sampling. Water sample of 500 ml was collected for each water source. Bacterial culture was made by using Membrane Lauryl Sulphate Broth method.Data analysis was performed using SPSS version 20. And then tables and graphs were used to display the result and important variables.Of the total 65 (100%) water sampled, 5 (31.25%) of the unprotected springs, 4(25%) of the protected springs and the single hand pump were positive; which add up to 10(15.4%) of the total sample size. Whereas the remaining 55(84.65%) were negative for fecal coliforms. Absence of regular disinfection was found to be the major predisposing factor for the contamination of the 10 water sources. Springs and well waters do not have regular disinfection which has resulted in the contamination of 9 spring water sources and the single hand pump. Therefore, regular disinfection of the springs and well water sources has to be implemented.

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INTRODUCTION

Water is the most abundant substance in nature and vital for life activities. The major water Sources for use are surface water bodies such as rivers and lakes, underground aquifers and pore Spaces down the water (USEPA, 2003). The fresh water we use comes from two sources: surface and ground Water. Precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration is surface water. The subsurface area where all available soil and rock are filled by water is ground water. Only a tiny fraction of the planet's abundant water is available to us as fresh water. Of the total water on earth only 3% of it is fresh. About 2.997% is locked up in ice cap or glaciers. Only 0.003% of the earth's total volume of water is easily available to us (USEPA, 2003).

Water derived from these sources is not necessarily pure since it contains dissolved inorganic and organic substances, living organisms such as viruses, bacteria, parasites and fungus. For this reason, water intended for domestic uses should be free from toxic substances and microorganisms that are of health significance (WHO, 2005). As water is essential to sustain life; adequate, safe and accessible supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve drinking water that is as safe as practicable (WHO, 2003).

As human life is supported by water, availability of potable water is one of the most important criteria of high standard of living (Polevoy, 2003). Ethiopia is naturally endowed with abundant water resources that help to fulfil domestic requirements, irrigation and hydropower with the annual rainfall runoff and ground water resource estimated 122 billion and 2.50 billion m^3, respectively (MOWR, 2003 and WAEA, 2008). However, with all this potential, Ethiopia is one of the countries with low access rate to drinking water and sanitation in the world. Nearly 50 million and 65million people (which are 62% and 81% of the total population respectively) lack access to safe

water and sanitation respectively (WHO and UNICEF, 2013). Therefore, the safety of drinking water can be monitored in a number of ways due to the constituents of drinking water (such as chemicals and microbes) which can compromise human health can be measured directly. The reason for monitoring drinking water quality is to determine whether the water supply system is being operated correctly, implying that the water is safe for drinking or not. Indicator microorganisms survive better and longer than the stable properties and may easily be detected by standard laboratory techniques (Battu and Reddy, 2009). The key to increase human productivity and long life is good quality of water. The provision of good quality drinking water is often regarded as an important means of improving health (Chan *et al*, 2007). Lack of access to improved drinking water is still a serious problem in large portions of Asia and Sub-Saharan Africa. Nearly 2.6 billion people (39% of the world's population) live without access to improved sanitation; 1.1 billion people (17% of world population) and 60% Ethiopia population in 2008 defecate in open field The World Health Organization (WHO) reported that nearly half of the population in developing countries suffers from health problems associated with lack of drinking water or with microbiologically contaminated water (WHO and UNICEF, 2004). Most of the population of Ethiopia did not have access to safe and reliable sanitation facilities. Still further, most of its population did not have access to safe and reliable sanitation facilities. On top of these, 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 (UN WWAP, 2004 and Keller, 2009).

The provision of piped water directly to the household has been associated with improved hygiene and reduction in disease. However, as standards of living has risen and water infrastructures have aged, there has been growing recognition that water distribution systems are vulnerable to intrusion and contamination and may contribute to endemic and epidemic waterborne disease (Moe *et al*, 2006). It is well established that a large number of infectious diseases are transmitted primarily through water sources contaminated with human and animal excreta particularly faeces. Outbreaks of water borne diseases continue to occur throughout the world but especially serious in developing countries (Reynolds *et al.*, 2003 and Jones *et al.*, 2007).

