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Drinking Water Quality Status of Boditi Town

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Abstract
This study assessed bacteriological and physicochemical water quality status of the Town. Purposive sampling was employed for sample sites selection. The inferential statistics ANOVA and LSD was employed for water quality analysis to see the statistical significances and association of the temporal and spatial variations of samples. Water quality assessed by membrane filtration and spectrophotometer methods. The resulted were compared with WHO and Ethiopian drinking water standards. Residual chlorine in the pipeline system and springs were extremely low when compared to the standards. Turbidity result showed that out of eight samples tested, four samples, i.e, one sample of pipe line and three samples of springs were above the standards. Bacteriological results showed that out of eight samples tested the presence of Escherichia Coli on seven water samples, i.e, four samples from pipe lines and three samples from springs exceeding the standards. Bacteriologically and physicochemically, the water in the distribution system violets the WHO and Ethiopian drinking water standards.
Keywords: Water quality, bacteriological, physicochemical, Boditi Town.

1. Introduction

Certain natural processes and anthropogenic activities change the biological, chemical and physical qualities of water system (the source, water movement, distribution system) in such a way result a problem to health and well being of human population. According to UNESCO/WWAP (2004), above 75% of the health problems in Ethiopia are due to communicable diseases attributed to unsafe and inadequate water supply and unhygienic waste management, particularly excreta. The contamination of drinking water by pathogens causing diarrheal disease is the most important aspect in decreasing drinking water quality (Fawell and Mark, 2012). From the bacteriological quality point of view, water quality can be described as drinking water should be free from disease causing microorganisms. The problem arises as a consequence of contamination of water by fecal matter, particularly human and animal fecal matter, containing pathogenic organisms.

The health concerns associated with chemical constituents of drinking water differ from those associated with microbial contamination and arise primarily from the ability of chemical constituents to cause adverse health effects after prolonged exposure (WHO, 2011). The water quality assessment process has now evolved into a set of sophisticated monitoring activities including the use of water chemistry, particulate material and aquatic biota (Hirsch et al, 1988). Their existence beyond accepted standards causes human health problems.

Poor environmental management, uncontrolled liquid and solid waste disposal, which are common in the study Town, need to be looked at to maintain water quality. This study therefore, specifically investigates the quality of water in distribution network, in other sources and may initiate intervention measures to address the mentioned problems.

1.1 Objective of the study

The purpose of this study is to assess the bacteriological and physico-chemical water quality of Boditi Town.

2. Materials and methods

2.1 Location

The study was conducted in Boditi Town which is located in Damot Gale Woreda, SNNPR regional state, having a total area of 1368.115 ha. Geographically, it is located: 6º56'0" to 8º58'0" N Latitude and 37º50'0" to 37°53'0" E Longitude. The Town is at an altitude ranging from 1880 m to 2112 m.The Town is 365 km from Addis Ababa and 140Km from Hawassa.
Figure 2.1 Location map of the study Town.

2.2 Indicator selected for the study

An indicator used in the study was water quality monitoring which is the potable water for drinking purpose and it depends upon the selected targets, i.e, WHO (2006)and Ethiopian (2011) standards.

2.3 Water quality assessment

2.3.1Sampling point selection

Purposive sampling method was employed. Based on the report of Boditi Town Health Center, the incidence of water related diseases and public complaint, five sample points from pipe line points, and two boreholes were selected for bacteriological and physicochemical water quality test. Samples from three springs were analyzed for water quality as option water source. The sample sites were shown in Figure 2.2

