Bacteriological and Physio Chemical Quality Assessment of Drinking Water:

The case of shambu Town,Oromia Region, Ethiopia

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ABSTRACT

Water quality is a critical factor affecting human health and welfare. Ethiopia is one of the countries with worst health status in the world water quality problems where only 52%of its population has access to safe water. For this reason, 60-80% of the population suffers from water-borne and water-related diseases. Shambu town is not out of this problem. Since people are still using unprotected wells and springs for their domestic water supply. Therefore this research was aimed to evaluate the bacteriological and physico-chemical quality of water in Shambu Town. Two rounds of water samples were taken from each site with A total of 48 water samples. From water sources (n=4), from reservoir(n=1)from tap water (n=4) and from household containers (n=15) were considered for physico-chemical and bacteriological drinking water quality determination. A the Samples were analyzed for phisico chemical parameters like Temperature, Turbidity, PH, TDS, EC and the presence of indicator bacteria such as Total coliformes (TC) and fecal coli form (FC).The method of sample collection at each sampling point was according to the WHO Guidelines for drinking water quality assessment. Water samples were collected using systematic random sampling method. The result showed that Highest counts of TC,and FC were detected in the house hold water containers, followed by unprotected well, unprotected springs protected well and protected spring. All raw water samples were positive for TTC and FC. High bacteriological load were found in the household water containers. This research concluded that the water quality of shambu town at household storage were very poor and were not free from free from contaminates. Thus, deliberate awareness creation of the community about sanitation and hygienic practices is crucial. The water sources should be protected from entry of animals, human excretes and it should be treated before used for drinking.

Keywords: water quality, bacteriological water quality, physico-chemical quality of water

1. INTRODUCTION

Water is the most abundant substance in nature and vital for life activities. The major water sources for use are surface water bodies. Water derived from these sources is not necessarily pure since it contains dissolved inorganic and organic substances, living organisms (viruses, bacteria, etc). For this reason, water intended for domestic uses should be free from toxic substances and microorganisms that are of health significance (WHO, 2005).

Water quality is a critical factor affecting human health and welfare. Studies showed that approximately 3.1% of deaths (1.7 million) and 3.7% of disability-adjusted-life-years (54.2 million) worldwide are attributable to unsafe water, poor sanitation and hygiene (WHO, 2005). More than 88% of the global diarrheal diseases are water-borne infections caused by drinking unsafe and dirty water

(Gundry *et al.*, 2004). It is estimated that 1.1billion people in developing countries have no access to clean water, and 2.4 billion people have no any form of sanitation services (WHO, 2002). Consequently, 250 million people are exposed to water-borne diseases resulting in 10-20 million deaths every year (Pironcheva, 2004).

Ethiopia is one of the countries with worst health status in the world water quality problems. The problem is the backward socio-economic development resulting in one of the lowest standard of living, poor environmental conditions and low level of social services (UNWATER/WWAP/, 2004).The dilemma of delivering safe water to the population is compounded by population growth and more demand for more water from ground and surface water sources (Gundry *et al.*, 2004). Consequently, the dual forces of pollution and population pressure have complicated the provision of safe water to the public. This shows that, despite the worldwide efforts of delivering safe drinking water, the transmission of water-borne diseases is still a matter of major concern (Venter, 2000).

Ethiopia is one of the developing countries where only 52% and 28% of its population have access to safe water and sanitation coverage, respectively (MOWR, 2007). For this reason, 60-80% of the population suffers from water-borne and water-related diseases (Anonymous, 1986; MOH, 2007). This burdens the country with enormous financial and social costs to take care of such a huge number of people suffering from these debilitating infections. In the country, 20% of the population lives in urban centers. Different reports showed that water sources and distributions systems are contaminated with water quality indicators such as turbidity, organic matter, and fecal microorganisms. These bacteria indirectly determine the risk of ingesting pathogens with polluted water (APHA, 1998).

1.3 Objectives

1. To evaluate the physico-chemical quality of water.
2. To evaluate bacteriological quality of water.
3. To assess the Treatment measures used by the community.

