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Comparative Study of Physico-Chemical and Microbiological Water Quality of Sebeta and Sululta Towns, Oromia Regional State, Ethiopia

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Abstract: The aim of study was to compare Physico-chemical and microbiological water quality of Sebeta and Sululta towns. Systematic grap sampling techniques were applied in this study. Physico chemical parameters were analyzed in the samples using pH meter for pH, conductivity meter for EC and TDS, total alkalinity, total hardness, acidity and chloride by volumetric method, fecal coli form and total coli form by biological test kit. Descriptive statistics was used to determine the value of water quality parameters along all the sites. Among the water sample site, highest value of EC was 521 µS/cm at kombolcha public bono sites, the highest turbidity value was 17 NTU at Sebeta Wasarbi house hold sites. The highest pH value was 9.5 at Sululta gora arba borehole, the highest total alkalinity value was 379 mg as $CaCO_3$/L at Sebeta Iyesus gedam borehole sites. The highest acidity value was 49 mg/L at Sululta Red Cross house hold site. The highest chloride value was 55 mg/L at Sululta kombolcha reservoir and tannery borehole sites. The TDS value was 568 mg/L at Sululta tannery borehole site. The highest total hardness value was 160 mg as $CaCO_3$/L at Sebeta alemgena awuragodana borehole site. Sebeta spring, Mokshe Safa Samira, Furi shina bore hole, Alemgena condominium Block 25 tap water, Silase poiner reservoir, Mokshe Abubaker, Iyesus Gedam bore hole, Alfirikan bore hole, Spring water, Masfin Bore hole, Fish spring water, Irrecha borehole, Gabriel bore hole, Abebe bore hole, and sululta: elemtu spring, kimbira spring, red cross borehole, prima milk house hold 2, Red cross Bore hole water were contaminated by both faecal coli form and total coli form. Water supplied for the communities shall be treated and disinfected before distributing. The reservoir also cleaned before storing and disinfecting the cumulative water. Periodically monitoring water at sources, reservoirs by means of conducting water quality test is very important.

Key words: Physico-chemical · Microbiological · Water Quality · Disinfection

INTRODUCTION

Drinking water quality is one of the major significances affecting human health, lifestyle and economic well-being. Water is life, only when it's safe and wholesome and therefore a vital element for the maintenance of life as well as safe and healthy environment. Drinking water quality is solemnly dependent on the quality of source water, the treatment in water treatment plants before distributed, the water distribution system and the containers/tanks used for water storage and the household filters. Groundwater is a primary water resource for drinking, irrigation and industrial uses in many countries. However, the quality is determined by various water quality parameters. The increase in human population has increased the demand for potable drinking water. Vendors are well patronized for this commodity within tertiary institutions as a means to satisfying their need for safe drinking water owing to its low unit cost price compared to bottled water. The major health challenges confronting most developing nations could be traced to the lack of adequate potable water [1].

The two general classifications of water sources are surface and groundwater. Surface water is the water that is available on the surface of earth, such as rivers, lakes and ponds while underground water is found beneath the earth's surface. Surface and underground water are polluted when exposed to natural factors like a volcanic eruption, growth of algae and microorganisms, soil erosion and anthropogenic factors like sewage, domestic waste, industrial and agricultural effluent which contain simple nutrients to highly toxic substances. Accessibility to potable drinking water is the most fundamental key factor in sustainable development. Water is essential for

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food production, quality health and poverty reduction. Portable drinking water, free from disease causing microorganisms or toxic chemicals, is important to life and a satisfactory safe supply must be made available for human consumptions [2].

The provision of good quality household drinking water is often regarded as an important means of improving health [3]. Drinking water quality is a global issue, with contaminated unimproved water sources and inadequate sanitation practices causing human diseases [4]. Approximately 2 billion people consume water that has been contaminated with feces [5]. As stated by Eberhard [6], 42% of the people living in Sub-Saharan Africa drank from unimproved water sources and 72% were without basic sanitation.

