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Evaluation of Physico-Chemical Water Quality of Bishoftu and Dukam Towns, Ada'a and Sebeta Hawas Districts, Oromia Regional State, Ethiopia

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Abstract: The aim of study was Evaluation of Physico-chemical water quality of Bishoftu and Dukam towns, Ada'a and Sebeta Hawas districts. 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, potassium, sulfates and nitrates by colorimetric method. Descriptive statistics was used to determine the mean value of water quality parameters along all the sites. Among the water sample site, highest mean value of EC was 1567.67 µS/cm at Dukam mandala bore hole and 1967 µS/cm at bishoftu gorgode borehole sites, the highest turbidity value was 13.20 NTU at Tafki house hold 8, 43.7 mg/L at ada'a borehole deep well hand pump 4 and 1.63 NTU at bishoftu rosemary house hold sites. The highest pH value was 8.20 at ada'a Kanoria textile tap water, the highest total alkalinity value was452 mg as $CaCO_3$/L at dukam mandalo borehole, 297 mg as $CaCO_3$/L at ada'a borehole deep well hand pump 4 and 526 mg as $CaCO_3$/L at bishoftu gorgode bore hole sites. The highest acidity value was 50 mg/L at bishoftu gorgode borehole site. The highest chloride value was 164.95 mg/L at bishoftu gorgode borehole site. The TDS value was 1307 mg/L at dukam mandalo bore hole and 1764 mg/L at bishoftu gorgode bore hole site. The highest total hardness value was 450 mg as $CaCO_3$/L at bishoftu gorgode bore hole site. The highest fluoride value was 1.65 mg/L at dukam condominium bore hole and all bishoftu sites. The highest nitrate value was 22.2 mg/L at bishoftu selam mender tap water site. The highest potassium value was 8.8 mg/L at awash melkasa tap water 2, 6.3 mg/L at Tafki water supply sites, Tafki reservoir, Tafki households (3, 7 and 9), 12.02 mg/L at dukam mandalo bore hole, 4.0 mg/L at ada'a Kanoria textile borehole and 12.02 mg/L at bishoftu gorgode borehole sites. The highest sulfate value was 18.0 mg/L at ada'a borehole deep well hand pump 4 site. Water supplied for the communities shall be treated and disinfected before distributing. The reservoir also cleaned before storing and disinfecting the cumulative water. The supplied water at every station should have to safe by protective guards like constructing compounds around the boreholes and reservoirs. Periodically, monitoring water at sources, reservoirs, distribution lines and house hold or public Bonos by means of conducting water quality test.

Key words: Water Quality · Disinfection · Treatment

INTRODUCTION

The key to increase human productivity and long life is good quality water [1]. The provision of good quality household drinking water is often regarded as an important means of improving health [2]. Drinking water quality is a global issue, with contaminated unimproved water sources and inadequate sanitation practices causing human diseases [3].

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 [4]. 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 [5].

The Ethiopian government has given considerable attention to the supply of adequate and safe water to the people. As a result, Ethiopia met the target of 60% safe

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drinking water coverage by 2015 [6]. However, water quality deterioration is still a serious health and development issue in Ethiopia. Safe drinking water coverage is about 66% and only 6.3% of households have access to improved sanitation [7-9]. Moreover, over 80% of people do not practice improved hygiene behaviors and live in unhealthy environments UNICEF Ethiopia [9]. As a result, communicable diseases related to limited access to safe water, inadequate sanitation and poor hygiene services accounted for 60-80% of all illnesses in Ethiopia UNICEF Ethiopia [9].

MATERIALS AND METHODS

Description of the Research Area: Sebeta Hawas district is found in the south west shoa zone which is closest distance (19 kilometers) to capital city Addis Ababa – Ethiopia. Bishoftu town is one of the hottest towns in the rift valley region in the Oromia Regional state of Ethiopia, about 39 kilometers from the capital, Addis Ababa, at east shoa. Ada'a district is found in the east shoa zone which rural area of around the Bishoftu town and distance from Addis Ababa is about 86.77 km. Dukam town is found in the east shoa zone, 38.2 km distance from capital city, Addis Ababa (From Wikipedia, free encyclopedia, accessed on 7/22/2022).

