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Water Quality Assessment of Water Supply System: Study of Enchini town, Ethiopia

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Abstract

The aim of this study was to examine the physicochemical and microbiological status of water quality from households tap, water source and reservoir in Enchini town. To achieve this objective water samples were collected from seven households tap, two sources (one spring and one borehole), and a reservoir. All samples were analyzed for Physico chemical and bacteriological water quality parameters by using standard procedures. The results show that pH, turbidity, total dissolved solid, electrical conductivity, residual chlorine, chloride of the water were ranges from 6.94-7.35,0.08-0.97 NTU,149 ppm to 343 ppm,297 µS/cm to 345 µS/cm, nill and 1.75 mg/l to 4.69 mg/l respectively. Phosphate, magnesium, calcium, nitrate, sulfate and fluoride of the water sample were also ranges between 0.18 mg/l to 0.635 mg/l, 24 mg/l to 84 mg/l, l10 mg/l to 319 mg/l ,1.4 mg/l to 3 mg/l, nill and nill-0.37 mg/l respectively. Results show that the concentration of calcium ranges from 110 mg/l to 319 mg/l in Enchini town, calcium quantity in spring (319 mg/l) was exceeding the limit set by WHO and may be harmful for local residents. All samples were positive for total coliform with counts ranging from 2-17 CFU/100 ml whereas fecal coliform were detected nill for all samples. In general the majority of the examined parameters were within the permissible limit set by WHO and Ethiopian drinking standards except calcium and total coliform.

Keywords: Microbiological • Physicochemical • Sanitation • Water quality

Introduction

Access to clean and safe drinking water is a fundamental human requirement. However, in many areas of the world natural water sources have been impacted by a variety of biological and chemical contaminants. The ingestion of these contaminants may cause acute or chronic health problems. To prevent such illnesses, many technologies have been developed to treat, disinfect and supply safe drinking water quality [1,2].

Waterborne diseases are caused by the ingestion of water contaminated with human or animal faeces or urine containing pathogenic bacteria or viruses including cholera, typhoid, bacillary dysentery, adenoviruses, retroviruses, and other diseases. Poor water quality is considered as one of the manifestations of poverty in developing countries. According, improvements in drinking water supply, quality and sanitation and reducing waterborne diseases have been major components of the sustainable development goal programmes in goal 6 formulated by UN [3].

Ethiopia is confronted with poor sanitation and drinking water infrastructure. About 52.1% of the population has been using unimproved sanitation facilities while 36% of them practiced open defecation. It is estimated that more than 60% of the communicable disease are due to poor environmental health condition arising from unsafe and inadequate water supply with poor hygiene and sanitation practices. Likewise, most health problems of the children in the country are communicable disease due to polluted water and improper sanitation.

Materials and Methods

Study area

Enchini town is situated in West Shoa Zone of Oromia National Regional State and capital town of Ada'a Berga Wereda. The town is reached *via* the main high way of Addis Ababa -Mugar. Geographically, the study area extends from 9015'0" N to 9039'0" N and 38020'30" E to 38034'30" E. According to the CSA estimated report in 2018 the total population of the town is about 11,443 (Figure 1).

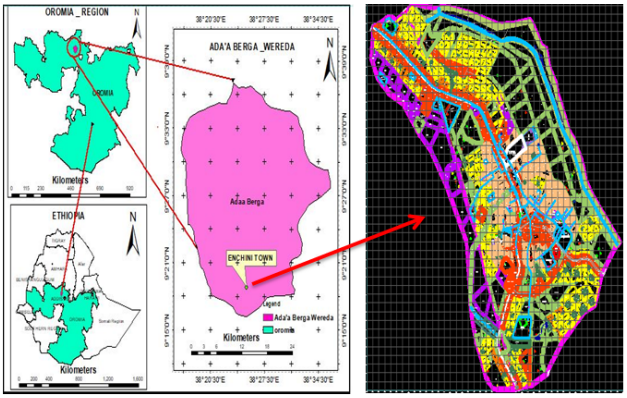

Figure 1. Location map of Enchini town.