Water quality concerns are frequently the most important component of drinking water as evaluated by physical, chemical and bacteriological factors, as well as consumer satisfaction [7]. Drinking water quality should meet physico-chemical pollutants criteria and be entirely free of pathogens that could harm people's health.

Despite the efforts, drinking water pollution continues to pose health threats to communities in low-income nations. Drinking water can be polluted at any point along the way from the sources to the point of consumption. Several human pathogens can be transmitted via polluted drinking water [8].

Waterborne diseases are very common in poor communities, where drinking water can easily be polluted due to mainly to lack of awareness about appropriate sanitary practices and low water supply. For instance, Wright *et al*. [9], pointed out that drinking water pollution in developing nations is mainly caused by poor handling practices and lack of knowledge about keeping drinking water safe.

Developing countries are on the alarming list due to insufficient availability of pure potable water and lack of good quality of health care [10]. Access to safe drinking water is critical to human health and development [11]. Three main drinking water chains are known to play a significant role in the safety of drinking water such as the quality raw water at the source, the purification process of water and the distribution system of water [12].

More than 75% of the health problems in Ethiopia are due to communicable disease attributed to unsafe and inadequate water supply and unhygienic waste management, particularly human excreta [13]. So, 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 standards of living, poor environmental conditions and low level of social services [13].

In addition to causing health problems, when waste products are introduced into water bodies it creates change in physical, chemical and biological water quality parameters. The contamination of water quality which determined by Physico-chemical and bacteriological methods affecting communities in low incoming countries particularly Ethiopia. Accordingly, several studies carried out in Ethiopia about drinking water quality. As Alemayehu Daba *et al*. [14], state that Physico-chemical and microbiological Assessment of Drinking Water Quality; according to Mekuanint Lewoyehu [15], the study based on the Evaluation of Drinking Water Quality; Meserate B Addisie also conducted research on Evaluating Drinking Water Quality Using Water Quality Parameters and Esthetics Attributes [16].

Ground water is a major source of drinking water supplied in Sebeta and sululta towns. It has been believed that ground water is pure and safer than surface water. The source of chemicals are both naturally and/or anthropogenic. Ground water quality can be contaminated and become unsafe for drinking and domestic uses as a result of lack of proper services in societies, which can lead to the contamination of ground water with different bacteria including pathogens, especially in the high-density residential areas where sewage disposal practices are not proper. Contamination of ground water due to human activities can lead to adverse effects on the health of mankind and ecosystems. Urbanization, climate changes and increase of the world's populations are the main factors for the limiting of fresh water resources as a result of increasing of water demand and pollution of fresh water ecosystems [17].

Nevertheless, in developing countries, especially Ethiopia, there is no study about Prevalence of Microbiological and Physico-chemical contaminants in Public Drinking Water in Sebeta and sululta towns. Therefore, this study aims to determine the Prevalence of Physico-Chemical and Microbiological contaminants in Public Drinking Water in Sebeta and sululta town of Ethiopia.

MATERIALS AND METHODS

Description of the Research Area: Sebeta town is one of the Oromia Special Zone Surrounding Addis Ababa and 19 km distance from Addis Ababa- Ethiopia. The latitude for Sebeta is 8°54'40.45"N and the longitude is 38°37'36.35"E and Sululta is part of the Oromia Special

Zone Surrounding Addis Ababa. Sululta town is found in the north shoa zone, 28.4 km distance from capital city Addis Ababa - Ethiopia. The latitude for Sululta is 9°11'7"N and the longitude is 38°45'37.36"E (From Wikipedia, free encyclopedia, accessed on 7/22/2022).

Research Design and Sample Location: This study was carried out and designed during May and June months, 2022 to determine physicochemical and microbiological parameters. The process was undertaken through observation and water sample test.