Research Design and Sample Location: This study was carried out and designed during April to determine physicochemical parameters. The process was undertaken through observation and water sample test.

The source of water supplied for ada'a, sebeta hawas districts, dukam and bishoftu towns were groundwater. 90 sampling sites from the two districts and two towns were selected for analyzing the physico-chemical water quality 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 polyethylene bottles. Before collection of water samples, bottles were washed with concentrated nitric acid (chromic acid for nitrate analysis) and distilled water to avoid contamination.

Disinfection is essential for surface waters after treatment and for protected groundwater sources when *E. coli* or thermotolerant (faecal) coliforms are detected. Chlorine is the most commonly used disinfectant worldwide. However, the ground water supplied for the community in all investigated sites were not disinfected and directly distributed to the house hold purpose. Since the environment was deteriorated by climate change and due to man activity, every water source should have to treated and disinfected for the protection of community health.

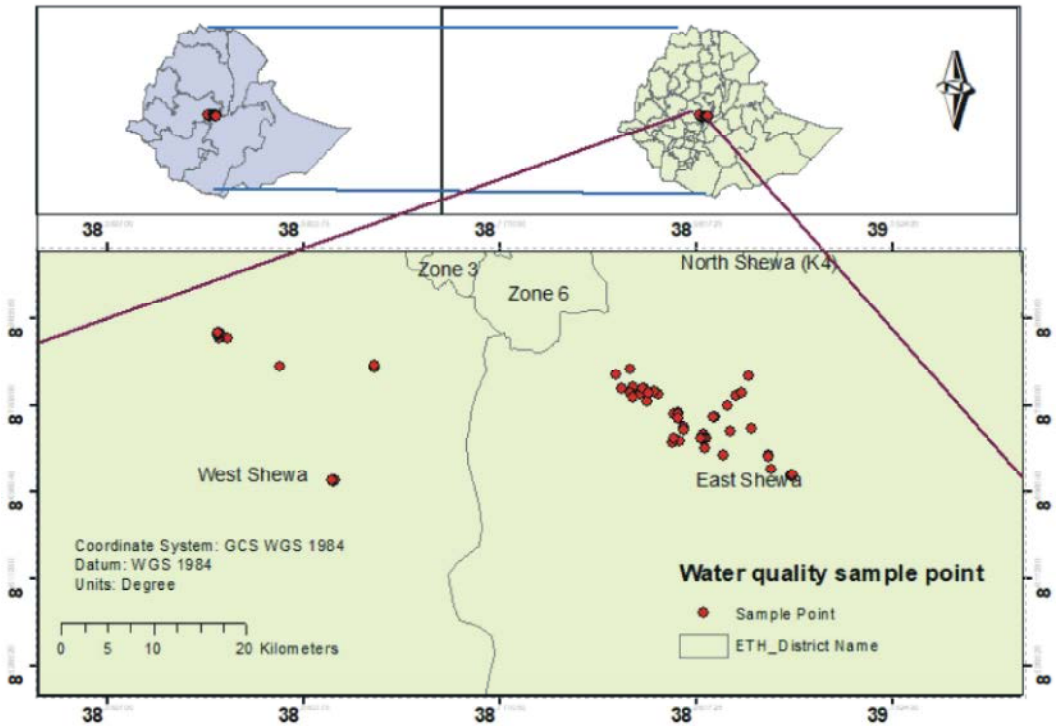

Fig. 1: Map of the study area

Table 1: Sampling sites and their GPS information

Sample source	Sampling site	Easting	Northing
Awash Melkasa	Bono	0456911	962300
	Bonaya house hold 1	0456909	962300
	Bonaya house hold 2	0457156	962493
	Bonaya house hold 3	0457156	962494
	Bonaya reservoir	041240	974763
	Tap water 1	0461286	974728
	Bonaya Bore hole	0456832	962597
	Tap water 2	0461338	974906
Tafki	Tafki water supply site	0445654	977890
	Reservoir	0445655	977892
	Mina borehole	0444781	978257
	Tafki House Hold 1	0444757	978260
	Tafki House Hold 2	0444780	9778324
	Tafki House Hold 3	0444835	978349
	Tafki House Hold 4	0444515	978129
	Tafki House Hold 5	0444524	978235
	Tafki House Hold 6	0444596	978333
	Tafki House Hold 7	0444633	978354
	Tafki House Hold 8	0444693	978453
	Tafki House Hold 9	0444648	978488
Dukam town	Dukam water supply and sanitation office	0489722	971831
	Dukam town agricultural center bore hole 1	0489002	971468
	Around Michael bore hole	0488889	972577
	Tadecha kebele household	0490135	972366
	Dukam Condominium borehole	0490425	970997
	Zukuala borehole	0488641	971841
	Tadecha Yatu gudo borehole	0491701	971763
	Gogecha 1 borehole	0487721	972426
	Dukam town agricultural center bore hole 2	0488979	971435
	Gogecha 2 borehole	0488660	974527
	Dukam yatu tiko bore hole	0490028	972371
	Mandalo bore hole	0487188	973858
	Tadecha nano Bekele gombore bore hole	0491157	9720226
	tadecha Atlabachew borehole	0490573	971846
Ada'a district	E mass pump borehole	0505893	963014