Note: ( ) Asa'a Berga Wereda; ( ) Oromia

Water samples collection for physico-chemical and bacteriological parameters

Water samples for physicochemical analysis is collected according to the procedure in. Water samples for the determination of pH, electrical conductivity, turbidity, free chlorine residual, nitrate and phosphate were collected after the tap was cleaned with cotton pad and run for two minutes in a clean 250 mL thoroughly rinsed conical.

The samples for Bacteriological test is collected and transported to the laboratory in ice box containing ice freezer packs and analysis conducted in less than 8 hrs time interval of sample collection. Samples was collected

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with 250 mL glass bottles which would be sterilized in an autoclave for 15 minutes at 130°C with and without 0.2 mL of 10% sodium thiosulphate solution for chlorinated and non-chlorinated samples, respectively. Each sample was collected after the taps was wiped with cotton pad, open to run the water for two minutes, sterilized the tap for a minute with the flame from ignited alcohol soaked cotton and allowed the water to flow for 2 minutes. The collected samples were transported to the laboratory in an ice box.

A total of 10 sampling points were randomly selected and water sample were collected from the water taps, source and reservoirs. The samples were designated as Tap-1, Tap-2, Tap-3, Tap-4, Tap-5, Tap-6, and Tap-7 for household's taps and Borehole, spring and Reservoir for water source and storage respectively (Figure 2).

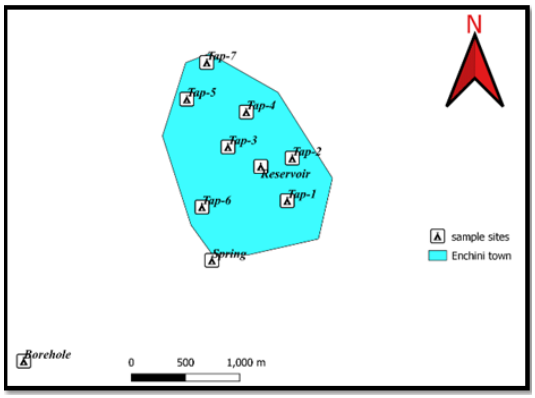

Figure 2. Points where samples were taken. Note: (▲) Samole sites; (▬) Enchini town

Analysis of physicochemical and bacteriological parameters of water quality

The physicochemical parameters are analyzed by standard procedures. pH and EC was analyzed using portable digital pH meter and EC meter Hanna instrument (HI-98129) respectively, at sites of sample collection. The pH meter was calibrated just before analysis using pH 4.0 and pH 7.0 and it was rinsed with distilled water from one sample to the other following the pH meter Hanna instrument operation manual (HACH, 1997).

Total Dissolved Solids (TDS) and electrical conductivity was analyzed using portable digital conductivity meter (Hanna instrument). With regard to turbidity, it was analyzed using portable microprocessor turbidity meter (HACH 2100 AN). Free residual chlorine test was made for all chlorinated samples. The test was performed using color wheel test kits (comparator).

Nitrate and phosphate was measured using HACH DR 5000 spectrophotometer following HACH instructions (HACH, 1997).The remaining water-quality parameters including, manganese, Calcium, and phosphate, fluoride were determined following standard methods using HACH DR 5000 spectrophotometer following HACH instructions (HACH, 1997).

Total and faecal coliform counts were carried out by membrane filtration technique. A sterilized pad dispenser was used to introduce the growth absorbent pads into the base of Petri dishes, and the growth pads were saturated with the Lauryl Sulphate Broth. 100 ml water sample was filtered using a membrane filter (0.45 µm) in a vacuum filtration apparatus, and all the filters were transferred to the absorbent pad which was saturated with the broth. The Petri dishes were incubated at 37°C for 4 hr for resuscitation to recover physiologically stressed coliforms before incubation. Then after, plates for total coliform and thermotolerant coliform counts were incubated at 37°C and 44°C, respectively, for 24 hrs. And then colonies were counted and recorded.