The source of water supplied for Sebeta and Sululta towns were both spring and groundwater. Water samples were took places from all water sources of water supply to both Sebeta and sululta towns. Generally, 37 sampling sites from the two towns were selected for analyzing the Physico-chemical and microbiological parameters of drinking water. The selected sampling points were: Source point, reservoir point, Tap water and house hold. Water samples were collected from each sampling points by using 1 liter polyethylene bottles for physicochemical and 0.5liter amber glass bottles for microbiological analysis. Before collection of water samples, polyethylene bottles were washed with concentrated nitric acid (chromic acid for nitrate analysis) and distilled water to avoid contamination. Glass bottles were washed by detergents followed by sterilization for microbiological parameter detection.

There are 19 sampling sites at Sebeta town and 18 sampling sites at Sululta town were collected and transported to the laboratory for further water characterization. Samplings were carried out in May and June months, 2022.

The in-situ parameters were determined for pH, EC, temperature, turbidity and laboratory conducted for the determination of TDS by potentiometer and acidity, total hardness, total alkalinity (as mg $CaCO_3$/L) and chlorides concentration using volumetric method.

pH meter was calibrated by buffer standards at pH 4, 7 and 9.2. Total Alkalinity was measured by the titration method using methyl orange indicator and titrating with standardized sulfuric acid. Chloride was measured by titration using Potassium chromate indicator and with standardized silver nitrate solution. Turbidity was measured by digital Turbidimetric HI88703 instrument. Total dissolved solids (TDS) were measured by Digital Conductometer (JENWAY). Total hardness was measured by titration using Eriochrome Black T as an indicator and with standardized sodium EDTA solution.

Source of Data: Primary data were collected from field observation and analysis of water quality parameter. Secondary data were collected from relevant books, journals, articles and research papers. Global Positioning Systems (GPS) were used for locating the sample sites. The nature of data is both quantitative and qualitative.

Sample and Data Collection Method:

Physico-Chemical Parameters: Representative water samples were collected by systematic random sampling technique and the representative samples collected into one liter polyethylene bottle. Water was collected from different sites and transported to laboratory for water quality analysis.

The sample holding bottles were labeled with appropriate information. The containers of the sample were rinsed 3 times with the sample to be examined. Sample containing bottles were placed in an ice box for transportation to the laboratory. About 1Liter of sample was collected and labels the sample for the selected parameters analysis. The representative samples were immediately arrived the laboratory for analysis before it would deteriorate.

Physico-Chemical Parameters Determination at In-situ: pH was measured by using pen type pH meter, EC were measured by using HANNA conductivity meter, Turbidity was measured by turbidity meter and water temperature were measured by mercury thermometer [19].

Physico-Chemical Parameters Determination in Laboratory: Acidity, chlorides, total alkalinity and total hardness of water were determined by volumetric method, TDS were determined by JENWAY 4520 conductivity meter.

The apparatus/equipment used for this study were Volumetric flasks, pipettes (1, 2, 5 and 10 mL), pipette filler, burette, measuring cylinder (50 and 100 mL), Erlenmeyer flasks (250 mL), beakers (100 and 250 mL), pipette filler, washing bottle (250 mL), magnetic stirrer, Hot plate with magnetic stirrer, laboratory balance, JENWAY 4520 conductivity meter [19].

All chemicals and reagents used for the study were analytical reagent: 69.0-72.0% Conc.HNO_3, NaOH pellets, Conc. 98.0% H_2SO_4, 37% HCl, NH_4Cl 99.5%, Potassium dichromate ($K_2Cr_2O_7$) 99% extra pure, 99.9% silver chloride, EBT, Na_2EDTA, Methyl orange indicator, Phenolphthalein indicator, 97% Alcohol, Soap, detergent, distilled water, buffer tablet (pH 4, 7 and 9.2) for pH calibration.

Statistical Analysis: The data obtained in this study had subjected to statistical analysis using descriptive statistics and one way ANOVA for water quality parameters.

RESULTS AND DISCUSSION

Physico-Chemical Parameters: The physical and chemical quality of water may affect its acceptability to consumers. Water quality refers to the physical, chemical and microbiological characteristics of water based on the standards of its usage. Each parameter includes different characteristics of water and all must be routinely evaluated to preserve optimal water quality.