	Deep well hand pump borehole	0505810	963143
	Bore hole rope pump	0505973	962956
	Dallo water pump	0503691	963791
	Kanoria textile reservoir	0503427	965198
	Kanoria textile bore hole	0503451	965202
	Kanoria textile tap water	0503453	965042
	Bore hole hand pump	0506040	963133
Bishoftu town	Kurkura borehole number 2	0493956	966691
	Dambi 3 borehole	0493712	969775
	Dambi 2 borehole	0493350	969649
	Lemlem 1 house hold	0494292	968272
	Selam mender tap water	0496612	965926
	Cheleleka 4 bore hole	0497677	969287
	Gorgode bore hole	0498549	965269
	Cheleleka 3 borehole	0497587	969279
	Lemlem 2 house hold	0494409	967955
	Cheleleka 1 kebele house hold	0496534	967437
	Kurkura house hold number 3	0493290	967082
	Dambi 1 house hold	0493696	969626
	Dambi 2 house hold	0493696	969166
	Arsema bore hole	0493190	966633
	Kurkura house hold number 1	0493291	967081
	Babo gaya bore hole	0499095	970486
	Rosemary house hold	0496762	967037
	Shumbura masa 7 bore hole	05001337	973727
	Around Michael house hold	0496470	967046
	Zero 2 kebele house sold	0496182	966986
	Babo gaya 2 house hold	0499919	971551
	Babo gaya 1 house hold	05000547	971931
	Kality bore hole	0501594	968049
	Hora Ras hotel around house hold	0499310	967838

There are 20 sampling sites at sebeta hawas district (8 from Awash melkasa and 12 from Tafki), 24 sampling sites at bishoftu town, 8 sampling sites at Ada'a district and 15 sampling sites at Dukam town were collected and transported to the laboratory for further water characterization. Samplings were carried out in April month, 2022. A global positioning system (GPS) was used to locate the sampling positions.

The in-situ parameters were determined for pH, EC, temperature 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 and potassium, nitrate, fluoride and sulfate were analyzed by Palin test method using photometer 7100.

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: Tap water (1L) was collected from each outlet of the tap, after flushing water for 2-5minutes to remove the stagnant water. 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 arrive 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.

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 and sulfate, fluoride, potassium and nitrate were analyzed by Palin test method using photometer 7100.

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, photometer 7100.

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 and Palin test tablet reagents for sulfate, fluoride, potassium and nitrate were consumed.

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 biological 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, potassium, sulfate, fluoride and nitrate of water were analyzed for the water samples collected from Sebeta Hawas, Bishoftu, Ada'a and Dukam.