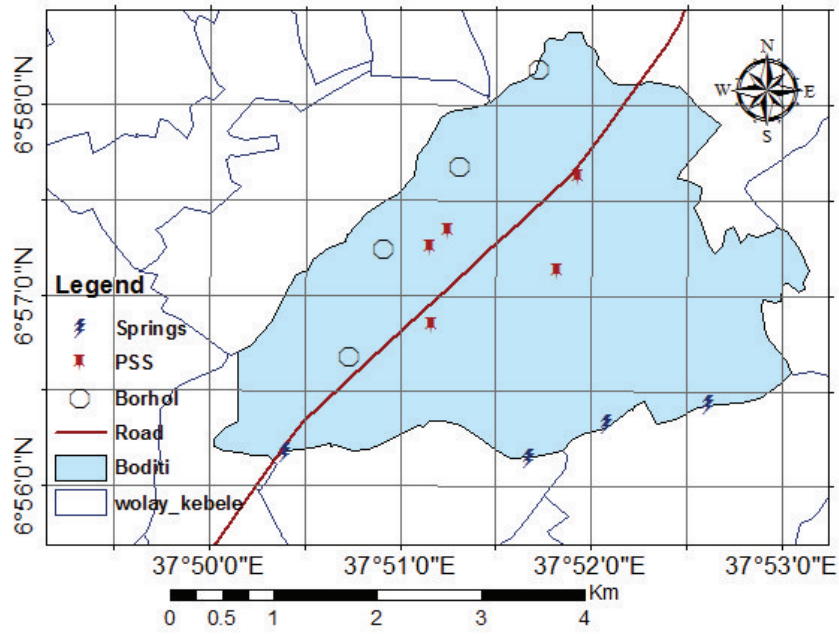

Figure 2.2 Sample site and water point map, PSS- pipeline sample site

Standard method of water sampling and preservation techniques were used (APHA, 1998). Bottles were washed with concentric nitric acid and distilled water before taking the samples. Triplicate samples in a 1000ml polyethylene bottle were collected from each sample site. The bottles were labeled, samples taken and put ice-box during transportation to Wolaita Zone Water, Mine and Energy Department for quality analysis. A total of 36 water samples were taken from selected sample sites and tested for selected physicochemical and biological parameters on July, August, and September, 2013. Known volumes of drinking water and number of samples were collected, stored in appropriate container, protected to preserve the original quality and transported to the testing laboratory in the soonest time possible.

Table 2.1 Selected physicochemical and bacteriological parameters and water quality standards.

Ser.No	Physicochemical parameter	WHO(2006) standard	Ethiopia standard (2011)	Bacteriological parameter	WHO (2006)	Ethiopian (2011)
1	P^H	6.5-8.5	6.5-8.5	Thermotolerant	0/100 ml	0/100 ml
2	Temperature	Less than 15^{o}C	--	Coliform		
3	Turbidity	5 NTU	5 NTU	(E.Coli)		
4	Conductivity	1000 µs/cm	1000 µs/cm			
5	TDS	1000 mg/l	1000 mg/l			
6	Iron	0.3 mg/l	0.3 mg/l			
7	Manganese	0.4 mg/l	0.5 mg/l			
8	Nitrate	50 mg/l	50 mg/l			
9	Sulfate	250 mg/l	250 mg/l			
10	Residual Chlorine	0.2-l mg/l	0.5 mg/l			

Source: WHO 2006 and WHO, 1996.

2.3.2 Bacteriological analysis

Fecal coliforms (thermotolerant) and total coliforms are detectable by practical techniques such as membrane filtration using agar solution. In this method fecal coliforms require incubation at 44.5^{0}C for 24 hours and for total colifoms incubation at 35^{0}C for 20-24 hours (Burgess and Pletschke, 2008). Fecal Coliforms, E.Coli were enumerated by a membrane filtration technique and the counts represent the total number of bacteria (as colony forming units, CFU) per 100 ml of water (Hyland *et al*., 2003; Jesuis and Terry, 1987).

Materials used Petri dishes, WAGTECH membrane filtration apparatus, filter paper with pore size of

0.45 µm and 47 mm diameter. In membrane filtration method, a 100 ml water samples was filtered. After filtration, the bacteria remained on the filter paper was placed in Petri dishes with nutrient solution (culture media, agar). A Petri-dish was placed in an incubator at 44-45^{o}C for 24 hours. The Petri-dish was incubated so that the bacteria would replicate as a concentric circles called colonies. After incubation typically blue colored E.Coli on the surface of membrane filter was counted by using a low power binocular microscope. The numbers of colonies formed on the media were reported as colony forming units (CFU) per unit of volume of the water sample, i.e, CFU/100 ml.

2.3.3 Physicochemical analysis

Electrical conductivity of water samples at pipe line locations and three samples at springs locations were measured in situ by using digital portable conductivity WAGTECH (WGPH 1102).Turbidity of water samples were measured by Micro-processor Turbidity Meter (HANNA HI 93703). The pH of water samples were measured by using a Digital P^{H} Meter (WAGTECH 661729). Temperature of water samples at pipe line locations and three samples at springs locations were measured in situ by using Portable Digital Sensor by adjusting WAGTECH 661729.

Chemical water quality was determined by Spectrophotometer method. Spectrophotometer, DR 2800 was used to detect the levels of iron, manganese, sulfate, nitrate and fluoride. Colorimeter (HACH) was used to detect the level of total chlorine. For detection of iron, manganese, fluoride, nitrate, sulfate and total chlorine reagents used were Ferrover Iron, sodium Bismuthate, spandns, nitraver 5, sulfver 4, and chlorine DPD respectively.

2.4 Statistical data analysis

Data were collected, recorded, analyzed, organized and summarized. Water samples were collected from sample sites and they were tested for physical, chemical and biological water quality, and analyzed by using SPSS 16.0, Statistical Packaging for Social Science. The inferential statistics like ANOVA and LSD was employed for water quality analysis to see the statistical significances and association of the temporal and spatial variations of samples. Results of water quality analysis were compared against the standards set by WHO and Ethiopian drinking water quality standards (WHO, 2006; Ethiopian Standard, 2011). The results were presented in both quantitative and qualitative terms.