Groundwater is an important source of drinking water and its quality is currently threatened by the combination of chemical pollution and microbiological contamination, especially microbes of sewage origin (Reid *et al.*, 2003). High incidence of diarrhea, helmenthiasis, trachoma and the overall high mortality rates are associated with poor environmental sanitation (GWSH, 2009 and Metcalf and Eddy, 2003).

The World Health Organization estimated that up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water. 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 (MOWR, 2001). Unsafe drinking water, along with poor sanitation and hygiene, are the main contributors to an estimated 4 billion cases of diarrheal disease annually, causing more than 1.5 million deaths, mostly among children less than 5 years of age (MOH, 2005). Since diarrheal diseases inhibit normal ingestion of foods and adsorption of nutrients, continued high morbidity also contributes to malnutrition, a separate cause of significant mortality; it also leads to impaired physical growth and cognitive function, reduced resistance to infection, and potentially long-term gastrointestinal disorders. Contaminated drinking water is also a major source of hepatitis, typhoid and opportunistic infections that attack the Immuno-compromised, especially persons living with HIV/AIDS (MOH, 2012).

Ethiopia is one of the developing countries where only 52% and 28% of the population have access to safe water and sanitation coverage, respectively (Ermias, 2007). As a result, 60% of disease burden is attributed to poor sanitation, 15% of total deaths from diarrhea mainly among children under five resulting into some 250,000 children deaths each year (Solomon *et al.,* 2011).

In addition, 60 - 80% of the population suffers from water borne and water related diseases.Water quality is therefore closely linked to the surrounding environment and land use. The quality of water is strongly influenced by community uses such as agriculture and urban use, and recreation. The modification of natural stream flows by dams and weirs can also affect water quality (WAEA, 2008 and WHO, 2008).

The dwellers of Nekemte town use water from different sources such as tap water, springs and wells for different purposes including for drinking. However, some of the water sources used by the people have greater chance to be contaminated via human and animal faecal materials and wastes disposed from households, and hotels (Choffnes and Rapporteurs, 2009).

Major source of drinking tap water in Nekemte town is Diga dam (Mekdim) after treatment. However, the Dam is not protected with fence and is prone to contamination due to possibility of drainage entry into it especially during rainy seasons. Along these water sources various organized and non-organized socio-economic activities are carried out by different communities, which discharge their wastes to these water sources. Therefore, different water sources including distribution system were not studied so far for quality check. Hence, the current study was designed to determine the bacteriological quality of protected and unprotected drinking water sources used for public use in Nekemte town.

MATERIALS AND METHODS

The study was conducted in Nekemte town, East Wollega zone, West Oromia, Ethiopia, in January - March, 2015. Nekemte town is located about 331km from the capital city Addis Ababa. Nekemte town is classified into 6 subcities (Chelelleki, Burka Jato, Derge, Bake Jama, Keso and Bekenisa Kase) with the total population of 104, 806 and an area of 1962 hectare, climate Weyina Daga. Diga Dam, which is located 7km away from the town which is expected to be used for 50 years and serves as main tap water source with its Belam treatment plant. Data from the Nekemte town water supply and sewerage office indicates that water enter to Reservoir 1(upper zone) at Bellem and serves population living from Board

to Wollega University which has a capacity of 500$m^3$and 3.3m depth and Reservoir 2 (Lower zone) from Bord to Sorga having a capacity of 2000$m^3$and 4.5m depth. In addition, the geographical setting of the town (ups and downs) makes all water sources prone to contamination. Different protected and unprotected spring water sources are also used for drinking purposes and well waters are utilized for domestic uses such as washing utensils and Preparation of food (Desalegn *et al.*, 2012).