2. MATERIALS AND METHODS

2.1 Description of the area

2.1.1 Location

Shambu Town is geographically located between 9^0 56' 6" N of latitude and 37^0 1'00" E of latitude. And also this town is bounded by Jima Geneti south direction, by Abbay Choomman in East, by Horro in North direction, and also in west.

2.1.2. Climate

The rain fall over the shambu Town is bi-modal and it receives its main rain fall from June to September and its minor rain fall is in other months. The maximum and minimum average Temperature of the town in 16.2c^0 and 14.2 c^0 respectively and the total average temperature is 15.5 c^0.

2.1.3. Population

According to the population and Housing casus carried out by the central statistical authority (CSA, 2007). The population of shambu Town was 14.995 in 2007. Out of this 7757 or 51.7% were males and 7238 or 48.3% were females.

2.1.4 Water source

The potential water source for shambu towns are surface water, ground water well and spring. However there was the scarcity of drinking water in Shambu Town. At the existing condition the town has got its water sources from different sources like from ground water, hand dug wells and from the spring water sources. Even though there are different water sources in the town, still the people are suffering from the lack of water distribution at the required time and the required quantity.

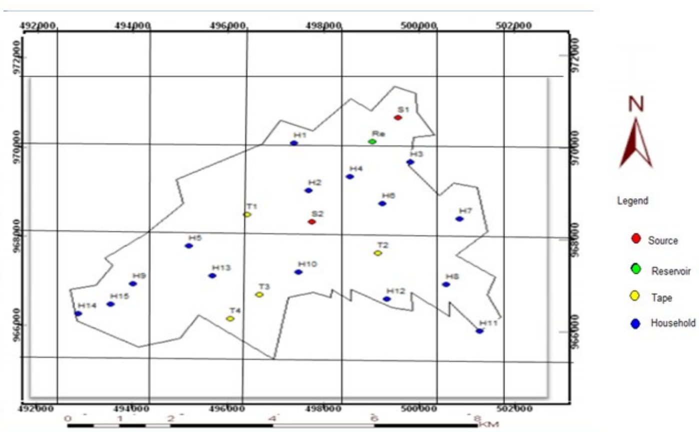
2.2 Set-up of the study

Water samples were collected from three unprotected springs in the upland part of the settlement and from the River representing the main watering points where the human and livestock population depend on for their daily water supply for drinking and other domestic purposes. During sampling, three sites of springs and four points along the river were chosen.

2.3 Experimental design

Cross sectional study was done to examine the bacteriological and related physico- chemical quality of drinking water at sources, disinfected and non disinfected points, and pipe water and household containers and also supported using a standard sanitary survey work sheet.

Location of sampling sites in Embacho town



2.4 Sampling points and frequency

Two rounds of water samples were taken from each site in this study. A total of 48 water samples within two rounds were taken. From water sources (n=4),from reservoir (n=1), from tap water (n=4) and from household containers (n=15) were considered for physico-chemical and bacteriological drinking water quality determination.

2.5 Sample collection and Analytical procedures

Physico-chemical parameters: (Temperature, Turbidity, PH, ECand TDS)

Bacteriological parameters :(Total coliformes (TC) and Faecalcoliforms (FC)

The method of sample collection at each sampling point was according to the WHO Guidelines for Drinking water quality assessment. Water samples were collected from the water sources, reservoir, and water point and from households using systematic sampling method. Sterile glass bottles in a cold box containing ice freezer packs were used to transport the sample to the laboratory.

- The turbidity of the sample were determined using spectrometer
- The pH of the sample was determined using pH meter.
- The temperature of each sample was determined on the site of collection with a digital Thermometer.
- With regard to bacteriological parameters, samples were analyzed using membrane filtration (MF) method for water quality to determine the degree of contamination.

All Samples were analyzed for the presence of indicator bacteria Total coliformes (TC) and fecal coli form (FC). One hundred milliliter of water sample for each test was filtered through a sterile cellulose membrane with a pore size of 0.45µm to retain the indicator bacteria. The filtration apparatus were sterilized before use and re-sterilized between samples using methanol when analyzing water samples. According to Michael H.,2006 about risk classification for thermo tolerant coliforms or *E. coli* of rural water supplies shown below.