The selected physico-chemical parameters such as pH, EC, total alkalinity, acidity, turbidity, TDS, total hardness, chloride of water was analyzed for the water samples collected from Sebeta and Sululta towns.

Electrical Conductivity: *Conductivity* is the capacity of water to carry an electrical current and varies both with number and types of ions the solution contains. The conductivity of water is an expression of its ability to conduct an electric current. Thus, the extent of dissolved solids in water determines the electrical conductivity.

In this study, the determined EC value at Sebeta town was in the range of 202 to 457µS/cm and Sululta town was in the range of 115 to 521µS/cm. The determined results from the two towns were less than the compulsory Ethiopian standard drinking water specification and WHO drinking water guideline [10, 18].

Temperature: Cool water is generally more palatable than warm water and temperature will impact on the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste [19].

The highest temperature measured value in this study was 32°C at Sebeta roge reservoir, Abebe borehole and 20.1 at Sululta Wele lube house hold water sample.

Turbidity: Turbidity is important because it affects both the acceptability of water to consumers and the selection and efficiency of treatment processes, particularly the efficiency of disinfection with chlorine since it exerts a chlorine demand and protects microorganisms and may also stimulate the growth of bacteria. High levels of turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria and give rise to a significant chlorine demand. Effective disinfection requires that turbidity is less than 5 NTU [10].

In this study, the highest turbidity mean value were 17 NTU at Sululta Wasarbi house hold, 13.2 NTU at Sululta Wasarbi borehole, 7.6 NTU at Sululta prime milk house hold and 5.38 NTU at Sebeta fish spring water. The remain water sample from the two towns were less than compulsory Ethiopian standard drinking water specification and WHO drinking water guidelines (5 NTU) [10, 18].

These sites whose turbidity values mentioned above are needs further filtration and treatment in order to fit for domestic and drinking purpose.

pH Value: The pH values measured at Sebeta town were in the range of 6.9 to 8.0 which are in the range of compulsory Ethiopian standard of drinking water specification and WHO drinking water guideline (6.5 up to 8.5). And Sululta town pH values were in the range of 6.5 to 9.5. The highest pH value determined at Sululta were 9.5 at gora arba borehole, 9.1 at Wele lube bore hole and Wele lube house hold water sample which are above compulsory Ethiopian standard of drinking water specification and WHO drinking water guideline [10, 18].

Total Alkalinity: Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic. It is primarily controlled by carbonate species and is therefore usually expressed in terms of equivalence to calcium carbonate ($CaCO_3$). Briefly, carbon dioxide dissolves in water to form carbonic acid (H_2CO_3) which, depending on pH, dissociates to form carbonate, bicarbonate and hydrogen ions [19].

The total alkalinity value determine at Sebeta town water samples were in the range of 154 to 379 mg as $CaCO_3$ per liter and at Sululta town were in the range of 45 to 155 mg as $CaCO_3$ per liter. Except Iyesus gedam borehole and spring water and Irrecha borehole all the tested water samples at Sebeta town were above the compulsory Ethiopian standard drinking water specification and WHO drinking water guidelines (200). Whereas, all the total alkalinity determined at Sululta water samples were less than Ethiopian and WHO drinking water guidelines [10, 18].

The Acidity: Acidity of water is its quantitative capacity to react with a strong base to a designated pH. There are two types acidity: Methyl orange acidity also known as mineral acidity ($PH < 4.0$). Phenolphthalein acidity or CO_2 acidity, which is due to dissolution of CO_2 in water and algal photosynthesis. Both CO_2 and mineral acidity can be measured by means of standard solution of alkaline reagents [20].