A cross-sectional study was conducted on the bacteriological quality of drinking water sources in Nekemte town. Water samples at the main distributions, selected public, private stand pipes and wells, and all springs for public use in Nekemte town was included in the study. Water samples from all/32 the springs found in Nekemte town and the two reservoirs, 1 well water from each of 6 sub cities, 2 private stand pipes and 2 public stand pipes from each sub-city were selected for analysis. Therefore, multi-stage sampling method was used to select two zones from each sub city and two households from each of the selected zones by simple random sampling technique using lottery method for the selection of private standpipes and well waters whereas the public stand pipe was by simple random sampling from each sub city. Institutions with large consumers of water like Nekemte Hospital, Prison, and the two High Schools were included in the study. In addition, the two treatment plants of tap water and a single hand pump used for drinking purpose in a primary school were included, adding up the sample size to 26 tap water sources, 32 springs,6 well waters and one hand pump, totally 65 water sources.

Bacteriological Quality of Water

Fecal coli form (*E.coli*), type of water source, observed protective activity, status of surrounding cleanliness, presence of latrine in the surrounding area, distance of latrine from the water source, presence of animal excreta around the water source, breakage of drainage channel, integrity of water line, regular disinfection, regular sanitary and laboratory monitoring.

Inspection check list, sterile bottle, MLSB, pota test kit, membrane filters, pads, alcohol, bunsen burner, marker, pipette, incubator are some of the listed under annex part. From individual water sources, 500 ml sample of water was collected by the trained laboratory personnel under the supervision of principal investigator. The water was collected using sterile bottles and transported for testing immediately to Nekemte Regional laboratory by cold box. Water at the main distribution, public and private stand pipe, wells, hand pump and spring were collected.

The water samples were tested by Membrane filtration technique, using a POTA test kit. A 100 ml water sample or a diluted sample is filtered through a membrane filter of pore size 0.45 micrometer in diameter. The membrane, with the coliform organisms on it is then cultured on a pad of sterile selective broth containing lactose (Membrane laury sulphate broth in this case) and incubated at 44-45 ^{0}C.After incubation; the numbers of coliform colonies were counted. This gives the exact number of *E. coli* in the 100 ml water sample. In addition, inspection checklist was filled around the water source during collection.

Water sources that were not used for drinking purpose or domestic use were not included in the study. Sample was rejected if not properly labeled, not described properly with the required information of collecting format, collected in unsterile material, transported in an ambient temperature for more than 6 hours and collected in open sample container. Samples that met the appropriate criteria as opposed under rejection were included in the study.

Data were entered, cleared and analysed using bivariate/cross tab, multivirate analysis of SPSS version 20. Descriptive statistics like percentage, mean, range were used to describe the finding. *P*-value of 0.05 was used for testing significance.

The water samples was collected aseptically by using sterile bottle and transported by cold box to regional laboratory and analyzed as soon as possible. Culture media was prepared aseptically and sterility check was made by incubating one of the media overnight in incubator. To confirm enhancement of growth, faecal suspension was made and inoculated in broth as control. All equipment used for culturing was sterilized and during culturing nake of the sample containing bottles was flamed. All test procedures were conducted by trained laboratory technologist by following Standard Operation Procedure.

Written official letter was sought from the Ethical Review Board of Wollega University and Permission from municipality of the town for public water source sample and consent from private water source owner were obtained for sample collection. Based on the finding of this study we have communicated with the responsible bodies such as Nekemte regional laboratory and town's health office and intervention was taken particularly on contaminated water sources.

RESULTS

In Nekemte town, due to the unavailability of sufficient improved water supply, different water sources like treated/untreated, protected/unprotected, monitored/unmonitored tap water, springs and hand pumps for drinking purposes and, in some households well waters are used for preparation of food and washing utensils.