Results and Discussion

Physicochemical parameters of water quality

In Enchini town pH ranges from 6.94-7.35; for all sample. The lowest value is 6.94 at reservoir and the highest value is at Tap-4 and Tap-5. The pH values of water obtained in this study are lower than the results of previous studies, i.e., the average basic pH records of various cities water sources, pH 7.03 at Nekemte town [2] pH 8.3 at Ziway [4,5]; and pH of 7.8 at Adama [6-9]. The variation could be due to geological conditions of the water sources. Hence, in study areas the pH values were not exceeded the standard limit of both WHO guide line and Ethiopian standard.

Table 1 clears that the TDS of the study area were ranges from 149 ppm to 343 ppm. The lowest value is 149 at Tap -5 and the highest value is at Tap-6. Hence, these ranges were acceptable and concentration of TDS is not harmful. Therefore the values were not exceeded the standard limit of both WHO guide line and Ethiopian standard.

Table 1. Results of Physico-chemical Parameters, permissible limit set by WHO and Ethiopian standard.

Location	Permissible limit set by WHO and Ethiopian standard													
	Sample	PH	TDS	EC	Turbidity	Total harness	Ca-hardness	Mg-hardness	Phosphate	Chloride	Residual chlorine	Sulfate	Nitrate	Fluoride
	WHO standard	6.5-8.5	500	400	1.5	500	300	150	5	250	0.2	250	10	1.5
	Ethiopian standard	6.5-8.5	1000	1200	5	500	300	150	5	250	0.5	250	10	3
Tap-1		7.11	138	297	0.17	153	120.6	32.4	0.18	2.25	nill	nill	1.4	0.13
Tap-2		7.08	152	322	0.26	145	121	24	0.4	2.15	nill	nill	1.6	0.22
Tap-3		7.24	150	314	0.16	186	125	61	0.48	1.75	nill	nill	1.9	0.22
Tap-4		7.35	151	317	0.23	162	129	33	0.35	2.55	nill	nill	1.8	0.45
Tap-5		7.35	149	311	0.08	153	127	26	0.4	2.25	nill	nill	1.9	nill
Tap-6		7.2	343	345	0.97	340	256	84	0.63	3	nill	nill	2.3	0.27
Tap-7		7.12	154	325	0.14	144	110	34	0.47	2.15	nill	nill	2.1	0.37
BH		7.13	153	321	0.16	149	111	38	0.39	2.25	nill	nill	2	0.26
Spring		7.2	351	345	0.18	355	319	36	0.33	4.69	nill	nill	3	0.2
Reservoir		6.9	155	326	0.1	160	120	40	0.21	2	nill	nill	2.9	0.21

Note: *All parameters are expressed in mg/l except EC in µS/cm, Turbidity in NTU and PH.

In study areas, EC value in all samples was 297 µS/cm to 345 µS/cm. These results clearly indicate that water in study areas was considerably ionized and has the higher level of ionic concentration activity due to excessive dissolve solids. Thus, it is a fine conductor of electric current. The EC records of water source from other cities of the country are much higher than the current study [10]. These variations might originate from geological factors, agricultural activity, and the soil types of the study area.

Results show that the Turbidity value in all samples was 0.08-0.97 NTU. The lowest and highest turbidity measurements were recorded from water Taps samples of Tap-5 and Tap-6. Hence, in study areas the Turbidity values were not exceeded the standard limit of both WHO guide line and Ethiopian standard.

According to World Health Organization (WHO) hardness of water should be 500 mg/l. In study areas, hardness ranges from 144 mg/l to 355 mg/l in Enchini town. These results clear, that hardness of water is according to the WHO standards and it is not harmful for local inhabitant.

According to WHO [10] standards its permissible range in drinking water is 300 mg/l for calcium. In study areas, results show that the concentration of calcium ranges from 110 mg/l to 319 mg/l in Enchini town, Calcium quantity in Spring-1(319 mg/l) was exceeded the limit by WHO and may harmful for local residents.

In study areas magnesium was ranges from 24 mg/l to 84 mg/l. Therefore the values were not exceeded the standard limit of both WHO guide line and Ethiopian standard.