Table 2: water quality counts per 100mL and the associated risk

Count per 100ml	Risk Category
0	In conformity with WHO guidelines
1 – 10	Low risk
11 – 100	Intermediate risk
101 – 1000	High risk
> 1000	Very high

This study was conducted from September 2014 to January2015. A survey of 48 water sample and sanitary surveys were conducted in 4 raw water sources, 4chlorinated and non chlorinated water points, and 15 randomly selected households' storage water containers. The water samples were examined for TTC and FS using membrane filtration method.

2.6 Statistical Data Analysis

Data were recorded, organized and summarized in sample descriptive statistics methods using SPSS-PC statistical package (SPSS 14 for windows version). These results were presented in correlations measures, ANOVAs, T-tests .Least Square of Differences (LSD) was applied to all physicochemical parameters and the bacterial counts to compare variation in water systems,. The data were interpreted by their frequencies and magnitudes such as concentration of the organisms in a liter of water sample. P-value of less than 0.05 considered statistically significant.

3. RESULTS

Table3.1: Mean physico-chemical and Bacteriological water quality at water Sources (n=4)

parameters	water source				standard	
	protected well	Unprotected well	Unprotected spring	protected spring	WHO	ES
Temp(oC)	9.4	15.45	15	11.87	<15	15
Turb(NTU)	1.02	15.71	5.5	2.00		
PH	7.9	7.13	6.95	7.5	6.5-8.5	6.5-8.5
TC(/100ml)	2	15	5	0	0	0
FC(/100ml)	2	7	11	0	0	0
EC(Ms/cm)	900	550	670	756	<1000	
TDS(mg/l)	5345	390	347	356	<500	<1000

Note:TDS-total dissolved solids,EC-electrical conductivity,FC-fecal coliform,TC-total coliform,PH-power of hydrogin,Turb-turbidity,Temp-temperature,ES-Ethiopian Standared,

Table 3.2 Mean Physico-chemical and bacteriological quality at the water points (n=4)

parameter	water samples points				standard
	Wabe hotel	ELPA	model school	Amin Clinic	WHO
Temp(^{o}C)	12.2	14.2	9.5	10.6	<15
Turb(NTU)	1.2	1.23	1.23	0.32	<5
PH	8.2	7.5	7.6	8.1	6.5-8.5
TC(/100ml)	4	5	10	12	4
FC(/100ml)	7	0	3	5	7
EC(Ms/cm)	900	550	670	756	<1000
TDS(mg/l)	5345	390	347	356	<500

Note:TDS-total dissolved solids,EC-electrical conductivity,FC-fecal coliform,TC-total coliform,PH-power of hydrogin,Turb-turbidity,Temp-temperature

Table 3.3 Physicochemical and bacteriological qualities at household water containers

Parameter	Samples selected for analysis(n=15)														
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10	HH11	HH12	HH13	HH14	HH15
Temp(^{o}c)	20.0	21.7	20.85	20.4	20.0	20.1	15.4	23.9	20.7	19.0	20.7	19.85	19.4	20.0	20.0
Turb(NTU)	0.20	0.21	0.21	0.22	0.21	2.0	0.45	3.4	3.0	2.4	0.2	0.21	0.22	0.21	0.21
PH	8.2	8.0	8.0	8.2	8.0	7.4	8.2	6.59	8.5	8.2	8.0	7.18	7.1	7.16	8
TC(/100ml)	16	24	13	14	17	9	23	46	9	16	24	13	14	17	17
FC(/100ml)	15	20	17	10	14	7	15	34	6	17	10	14	12	16	14
EC(Ms/cm)	1000	750	770	750	987	876	678	978	786	876	987	876	954	765	734
TDS(mg/l)	555	390	347	356	456	650	760	345	543	456	673	345	456	476	673

Note: HH-household,TDS-total dissolved solids,EC-electrical conductivity,FC-fecal coliform,TC-total coliform,PH-power of hydrogin,Turb-turbidity,Temp-temperature

4. DISCUSSION

Bacteriological water quality at the water sources.