In this study,65 samples from seven types of water sources: 16 protected and 16 unprotected springs,2 resorviors,12 private and 12 public stand pipes, 6 well and 1 hand pump water sources have been included. All of the 26 tap and 6 well water sources were found to be negative for the indicator bacteria. However, 4 of the 16 protected springs and 5 of the 16 unprotected springs and 1 hand pump water sources, totally 10(15.4%) of the samples, were found to be contaminated (Table 1). Therefore, in this study, 65 water sources of which 10(15.4%) were contaminated whereas the remaining 55(84.6%) were not contaminated or are potable (Figure 1).

Table 1: Type of water sources, their frequency and result of the water analysis in Nekemte town, January-March 2015

No	Type of water source	Result of the water analysis			
		Frequency	%	Negative	Positive
1	Protected spring	16	24.6	12	4
2	Unprotected spring	16	24.6	11	5
3	Private standpipe	12	18.5	12	0
4	Public standpipe	12	18.5	12	0
5	Hand pump	1	1.5	0	1
6	Well	6	9.2	6	0
7	Reservoirs	2	3	2	0

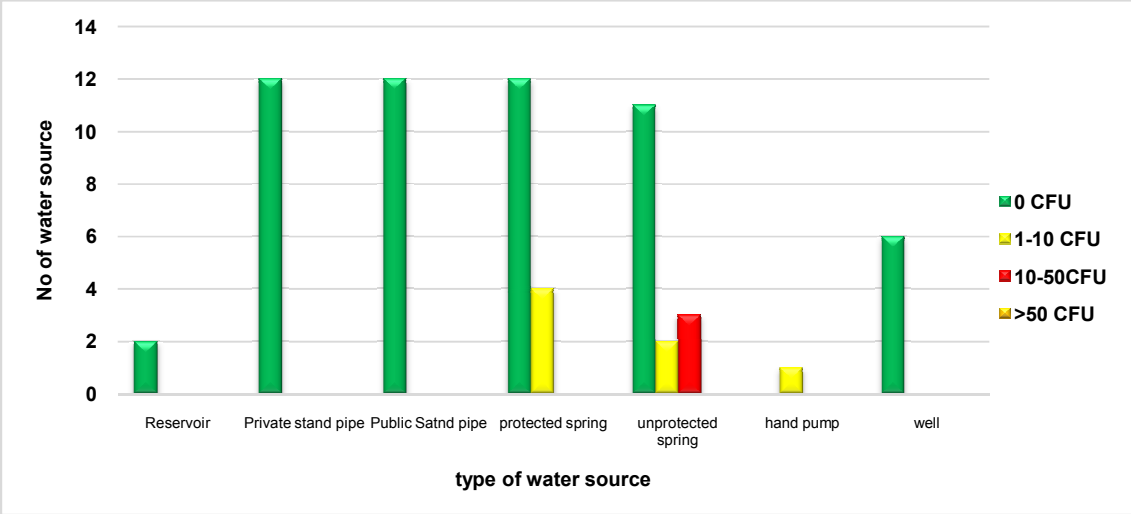

Figure 1: Findings of the bacteriological contamination of drinking water sources in Nekemte town, Jan - Mar, 2015

According to this study, 38(58.5%) of the samples were protected with concrete, 5(7.7%) with fence, and 22(33.8%) were not protected at all with *P*=0.6 (0.15-17.91) which was not significant statistically. Concerning the surrounding cleanliness, 26(40%) of the samples were from unclean surrounding, 32(49.2%) from partially clean, and 7(10.8%) were from clean surrounding with *P*=0.18(0.06-1.22). Although not significant according to this study, 23(35.4%) of the samples were near latrine, 42(64.6%) >30m far from latrine with *P*=0.08, OR (CI)=0.86(0.29-13.4). Whereas, 41(63.1%) of the samples were greater than 30 meters away from latrine and waste disposal as recommended by WHO, while 24(36.9%) were located less than 30 meters, with *P*=0.35, OR(CI)=1.89(0.49-7.38). In addition, 39(60%) of the samples were from areas with animal excreta in open field around them among which 9 samples were contaminated, whereas 26(40.0%) were from animal excreta free area among which 1 was contaminated with *P*=0.03 and OR(CI)=7.5(3.88 61.30) which is significant according to the bivariate analysis (Table 2).