3. Results

3.1 Water Quality

Based on the selected parameters, the bacteriological and physicochemical water quality analysis results were shown in Table 3.1.

Table 3.1 Physicochemical and bacteriological water quality characteristics of Boditi Town

Water quality parameters	Water samples										Drinking water quality standards	
	Pipeline					Boreholes		Sprigs			WHO (2006)	Ethiopian (2011)
	SS_1	SS_2	SS_3	SS_4	SS_5	Fate BH	Chayna BH	Woysha	Bolo	Seesona		
PH	7.8	7.6	6.7	7.5	7.5			6.0	7.0	6.8	6.5-8.5	6.5-8.5
Temp (^{o}C)	21.3	23.2	22.5	22.2	20.2			22.0	23	22.5	<15^{o}C	
Turbidity (NTU)	0.77	0.08	6.3	0.3	0			28	81	6.3	5	5
Conductivity(µs/cm)	419	553	556	574	554			450	547	588	1000	-
TDS (mg/l)	214	272	268	284	273			225	225	282	1000	1000
Fecal coliform(E.Coli)/100m	2	2	14	3	0			14	23	14	0/100	0/100
Fe^{2+} (mg/l)			0.15	0.12		0.12	0.03		0.19	0.18	0.3	0.3
Mn^{2+} (mg/l)			0.02	0.02		0.02	0.02		0.03	0.02	0.4	0.5
NO_3^-(mg/l)			0.31	0.31		0.52	0.31		4.6	2.41	50	50
F^- (mg/l)			0.52	0.13		0.52	0.46		1.02	0.33	1.5	1.5
SO_4^{2-}(mg/l)			10.0	9.0		9.0	9.0		39.0	12.0	250	250
Residual chlorine (mg/l)			-0.24	-0.25		-0.24	-0.26		-0.62	-0.21	0.2 - 1	0.5

Note: SS_1, SS_2, SS_3, SS_4 and SS_5 refer water samples from pipe line point one, two, three, four and five respectively, BH-borehole.

3.2 One way and multiple comparison of samples.

One Way Analysis of Variance (ANOVA) test showed that significance differences ($P<0.05$) for samples taken from springs and pipelines. Turbidity of samples from springs has significant differences between and within groups and at significant level of ($p < 0.05$). Conductivity of samples from pipe lines have significance differences within and between groups at significance level of ($p < 0.05$) [$Referappendix$ 1].

To indicate the significance differences between data of samples LSD method was used([$Referappendix$ 2]. Conductivity of Woysha spring with Bolo spring has significance difference, from Seesona spring ($p < 0.05$). This may be due to the highest amount of dissolved solids in Seesona spring and the inner geology variation. Total dissolved solids of Woysha spring with Bolo spring has significance difference from Seesona ($p < 0.05$).

Turbidity of Woysha spring with Seesona has significance different from Bolo spring ($p < 0.05$). Turbidity of Seesona spring has significance difference from Bolo ($p < 0.05$). This may be due to the high infiltration of particulate matter at Bolo and woysha springs, the areas were highly cultivated compared with the others and the area to Seesona spring has conservation practices.

E.Coli of Woysha spring has significance difference from Bolo ($p < 0.05$). This may be related with turbidity, contamination of springs with fecal matter. The temperature and P^H of the three springs were not significantly different. The significance differences of other parameters and sample were shown[$Referappendix$ 2].

4. Conclusion

The Town's water samples from springs, pipelines and boreholes were analyzed for bacteriological and physicochemical water quality. The bacteriological analysis showed that pipeline points: one, two, three, four and springs: Woysha, Bolo, Seesona respectively have 2, 2, 14, 3, 14, 23, 14 colonies per 100ml water of E. Coli. The physical analysis, turbidity showed that pipeline point three, and springs: Woysha, Bolo, Seesona (NTU) respectively have 6.3, 28, 81, 6.3. The chemical quality analysis result showed that the residual chlorine in all samples was below WHO and Ethiopian standards. The chemical quality tests for iron, manganese, fluoride, nitrate and sulfate were found to have good chemical quality.

Turbidity of samples from one pipe line and three springs have greater than WHO and Ethiopia standards, 5 NTU. Coliform (E.Coli) of samples from four pipe lines points and three springs were greater than WHO and Ethiopian standards, i.e, 0/100 ml water. Residual chlorine for all samples were below WHO and Ethiopia standards, 0.2-1 ml/gm. Water quality analysis indicates that pathogens, E.Coli are present in the distribution system and springs. Since their existence beyond the selected WHO and Ethiopian standards could cause health problems.