Table 1: Physico-chemical and microbiological water quality parameters of Sebeta Town

Sampling sites	Temp (°C)	pH	EC (µs/cm)	Total Alkalinity, mg as $CaCO_3$ per L	Cl^-, mg/L	Acidity, mg/L	Total Hardness, mg as $CaCO_3$ per L	Turbidity, NTU	TDS, mg/L	Fecal coliform	Total coliform
Chichen Bore hole	23	7.6	252	200	4	14	100	0.64	252	0	0
Mokshe Safa Samira	22	7.2	341	251	10	15	151	2.8	364	0	64
Furi shina bore hole	22	7.6	265	212	3	21	100	0.91	267	0	12
Zewde house hold	23	8.0	457	260	6	11	99	1.11	333	0	0
Alemgena condominium Block 25 tap water	22	7.5	245	209	4	14	103	0.74	268	0	28
Silase poiner reservoir	23	7.6	330	261	6	10	97	1.60	332	0	125
Mokshe Abubaker	22	7.2	342	254	10	10	148	0.93	350	0	65
Alemgena Awuragodana bore hole	22	7.3	363	304	1.62	19	160	0.73	362	0	0
Alemgena condominium Block 4 Tap water	22	7.5	263	210	6	19	100	0.97	261	0	0
Iyesus Gedam bore hole	24	7.7	428	154	11	14	51	0.73	418	0	8
Alfirikan bore hole	22	7.5	453	200	4	22	112	0.45	478	0	4
Water AID bore hole	27	7.6	392	379	3	24	95	0.71	448	0	0
Spring water	22	6.9	202	180	3	14	52	0.91	211	0	18
Masfin Bore hole	29	7.2	322	256	5	20	69	0.35	298	0	11
Fish spring water	26	7.6	336	295	4	19	73	5.38	341	12	25
Irrecha borehole	27	6.9	243	188	5	19	58	0.88	253	1	TNTC
Gabriel bore hole	29	7.5	372	285	3	13	68	0.54	350	0	TNTC
Roge Reservoir	32	7.6	422	305	1.62	17	73	1.83	369	0	0
Abebe bore hole	32	7.6	423	302	3	16	75	1.83	357	0	10
Compulsory Ethiopian Standard, 2013		6.5-8.5	1000	200	250		300	5	500-1000	Must not be detected	Must not be detected
WHO, 2004		6.5-8.5	1000	200	250		300	5	500-1000	Must not be detected	Must not be detected

TNTC= to numerous to count

Table 2: Physico-chemical and microbiological water quality parameters of Sululta Town

Sampling sites	Temp (°C)	pH	EC (µs/cm)	Total Alkalinity, mg as $CaCO_3$ per L	Cl^-, mg/L	Acidity, mg/L	Total Hardness, mg as $CaCO_3$ per L	Turbidity, NTU	TDS, mg/L	Fecal coliform	Total coliform
Kombolcha public bono	20	8	521	155	53	21	122	0.16	556	0	0
Red cross Bore hole	20	7.8	423	142	35	15	126	0.68	505	0	3
Red cross house hold	20	7.8	462	146	36	49	120	0.68	506	0	0
Kombolcha reservoir	20	8	514	153	55	21	112	0.93	555	0	0
Tannery bore hole	20	8.1	505	150	55	47	114	0.44	568	0	0
Bilo house hold	20	8.1	505	91	31	18	70	0.44	378	0	0
Gora Arba bore hole	20	9.5	250	84	16	25	20	2.22	279	0	0
Wele lube bore hole	20	9.1	241	80	15	11	28	0.99	268	0	0
Wele lube house hold	20.1	9.1	247	74	14	15	28	0.62	267	0	0
Prime milk house hold 1	20	7.3	143	64	3	14	30	7.6	150	0	0
Prime milk house hold 2	20	7.2	135	59	3	20	26	4.91	151	1	2
Elemtu spring	20	7.5	153	63	9	15	56	2.8	175	12	15
Mizan public bono	20	7.5	121	59	3	11	38	0.84	142	0	0
Kimbira house hold	20	7	122	55	4	26	26	1.56	114	0	0
Weserbi house hold	20	7	115	56	5	24	36	17	133	0	0
Weserbi borehole	20	7.1	131	59	4	16	28	13.2	133	0	0
Atlet house hold	20	7.1	125	59	1.5	15	30	3.28	135	0	0
Kimbira spring	19	6.5	0.81	45	2	16	26	2.51	112	8	11
Compulsory Ethiopian Standard, 2013		6.5-8.5		200	250		300	5	500-1000	Must not be detected	Must not be detected
WHO, 2004		6.5-8.5		200	250		300	5	500-1000	Must not be detected	Must not be detected

TNTC= To numerous to count

The total acidity value determined at Sebeta towns water samples were in the range of 10 to 24 mg/L and at Sululta town water sample were in the range of 11 to 49 mg/L. There was no acidity limit value laid by the compulsory Ethiopian standard drinking water specification and WHO drinking water guidelines [10, 18].