On the other hand, 20(30.8%) of the water sources are in close proximity to broken drainage channel (5 of them contaminated), 45(69.2%) away from broken drainage channel(5 of them contaminated),with *P*=0.16,OR(CI)=2.66(0.67-10.54). while, the integrity of 30(46.2%) of the water sources were protected (only 1 of them contaminated) where as those of the remaining 35(53.8%) were not protected (9 of which contaminated) with *P*=0.03, OR (CI) =10.3 (1.19-84.70) showing significance according to the bivariate analysis (Table 2).

Of the total tested samples, 26(40%) of the water sources, all of which were tap waters, have regular disinfection (none of them contaminated) while 39(60%) of the water sources (springs ,hand pump and well waters) do not have regular disinfection among which are all of the 10 (15.4%) contaminated with *P*=0.01,OR(CI)= 6.03(1.12-11.61). This is significant according to the bivariate analysis. On the other hand, 61(93.8%) of the water sources have no regular sanitary and laboratory monitoring which might help to predict the risk of contamination of them in the future (10 of them contaminated) while 4(6.2%) of the water sources have regular sanitary and laboratory monitoring, with *P*=0.37, OR (CI) =0.78 (0.22-1.61) (Table 2).

As a result, 7(70%) of the contaminated water samples have indicator bacterial range of 1 10cfu/100 ml of sample (acceptable limit for developing countries according to WHO guideline-2008), whereas the remaining 3(30%) were in the range of 10-50cfu/100ml of sample. The standard for safe water is no growth (0 cfu/100 ml) of water sample of the indicator bacteria (TT coliform-*E.coli*). Among the three significant variables in the bivirate analysis, only the absence of regular disinfection has shown association with the contamination of the drinking water sources with (*P*= 0.05, AOR=3.64 and CI= 1.98-9.43) (Table 3).

Table 2: The result of the analysis in reation with the factors affecting the bacteriological quality of water in Nekemte town, January - March 2015

No	Independent Variables		Result of the water analysis					
			Frequency	%	Negative	Positive	P-value	OR(CI)
1	Observed protective activities	1.Concrete	38	58.5	33	5		
		2.Fence	5	7.7	4	1	0.68	1.46(0.34-6.15)
		3.Not at all	22	33.8	18	4	0.60	1.65(0.15-17.91)
2	Status of surrounding cleanliness	1.Not clean	26	40.0	19	7	0.18	20
		2.Partially clean	32	49.2	29	3	0.999	18
		3.Clean	7	10.8	7	0		
3	Presence of latrine in the surrounding area	1.yes	23	35.4	17	6	0.08	0.29(0.83-13.40)
		2.No	42	64.6	38	4		
4	Distance from latrine and waste disposal	1.>30meters	41	63.1	36	5	0.35	1.89(0.48-7.37
		2.<30meters	24	36.9	19	5		
5	Presence of animal excreta in open field around the water	1.yes	'39	60.0	30	9	0.035	7.5(3.88-61.30)
		2.No	26	40.0	25	1		
6	Breakage of drainage cannel	1.yes	20	30.8	15	5	0.16	2.66(0.67-10.54)
		2.No	45	69.2	40	5		
7	Integrity of the water system	1.Protected	30	46.2	29	1		
		2.Unprotected	35	53.8	26	9	0.034	10.3(1.19-84.70)
8	Regular disinfection	1.yes	26	40.0	26	0		
		2.No	39	60.0	29	10	0.01	6.03(1.12-11.61)
9	Regular sanitary and laboratory monitoring	1.yes	4	6.2	4	0		
		2.No	61	93.8	51	10	0.37	0.77(0.22-1.61)