Table 2: Determined Physico-chemical parameters (mean ± SD)of Awash melkasa

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	K, mg/L	NO_3^-, mg/L	SO_4^{2-} (mg/L)	F, mg/L	TDS, mg/L
Public Bono	24±0.0	7.30±0.00	563.50±0.71	183.00±1.41	10.00±0.00	30.00±2.83	184.00±4.00	0.00±0.00	8.60±0.00	1.44±0.00	2.00±0.00	1.20±0.00	532.00±0.00
Bonaya house hold 1	24±0.0	7.40±0.00	452.33±1.53	158.00±0.00	10.33±0.58	24.00±0.00	220.00±0.00	1.72±0.00	1.40±0.00	1.90±0.00	0.00±0.00	0.91±0.00	455.00±0.00
Bonaya house hold 2	24±0.0	7.30±0.00	565.33±1.53	162.00±0.00	5.00±0.00	20.00±0.00	186.67±2.31	0.00±0.00	1.40±0.00	3.94±0.00	0.00±0.00	0.94±0.00	458.00±0.00
Bonaya house hold 3	24±0.0	7.60±0.00	561.00±1.00	180.00±0.00	10.00±0.00	32.00±0.00	238.67±2.31	0.00±0.00	0.00±0.00	2.12±0.00	0.00±0.00	1.20±0.00	527.00±0.00
Bonaya reservoir	22±0.0	7.40±0.00	441.67±0.58	156.00±0.00	10.00±0.00	16.00±0.00	220.00±0.00	3.31±0.00	1.30±0.00	4.47±0.00	0.00±0.00	0.77±0.00	457.00±0.00
Tap water 1	22±0.00	7.50±0.00	556.00±1.00	184.00±0.00	6.00±1.00	20.00±0.00	181.33±2.31	0.00±0.00	8.00±0.00	1.46±0.00	1.00±0.00	1.12±0.00	523.00±0.00
Bore hole	23±0.00	7.40±0.00	562.00±2.00	184.00±0.00	10.00±0.00	20.00±0.00	182.67±2.31	0.00±0.00	0.00±0.00	1.72±0.00	0.00±0.00	1.27±0.00	526.00±0.00
Tap water 2	21±0.00	7.50±0.00	392.67±2.52	183.00±1.41	10.00±0.00	24.00±0.00	192.00±0.00	0.00±0.00	8.80±0.00	1.50±0.00	0.00±0.00	1.27±0.00	526.00±0.00

*All parameters were analyzed in three replicates

Table 3: Determined Physico-chemical parameters (mean ± SD) of Tafki

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	K, mg/L	NO_3^-, mg/L	SO_4^{2-} (mg/L)	F, mg/L	TDS, mg/L
Tafki water supply site	24±0.0	7.60±0.00	431.67±1.15	152.00±0.00	17.99±0.00	16.00±0.00	144.00±0.00	0.00± 0.00	6.30±0.00	1.19±0.00	1.00±0.00	1.37±0.00	431.00±0.00
Reservoir	23±0.0	7.80±0.00	459.33±2.08	140.00±0.00	16.00±0.00	20.00±0.00	152.00±0.00	0.53±0.00	6.30±0.00	1.02±0.00	0.00±0.00	1.34±0.00	443.00±0.00
Mina borehole	22±0.0	7.80±0.00	392.67±2.52	136.00±0.00	15.66±0.58	20.00±0.00	136.00±0.00	0.00±0.00	6.10±0.00	1.50±0.00	0.00±0.00	1.32±0.00	415.00±0.00
Tafki house hold 1	22±0.0	7.90±0.00	428.33±0.58	134.00±0.00	16.00±1.00	16.00±0.00	144.00±4.00	0.24±0.00	5.60±0.00	1.02±0.00	1.00±0.00	1.36±0.00	426.00±0.00
Tafki house hold 2	22±0.0	7.90±0.00	430.00±0.00	129.00±1.41	13.00±1.00	8.00±0.00	166.67±2.31	3.35±0.00	6.20±0.00	0.92±0.00	0.00±0.00	1.40±0.00	423.00±0.00
Tafki house hold 3	21±0.0	7.90±0.00	413.00±1.00	133.00±1.41	15.33±0.58	12.00±0.00	148.00±4.00	0.77±0.00	6.30±0.00	2.26±0.00	0.00±0.00	1.48±0.00	421.00±0.00
Tafki house hold 4	21±0.0	7.80±0.00	439.00±0.00	136.00±0.00	17.66±0.58	16.00±2.83	145.33±2.31	0.27±0.00	5.40±0.00	1.33±0.00	2.00±0.00	1.44±0.00	449.00±0.00
Tafki house hold 5	22±0.0	7.90±0.00	447.33±0.58	134.00±2.83	18.66±0.58	20.00±0.00	144.00±4.00	0.30±0.00	6.00±0.00	1.71±0.00	0.00±0.00	1.47±0.00	455.00±0.00
Tafki house hold 6	21±0.0	7.90±0.00	405.00±0.58	134.00±0.00	15.00±0.00	20.00±2.83	145.00±6.11	0.15±0.00	5.90±0.00	1.60±0.00	0.00±0.00	1.25±0.00	428.00±0.00
Tafki house hold 7	21±0.0	7.80±0.00	405.00±0.58	140.00±0.00	17.66±0.58	20.00±2.83	148.00±4.00	0.14±0.00	6.30±0.00	1.14±0.00	4.00±0.00	1.37±0.00	461.00±0.00
Tafki house hold 8	23±0.0	7.90±0.00	432.67±0.58	140.00±0.00	23.33±0.58	12.00±0.00	141.33±2.31	13.20±0.00	5.50±0.00	1.56±0.00	0.00±0.00	1.20±0.00	425.00±0.00
Tafki house hold 9	22±0.0	7.80±0.00	417.33±0.58	141.00±1.41	16.99±0.00	16.00±0.00	142.67±2.31	0.15±0.00	6.30±0.00	1.76±0.00	0.00±0.00	1.32±0.00	431.00±0.00