Highest counts were detected in the unprotected well, followed by unprotected springs protected well and protected springs. The lowest average count of bacteriological indicators in the protected springs was detected, possibly due to reduced impacts incurred by people and livestock. The highest average indicator bacteria concentrations in all wells and springs were observed in January and February. This might be due to elevated surface flow into the water sources as these months are considered as short rainy season. In contrast, lower average counts of indicator bacteria were mostly recorded in December, a month of the dry season in which flood contamination would not be expected. Residents at the sampling points of the water sources from the unprotected springs drew water using cans and cups for drinking and domestic consumption without any treatment. In addition, they washed their clothes and body only a little bit away from the collection points which could be sources of contamination. Livestock have free access and directly get into the water source to drink; hence there was an opportunity of animal defecating and urinating inside water sources.

ANOVA of total coli form concentration among all sites showed that there was a significant difference ($p< 0.01$) in the average counts of TC between the sampling sites. Total coliforms in unprotected wells and springs were significantly higher than in all other protected wells and spring water sources. The sanitary inspection and personal observation revealed that a high number of people used this site for different purposes including livestock water, washing clothes and domestic water. Moreover, there were big trees over the water source and debris falls into the water, sometimes covering it.

In a study conducted on unprotected springs in North-Gondar, Ethiopia, Mengesha and his coworkers demonstrated that fifty percent of the samples had a coli form count of 180 and above/100 ml and the lowest coliform count was 13 coliform /100 ml (Mengesha *et al*., 2004), which are lower than the present study which were found to be 19 coliform /100 ml. In another study in South Wello, Ethiopia, demonstrated that two thirds of the samples from protected springs were contaminated with total coliforms (Atsnaf, 2006).

This was less than in the present study, where all water sources were contaminated with total coliform. This difference can possibly be attributed to the protection around the springs as usually is the case in Wello province and not in this study area. The Sanitary inspection and personal observation also revealed that a high number of people defecating near to this water source and animals were also sharing this water source with humans. Moreover, trees over the site and debris failed into the water, sometimes covering it

In addition drawing water was done using unclean cups and cans, domestic consumption without any treatment .In addition; they washed their clothes and body while there is also open access for livestock and wildlife. All these factors might be possible reasons for the high concentrations in total coli forms in this water source.

Analysis of variance was used to test whether the average counts of physico-chemical and bacteriological water quality parameters were the same or not between water sources at 5% level of significance based on the result. There was significant difference in the average values all of parameters between water sources and disinfection point since (F calculated <F (ratio) tabulated and p > 0.05)

Temperature

The mean temperature records of all spring and wells water sources were found to be within the permissible limit of 15^{o}C recommended by WHOM (1996).

Turbidity

This study showed that the turbidity level of the water source samples of the study area were compliant with WHO of less than 5NTU (WHO, 1997). But the mean turbidity recorded of unprotected springs and unprotected wells did not meet the standard (WHO, 1996).This seems due to the fact that human and animal wastes turbid the water source, since it has no fence, cattle trough, no protected in any means as it was observed by field visit.

PH

It was found to fall in the standard of WHO (1996) which recommend the PH of drinking water should be 6.5-8.5. The slightly lower pH recorded from water samples from the unprotected spring may be due to the swampy surrounding of the area that enhances microbiological activities that release acidic leakages into the source water. Given that all the towns are located in, the highlands whose soil and water bodies showed acidic pH (Elizabeth, 2009).

Tap water

The pH measurements of all tap water samples were within the acceptable limit .As indicated in the table, the TC and the FC indicators of water quality parameters were not within the recommended limit of WHO standard of 0/1000ml. There was record of bacteriological indicators, in all the sampled taps

Household water container water

The maximum and minimum record of TC of the household containers were found to be 46 at HH9 and 2 at HH1espectively and are not in the recommended limit (WHO, 1996).which recommend that TC to be less than 10(/100ml.The maximum record of FC was found to be 34 at HH9 and the minimum was found to be 1 at HH2 which is beyond the recommended limit of WHO standard to be 0 /100ml (WHO,1996).Among the total samples (15), (40%) of TC and FC range from 1.01-9.99, 9(60%) were in the range of 10-100/100ml.