Chloride: The measured value of chlorides at Sebeta water samples were in the range of 1.62 to 11 mg/L and at Sululta water sample were in the range of 1.5 to 55 mg/L. All the determined chlorine value at all sites of both Sebeta and Sululta towns were less than the compulsory Ethiopian standard drinking water specification and WHO drinking water guide lines which is 250 mg/L [10, 18].

Total Dissolved Solids: The total dissolved solids (TDS) concentration is a measure of the quantity of all compounds dissolved in water. The total dissolved salts concentration is a measure of the quantity of all dissolved compounds in water that carry an electrical charge [20].

The measured TDS value at Sebeta town water sample were in the range of 211 to 478 mg/L and at Sululta town water sample were in the range of 112 to 568 mg/L. All the tested water sample at Sebeta and Sululta water sample were less than compulsory Ethiopian standard drinking water specification and WHO drinking water guidelines [10, 18].

Total Hardness: The measured value of total hardness value at Sebeta town water samples were in the range of 51 to 160 mg as $CaCO_3$ per liter and at Sululta town water samples were in the range of 20 to 126 mg as $CaCO_3$ per liter. All the determined total hardness at Sebeta and Sululta towns was less than compulsory Ethiopian standard drinking water specification and WHO drinking water guidelines [10, 18].

Faecal Coli Form: The count of faecal coli form at Sebeta spring water were 12 and at Sebeta Irrecha borehole were 1 and the remaining water samples were 0. Whereas the faecal coli form determined at Sululta elemtu spring water was 12, Sululta prime milk house hold 2 water samples was 1 and Sululta kimbira spring water sample was 8. According to compulsory Ethiopian standard of drinking water specification and WHO drinking water guidelines the faecal coli form must be not detected [10, 18].

Total Coli Form: Almost all Sebeta water sample were contaminated by total coli form and therefore, Sebeta water supply system needs disinfection processes to secure healthy water availability for the Sebeta town societies. Whereas the total coli form determined at Sululta prime milk house hold 2 water sample was 2, Sululta elemtu spring water sample was 15, Sululta kimbira spring water sample was 11 and Sululta red cross borehole water sample was 3. According to compulsory Ethiopian standard of drinking water specification and WHO drinking water guidelines the total coli form must be not detected [10, 18].

CONCLUSION

The present study aimed to compare physico-chemical and microbiological water quality parameters of Sebeta and sululta towns water supplied for communities. Among the tested parameters, pH results at sululta Gora Arba bore hole, Wele lube bore hole and Wele lube house hold sites were 9.5 and 9.1 which were above the range of compulsory Ethiopian standard of drinking water specification and WHO drinking water guide lines. Except Sebeta Iyesus Gedam borehole, spring water and Irrecha borehole 154, 180 and 188 mg as $CaCO_3$ per L respectively, all Sebeta town measured values of total Alkalinity were above compulsory Ethiopian standard of drinking water specification and WHO drinking water guide lines. Except Sululta Prime milk house hold 1, Wasarbi house hold and Wasarbi borehole sites measured turbidity were 7.6, 17 and 13.2 NTU which were above compulsory Ethiopian standard of drinking water specification and WHO drinking water guide lines. Sebeta Fish spring water and Irrecha borehole sites were contaminated by faecal coli form and needs disinfection. While total coli form was detected almost in all Sebeta town water supplied sites and all are needs to be disinfection processes before usable for domestic purposes.

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