*All parameters were analyzed in three replicates

Table 4: Determined Physico-chemical parameters (mean ± SD) of Dukam

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	K, mg/L	NO_3^-, mg/l	SO_4^{2-} (mg/L)	F, mg/L	TDS, mg/L
Dukam water supply and sanitation	30.00±0.00	8.17±0.06	462.33±3.21	138.00±0.00	13.00±0.00	28.00±0.00	120.00±0.00	0.06±0.00	12.00±0.00	1.69±0.00	ND	1.44±0.00	404.00±0.00
Dukam town agricultural center bore hole -1	25.00±0.00	7.67±0.06	654.33±1.53	222.00±0.00	14.00±1.00	42.00±2.83	264.00±0.00	0.08±0.00	6.80±0.00	3.87±0.00	ND	1.10±0.00	641.00±0.00
Dukam around Michael bore hole	32.00±0.00	7.60±0.00	651.00±2.65	239.00±1.41	15.00±0.00	28.00±0.00	237.33±2.31	0.05±0.00	6.30±0.00	3.87±0.00	ND	0.84±0.00	641.00±0.00
Dukam tadecha kebele household 1	37.00±0.00	8.00±0.00	473.00±0.00	147.00±1.41	15.00±0.00	32.00±0.00	144.00±4.00	0.05±0.00	12.00±0.00	1.68±0.00	ND	1.48±0.00	410.00±0.00
Condominium bore hole	40.00±0.00	7.93±0.06	646.00±0.00	176.00±0.00	15.00±0.00	22.00±0.00	112.00±0.00	0.13±0.00	12.00±0.00	0.66±0.00	ND	1.65±0.01	492.00±0.00
Dukam zukala borehole	24.00±0.00	7.60±0.00	703.67±7.09	232.00±0.00	18.99±1.00	24.00±0.00	229.33±4.62	0.09±0.00	7.60±0.00	3.18±0.00	0.00±0.00	0.81±0.00	630.00±0.00
Yatu gudo borehole	39.00±0.00	7.57±0.06	496.00±5.57	138.00±0.00	14.00±1.00	20.00±0.00	120.00±0.00	0.27±0.00	12.00±0.00	1.78±0.00	2.00±0.00	1.29±0.00	389.00±0.00
Dukam gogecha borehole 1	32.00±0.00	7.47±0.06	753.33±5.86	241.00±1.41	18.99±1.00	44.00±0.00	310.67±2.31	0.04±0.00	5.00±0.00	21.00±1.41	2.00±0.00	0.69±0.00	711.00±0.00
Dukam town agricultural center bore hole -2	24.00±0.00	7.50±0.00	709.33±0.58	223.00±1.41	16.00±1.00	44.00±0.00	220.00±0.00	0.10±0.00	6.70±0.00	2.44±0.00	ND	0.98±0.00	640.00±0.00
Dukam tadecha kebele household 2	25.00±0.00	8.00±0.00	474.00±1.00	148.00±0.00	9.00±1.00	22.00±0.00	120.00±0.00	0.08±0.00	12.00±0.00	1.68±0.00	ND	1.49±0.00	395.00±0.00
Dukam gogecha borehole 2	23.00±0.00	7.50±0.00	712.00±7.55	222.00±0.00	10.00±0.00	38.00±2.83	240.00±0.00	0.15±0.00	7.10±0.00	21.00±0.71	ND	0.52±0.00	659.00±0.00
Dukam yatu tiko bore hole	25.33±0.58	8.07±0.06	468.00±2.00	146.00±0.00	6.00±0.00	28.00±0.00	149.33±2.31	0.25±0.00	9.00±0.00	2.26±0.00	1.00±0.00	1.28±0.00	399.00±0.00
Dukam mandalo bore hole	32.00±0.00	7.30±0.00	1567.67±2.52	452.00±0.00	40.99±0.00	38.00±2.83	232.00±0.00	0.33±0.00	12.02±0.01	3.29±0.00	0.00±0.00	0.59±0.00	1307.00±0.00
Dukam tadecha nano bekele gombore bore hole	26.00±0.00	7.30±0.00	442.00±0.00	134.00±0.00	6.00±0.00	20.00±0.00	157.33±2.31	0.15±0.00	10.50±0.00	1.38±0.00	ND	1.49±0.00	389.00±0.00
Dukam tadecha atlabachew bore hole	40.00±0.00	7.40±0.00	606.33±0.58	147.001.41	14.00±1.00	32.00±0.00	120.00±0.00	0.05±0.00	11.50±0.00	2.81±0.00	ND	0.02±0.00	447.00±0.00