No samples were found 0 of TC per 100ml which is in the acceptable limit of WHO nil /100ml. All samples taken from the households containers who used alternative water source were positive for total coli forms and fecal coli forms, according to the suggested criteria for drinking (WHO, 1996).which recommend that the drinking water should be free from bacterial contamination which should be 0 /100ml, but in each of the sampled household containers there were indicators.

As household interview reported, there were repeated water and sanitation related diseases These were due to low sanitation habit of the town after the water has riches to the consumers home .This indicates that there should be greater attention to aware the consumers .as it was also checked by observation and during household survey, most of the containers were opened, not put in safe manner, not clean and not washed regularly. These may be the possible reasons for high value of bacterial counts in the household containers, despite the fact that the water they get from the pipe system was clean and safe for drinking.

With regard to temperature, from 15 samples, 13 (86.67%) were >20 oC, only2 (13.33%) were in the range of 15.01-20 oC medium, recommended limit by WHO (1996). The average temperature of household water containers were in the range of 12.9-24.7^{O}c.Regarding to turbidity, 15(100%) showed levels within WHO limit of <5 FAU.

From 15 storage water samples, 15 (100%) was found to met WHO recommended range of pH 6.5-8.5. From the total of 15 examined storage containers for the concentration of FCR, 15(100%) of the representative samples have no any chlorine, this was due to the fact that chlorine was added before two months of conducting this thesis.

In the ANOVA Table, it is possible to see the mean difference for all parameters between and within groups. The result indicted that there were no significant differences among the point of disinfection, pipe water and household water containers for all the parameters (F calculated < F (ratio) tabulated, p < 0.05).except bacterial counts. From the table we can see that

- ✓ There was no significant difference between the mean temperature values of water samples (P>0.05)
- ✓ There was significant difference between the mean TC values of water samples (P<0.05).
- ✓ There was significant difference between the mean FC values of water samples (P<0.05).
- ✓ There was no significant difference between the mean turbidity values of water samples (P>0.05)
- ✓ There was no significant difference between the mean PH values of water samples (P>0.05)

Correlations of physico-chemical and bacteriological indicators in the household water containers

The data were analyzed using Pearson's correlation to see the correlation of bacteriological and physico chemical parameters in the sampled household water containers (n=15)

- ✓ Temperature and turbidity were positively correlated with a value of 0.349
- ✓ There was a significant positive relationship between bacterial counts and temperature with a value of 0.422 for TC and 0.453 for FC respectively.
- ✓ There was negative correlation between temperature and PH with a value of -0.385
- ✓ There was strong correlation between TC and FC with a value of 0.859

Table 6: Paired samples correlations of physico-chemical and bacteriological indicators in The household water containers (n=15).

All 15 pairs	Temp		Turb		PH		TC		FC	
	Corr.	sig	Corr.	sig	Corr.	Sig	Corr.	sig	Corr.	sig
Temp	1	-	0.349	0.202	-0.385	0.156	0.422	0.117	0.453	0.090
Turb	.0349	0.202	1	-	-0.164	.559	0.295	0.286	0.264	0.342
PH	-0.385	0.156	-0.164	0.559	1	-	-0.436	0.105	-0.501	0.057
TC	0.422	0.117	0.295	0.286	-0.436	0.105	1	-	0.859**	0.000
FC	0.453	0.090	0.264	0.342	0.501	0.057	0.859**	0.000	1	-