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Appendix 1- One way ANOVA analysis of samples from springs, pipelines and boreholes. A/ Samles from springs

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Condu	Between Groups	29940.667	2	14970.333	4.797	.057
	Within Groups	18725.333	6	3120.889		
	Total	48666.000	8			
TDS	Between Groups	5643.556	2	2821.778	4.172	.073
	Within Groups	4058.000	6	676.333		
	Total	9701.556	8			
Tem	Between Groups	3.582	2	1.791	.183	.837
	Within Groups	58.653	6	9.775		
	Total	62.235	8			
Turbd	Between Groups	8997.238	2	4498.619	24.089	.001
	Within Groups	1120.502	6	186.750		
	Total	10117.741	8			
PH	Between Groups	.269	2	.135	.584	.586
	Within Groups	1.383	6	.231		
	Total	1.652	8			
E.Coli	Between Groups	536.167	2	268.083	4.251	.083
	Within Groups	315.333	5	63.067		
	Total	851.500	7			

B/ Samples from pipe lines

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Condu	Between Groups	47912.000	4	11978.000	4.070	.033
	Within Groups	29433.333	10	2943.333		
	Total	77345.333	14			
TDS	Between Groups	9082.267	4	2270.567	2.877	.080
	Within Groups	7891.333	10	789.133		
	Total	16973.600	14			
Tem	Between Groups	140.777	4	35.194	1.154	.387
	Within Groups	304.987	10	30.499		
	Total	445.764	14			
Turbd	Between Groups	89.708	4	22.427	9.444	.002
	Within Groups	23.748	10	2.375		
	Total	113.456	14			
PH	Between Groups	129304.881	4	32326.220	.991	.455
	Within Groups	326059.942	10	32605.994		
	Total	455364.823	14			
E.Coli	Between Groups	429.333	4	107.333	11.181	.001
	Within Groups	96.000	10	9.600		
	Total	525.333	14			

Appendix 2.Comparision results of Woysha, Bolo and Seesona springs

Multiple Comparisons

LSD

Dependent Variable	(I) repl	(J) repl	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
cond	1	2	-96.33333	45.61351	.079	-207.9456	15.2789
		3	-137.66667*	45.61351	.023	-249.2789	-26.0544
	2	1	96.33333	45.61351	.079	-15.2789	207.9456
		3	-41.33333	45.61351	.400	-152.9456	70.2789
	3	1	137.66667*	45.61351	.023	26.0544	249.2789
		2	41.33333	45.61351	.400	-70.2789	152.9456
TDS	1	2	-48.66667	21.23414	.062	-100.6247	3.2914
		3	-56.66667*	21.23414	.037	-108.6247	-4.7086
	2	1	48.66667	21.23414	.062	-3.2914	100.6247
		3	-8.00000	21.23414	.719	-59.9581	43.9581
	3	1	56.66667*	21.23414	.037	4.7086	108.6247
		2	8.00000	21.23414	.719	-43.9581	59.9581
temp	1	2	-1.49000	2.55283	.581	-7.7366	4.7566
		3	-.39000	2.55283	.884	-6.6366	5.8566
	2	1	1.49000	2.55283	.581	-4.7566	7.7366
		3	1.10000	2.55283	.682	-5.1466	7.3466
	3	1	.39000	2.55283	.884	-5.8566	6.6366
		2	-1.10000	2.55283	.682	-7.3466	5.1466
turb	1	2	-52.68667*	11.14270	.003	-79.9519	-25.4215
		3	22.68333	11.14270	.088	-4.5819	49.9485
	2	1	52.68667*	11.14270	.003	25.4215	79.9519
		3	75.37000*	11.14270	.001	48.1048	102.6352
	3	1	-22.68333	11.14270	.088	-49.9485	4.5819
		2	-75.37000*	11.14270	.001	-102.6352	-48.1048
PH	1	2	-.22667	.39329	.585	-1.1890	.7357
		3	.19000	.39329	.646	-.7723	1.1523
	2	1	.22667	.39329	.585	-.7357	1.1890
		3	.41667	.39329	.330	-.5457	1.3790
	3	1	-.19000	.39329	.646	-1.1523	.7723
		2	-.41667	.39329	.330	-1.3790	.5457
Ecoli	1	2	-18.66667*	6.40602	.027	-34.3416	-2.9917
		3	-9.33333	6.40602	.195	-25.0083	6.3416
	2	1	18.66667*	6.40602	.027	2.9917	34.3416
		3	9.33333	6.40602	.195	-6.3416	25.0083
	3	1	9.33333	6.40602	.195	-6.3416	25.0083
		2	-9.33333	6.40602	.195	-25.0083	6.3416

*. The mean difference is significant at the 0.05 level.

Note:1=Woysha sp, 2= Bolo sp and 3= seesona sp.