Phosphorous concentration in raw waters has been reported to be 100% of the samples tested, with mean concentration of below standard limit and maximum of 5 mg/l. The laboratory results of phosphate of the study area were shows 0.18-0.63.

According to WHO standards concentration of chloride should not exceed 250 mg/l. In study areas the chloride value ranges from 1.75 mg/l to 4.69 mg/l. Consequently, all the samples have lower concentration of chloride maximum permissible limit value set by WHO guidance level.

The World Health Organization guidance level for drinking water supply recommends a minimum free Chlorine residual of 0.2 mg/l and maximum residual chlorine 0.5 mg/l in the distribution systems of any water supply. In study areas, there was no residual chlorine content detected from all water samples which is below the maximum permissible limit value set by WHO guidance limit.

In study areas, there was no sulfate content detected from all water samples. Based to that, the researchers conclude that all samples of the town it is within the standards.

The WHO allows maximum permissible limit of nitrate in drinking water is 10 mg/l. In study areas, results clear that the concentration of nitrate ranges from 1.4 mg/l to 3 mg/l. based to these standards the researcher obtained that there is no any the nitrate problem in the study area and it was within the standard limit.

In the study area, the fluoride concentration were ranging between nill-0.37 mg/l, which is below the maximum permissible limit value set by WHO guidance level. As a result, clearly observed values from the study area there is no health effect of fluoride on the community that use the water (Table 1).

Bacteriological parameters of water quality

Total coli forms were used as indicator bacteria to assay the level of bacteriological contamination of the water supplies. A total of 10 water samples were analyzed for Total coli forms and the result indicates water taps and other shows low risk counted below 50 in number. Generally result indicates that chlorine is needed in the distribution systems to be applied to assure a better quality of drinking water.

The highest TC count was recorded from tap water at sampling site of the spring with 17 CFU/100 ml, followed by 9 CFU/100 ml at sampling site of BH (Table 2).The lowest TC count was found at sampling sites from tap4 and Reservoir with 2 CFU/100 ml.

All household samples were tested in for all sample selected from the total study area shows no existence of (fecal) coli form. In drinking water presence of fecal coli form should not be ignored as the basic assumption that pathogens would not be presented in drinking water. In this study the average count of fecal coli forms were below the recommended value of WHO and Ethiopian Standards set limit. Generally, from bacteriological water quality tests all sample tap water samples meet the standard set by WHO and Ethiopian Standards.

Table 2. Laboratory test results for Total Coliform and *Escherichia coli.*

S.no	Location	Result test of Total Coliform	Result test of *E. coli.*	WHO standard	Ethiopian standard
1	Tap-1	3	nill	0/100 ml	0/100 ml
2	Tap-2	4	nill	0/100 ml	0/100 ml
3	Tap-3	7	nill	0/100 ml	0/100 ml
4	Tap-4	2	nill	0/100 ml	0/100 ml
5	Tap-5	6	nill	0/100 ml	0/100 ml
6	Tap-6	7	nill	0/100 ml	0/100 ml
7	Tap-7	3	nill	0/100 ml	0/100 ml
8	BH	9	nill	0/100 ml	0/100 ml
9	Spring	17	nill	0/100 ml	0/100 ml
10	Reservoir	2	nill	0/100 ml	0/100 ml

Conclusion

The main Physico-chemical parameters considered for investigation include turbidity, pH, electrical conductivity, total dissolved solids, total hardness, calcium, potassium, magnesium, chloride, fluoride, nitrate, phosphate, Sulfate and residual chlorine.

Bacteriological tests such as faecal coliforms and total coliforms were analyzed in relation to the health prevalence of water-associated diseases. The laboratory results have shown that except for Calcium quantity the Physico-chemical parameters, the remaining all parameters were found within the permissible limit of WHO guidelines and Ethiopian recommended values concerning the safety and acceptability level for the end users. Generally, concerning the Physico-chemical parameters, the water seems to be safe and there is no significant effect on the health of the users. However, further researches that involve a wide-scale and an intensive data collection and sophisticated laboratory analyses are necessary to arrive at precise and ultimate conclusions.

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Declaration

The authors declare that they have no conflicts of interest.

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