**. Correlation is significant at the 0.01 level (2-tailed).

The survey result showed 85% of the urban and 86% of the rural respondents did not use any treatment measures. Since the main source of water was improved sources for this study bench mark and many of the people assumed the water sources once protected so no risk was expected. The urban residents believed that once the water treated by chlorine there was no problem. But a significant number of people used Aqua tab, boiling and sedimentation as treatment measures. From the total number of respondents 10% of the urban and 2% of the rural used to treat using boiling techniques. Traditional techniques were also adopted like smoking and washing the container with a special wood, plant leaves and sand. Because they thought that it could increase the better test of the water and killed the remaining pathogens within the container. But it needs especial attention and extension works to enhance people's attitude to use different techniques

Treatment measures used

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Traditional techniques were also adopted like smoking and washing the container with a special wood, plant leaves and sand. Because they thought that it could increase the better test of the water and killed the remaining pathogens within the container. But it needs especial attention and extension works to enhance people‟s attitude to use different techniques.

5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

All raw water samples were positive for TTC and FC. High bacteriological load were found in BH8 (52.5/100ml) for FS and FSNC (29 /100ml) for TTC. TTC and FC concentrations detected were 12.3 and11.6 /100ml, respectively for bore hole EP4. For un-treated water sources the (KGW, EP5) TTC counts were higher (>15 per 100). Similarly, the FS count for KGW (>15 per 100 ml) was higher thanEP5 (2 /100ml). The health risk matrix assessment indicated that both the EP5 and KGW for TTCwere within high risk score while FS risk to health classification EP5 and KGW lie on medium and high-risk score, respectively.

Temperature at all three disinfection points were above permissible limit of 15 oC. Turbidity at CTR andFSC met the acceptable level of WHO and National standard limit of potability < 5 FAU. TDR was abovethe recommended limit. The pH values at all the three points were within the recommended limit (6.5 -8.5). The free chlorine residual were 0.67, 0.6, 0.68 mg/l at CTR, TDR and FSC respectively which are less than the average value of the recommended limit of WHO (>0.8mg/l). Even if disinfected watercourses (CTR, TDR, FSC) were better than non disinfected water sources (EP5, KGW), all sample sources were contaminated with TTC and FS having >1 per 100ml and this were found out to be above WHO and National standards (/100ml=0).Only 1(2.9%) of pipe water samples was <15 oC whereas others were found to be above the limit of 15 oC. The temperature of pipe water was in the rage of 14.5 -22.5 oC which was warmer as compared to the standard temperature (15oc). This favors the regrowth of some indicator organisms like TTC in distribution systems. Out of the examined sampling sites 48.6% of them were within the range of acceptable chlorine residual limit (0.2-0.5 mg/l) and 17.1% were above the recommended level (0.5 mg/l).In all tap water samples, pH values were within the recommended limit (6.5-8). In the pipeline, only17.1% and 31.4% of sampling sites were found acceptable based on WHO and National standard for TTC and FS counts, respectively. The overall risk-to-health classification at tap water (N=35) were19(54.29%) as intermediate and 16(45.7%) as low classification range for FS whereas for TTC, 19(54.29%), 8(22.88%) and 8(22.88%) were as intermediate, high and low risk to health matrix score, respectively. For water samples at the household, only 14.3% were within the recommended free chlorine residual level. 8.6% and 17.1% of sample sites (N=35) were above the recommended limit of temperature (<15oC),and turbidity (<5FAU), respectively and only 1 (2.9%) was acceptable for both TTC and FS levels. The health matrix classifications for bacteriological indicators (TTC and FS) were found to be 65.7% and20% within the high risk and medium risk score, respectively. Ingeneral,the mean values of physico-chemical water quality of all water sources and household water containers of the study area were in the range of who limit but the bacteriological quality of all water sources was not in agreement with the standard set by who drinking water standared .

5.2 RECOMMENDATIONS

- Although the water quality determined at the distribution system seems safe, the water quality at household storage were very poor and were not free from free from contaminates. Thus, deliberate awareness creation of the community about sanitation and hygienic practices is crucial.
- Chlorine tablet or wuha aguar have to be addressed to the community
- The alternative spring water should be protected from entry of animals, human excretes and it should be treated before used for drinking purpose.
- Deliberately checking of drinking water quality for the physicochemical parameters such as free chlorine residue, turbidity and pH.
- Further studies should be conducted during the rainy season

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