Table 3: Multivariate analysis of significant variables by biviriate analysis of drinking water sources in Nekemte town, January – March, 2015

No	Independent Variables	Frequency		P value	AOR	CI
		Yes	No			
1	Presence of animal excreta in open field around water	39(60%)	26(40%)	0.75	0.69	(0.06-7.17)
2	Integrity of the water system	30(46.2%)	35(53.8%)	0.99	0.99	(0.89-11.01)
3	Regular disinfection	26(40%)	39(60%)	0.05	3.64	(1.98 – 9.43)

DISCUSSION

Of the total 65(100%) water samples; 4(25%) of the protected springs, 5(31.25%) of the unprotected springs and the single hand pump ,totally 10 (15.4%) were positive for the indicator bacteria (fecally contaminated). The reason for this contamination might be the absence of regular disinfection of all the spring and well water sources. Similarly, a study conducted in Dire Dawa using the same method indicated high risk of contamination of spring and well waters in the absence of regular disinfection (Mengesha *et al*., 2004).

All of the 26 (100%) piped water sources were not contaminated in this study which was in contrast to study done in Dire Dawa (Mengesha *et al*., 2004) and in Gonder (Atnafu, 2006) in which 50% of the tap/piped waters were contaminated. This difference might be due to study area set up difference.

Protected water sources are generally better than unprotected ones, but, according to this study the difference was only with one sample, that is , four of the protected and five of the unprotected water samples were contaminated, indicating the significance of regular disinfection which was absent in both water types. But, still this is findings differ from study done in Dire Dawa (Mengesha *et al*., 2004) and Gonder (Atnafu, 2006) , in which 100% and 35.7% of the spring water samples were contaminated, respectively.

Well waters have less probability of being contaminated and the indicator bacteria also survives for short period of time in deep wells as implied also under this study. But, contrary to this, in the study done in September to October 2010 in Jimma (Solomon *et al*., 2011)' 87.5% of the well waters were contaminated; this difference may be due to variation in the study period.

The single hand pump included in the study was contaminated demanding an urgent treatment as far as it is used as a second option for drinking purpose when there is no tap water in a Sunshine primary school.

The result of this study has indicated low level of contamination (15.4%) in contrast to studies done in Jimma (Solomon *et al*., 2011), and in South Wello (Desta, 2009), in which 23% ,and 75% of the water samples were contaminated, respectively. This might be due to seasonal variation with previous study done.

The water in this town is therefore bacteriologically has less contamination level when compared with studies done in other areas (Solomon *et al*., 2011 and Desta, 2009 in which the water samples were 75%, 100% and 23% contaminated, respectively. This might be due to the study was not during rainy season in which springs have high potential of being contaminated.

The absence of regular disinfection was the independent predictor variable (*P*=0.05, OR=3.64 CI= 1.98-9.43) of the outcome of the study in which 39 (60%) of the water sources in this town do not have regular disinfection which has resulted in the faecal contamination of 10 water samples and risk for the remaining 29 water

sources. In contrast to the present study, study conducted in Gondar (Atnafu, 2006) revealed that only 6 (14.3%) of the water sources had regular disinfection resulting in the contamination of the remaining 85.7% of the water sources. This difference might be due to difference in the study season.

CONCLUSION

The protection and monitoring of the springs, hand pumps and wells is very poor. Although only 10 of the 39 water sources without regular disinfection are found to be contaminated with the indicator bacteria in this study, the remaining 29 are at a great risk during the rainy season when drainage and erosion could contaminate this water sources. Regular disinfection according to the standard for each type of the water source, in particular for the non-pipe line sources with great attention since their integrity is not protected, can assure the provision of quality water supply for the community. The presence of indicator organisms calls a need for further survey, investigation and examination of drinking water sources.

Conflict of Interest

None declared.

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