ND - Not Detected*All parameters were analyzed in three replicates

Table 5: Determined Physico-chemical parameters (mean ± SD) of Ada'a

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	K, mg/L	NO_3, mg/l	SO_4^{2-} (mg/L)	F, mg/L	TDS, mg/L
Ada'a borehole E mass pump 3	21.00±0.00	7.60±0.00	712.00±0.00	244.00±0.00	21.99±0.00	40.00±0.00	277.33±4.62	9.33±0.00	1.70±0.00	2.79±0.00	0.00±0.00	0.84±0.00	746.00±0.00
Ada'a borehole deep well hand pump 4	22.00±0.00	7.53±0.06	732.00±0.00	297.00±1.41	21.66±0.58	20.00±0.00	274.67±2.31	43.70±0.00	0.90±0.00	3.39±0.00	18.00±0.00	0.74±0.00	877.00±0.00
Ada'a bore hole rope pump 2	21.00±0.00	7.40±0.00	736.33±0.58	253.00±1.41	21.99±1.00	20.00±0.00	248.00±0.00	4.36±0.00	ND	3.28±0.00	0.00±0.00	0.88±0.00	780.00±0.00
Ada'a dallo water pump 5	23.00±0.00	7.90±0.00	739.00±1.00	231.00±1.41	29.99±0.00	20.00±0.00	260.00±0.00	0.32±0.00	3.90±0.00	3.15±0.00	0.00±0.00	1.10±0.00	730.00±0.00
Ada'a Kanoria textile reservoir	22.00±0.00	7.90±0.00	719.33±1.53	225.00±1.41	29.99±0.00	20.00±0.00	260.00±0.00	0.13±0.00	3.30±0.00	4.20±0.00	0.00±0.00	1.00±0.00	742.00±0.00
Ada'a Kanoria textile bore hole	22.00±0.00	7.63±0.06	731.00±1.00	228.00±0.00	33.99±1.00	20.00±0.00	278.67±2.31	0.14±0.00	4.00±0.00	3.19±0.00	0.00±0.00	1.02±0.00	736.00±0.00
Ada'a Kanoria textile tap water	22.00±0.00	8.20±0.00	750.33±0.58	233.00±1.41	32.32±0.58	20.00±0.00	272.00±4.00	0.43±0.00	2.70±0.00	3.81±0.00	0.00±0.00	1.04±0.00	743.00±0.00
Ada'a bore hole hand pump	21.00±0.00	8.10±0.00	824.67±0.58	231.00±1.41	29.99±0.00	20.00±0.00	284.00±4.00	0.33±0.00	3.40±0.00	22.00±0.00	0.00±0.00	0.97±0.00	758.00±0.00

ND - Not Detected*All parameters were analyzed in three replicates

Table 6: Determined Physico-chemical parameters (mean ± SD) of Bishoftu

Sample	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	K, mg/L	NO_3^-, mg/l	SO_4^{2-} (mg/L)	TDS, mg/L
Kurkura 2 Borehole	22.00±0.00	7.57±0.06	648.33±1.53	216.00±0.00	11.00±0.00	20.00±0.00	292.00±0.00	0.07±0.00	6.90±0.00	21.00±0.00	ND	646.00±0.00
Dambi 3 Borehole	30.00±0.00	7.80±0.00	440.67±2.08	145.00±1.41	4.00±0.00	20.00±0.00	134.67±2.31	0.36±0.00	5.80±0.00	0.30±0.00	ND	425.00±0.00
Dambi 2 Borehole	24.00±0.00	7.90±0.00	460.33±6.66	158.00±0.00	5.00±0.00	20.00±0.00	164.00±4.00	0.16±0.00	6.10±0.00	0.42±0.00	ND	446.00±0.00
Lemlem 1 House Hold Selam Mender	23.00±0.00	7.90±0.00	421.00±3.46	175.00±1.41	2.00±0.00	24.00±0.00	132.00±4.00	0.16±0.00	7.70±0.00	0.58±0.00	ND	404.00±0.00
Tap Water	22.00±0.00	7.60±0.00	824.33±5.86	291.00±1.41	27.99±0.00	20.00±0.00	368.00±8.00	0.16±0.00	9.50±0.00	22.00±0.00	ND	825.00±0.00
Cheleleka 4 Bore Hole	23.00±0.00	7.90±0.00	592.67±0.58	235.00±1.41	5.00±0.00	20.00±0.00	224.00±4.00	0.39±0.00	5.90±0.00	0.26±0.00	ND	584.00±0.00
Gorgode Bore Hole	30.00±0.00	7.40±0.00	1967.00±2.65	526.00±0.00	164.95±1.00	50.00±2.83	450.67±6.11	0.27±0.00	12.02±0.01	0.52±0.00	ND	1764.00±0.00
Cheleleka 3 Borehole	34.00±0.00	8.10±0.00	680.00±0.00	226.00±0.00	5.00±0.00	24.00±0.00	240.00±0.00	0.09±0.00	6.30±0.00	0.29±0.00	ND	595.00±0.00
Lemlem 2 House Hold	23.00±0.00	7.53±0.06	648.33±1.53	225.00±1.41	11.00±1.00	30.00±2.83	288.00±8.00	0.08±0.00	6.40±0.00	3.52±0.00	ND	643.00±0.00
Cheleleka 1 Kebele House Hold	30.00±0.00	8.13±0.06	627.33±2.52	233.00±1.41	6.00±0.00	20.00±0.00	229.33±6.11	0.07±0.00	6.00±0.00	1.50±0.00	ND	590.00±0.00
Kurkura 3 House Hold	22.00±0.00	7.83±0.06	680.00±1.00	250.00±0.00	11.00±0.00	24.00±0.00	312.00±0.00	0.12±0.00	6.60±0.00	0.81±0.00	ND	713.00±0.00
Dambi 1 House Hold	24.00±0.00	7.60±0.00	436.00±2.65	167.00±1.41	3.00±0.00	16.00±0.00	170.67±6.11	0.06±0.00	5.60±0.00	0.21±0.00	ND	446.00±0.00
Dambi 2 House Hold	24.00±0.00	7.90±0.00	430.00±2.00	153.00±1.41	3.00±1.00	16.00±0.00	120.00±0.00	0.35±0.00	8.00±0.00	1.38±0.00	ND	410.00±0.00
Arsema Bore Hole	24.00±0.00	7.80±0.00	506.33±1.53	165.00±1.41	5.00±0.00	16.00±0.00	140.00±0.00	0.13±0.00	6.90±0.00	0.61±0.00	ND	486.00±0.00
Kurkura 1 House Hold	22.00±0.00	7.80±0.00	494.00±3.46	168.00±0.00	6.00±1.00	12.00±0.00	160.00±4.00	0.10±0.00	6.40±0.00	0.64±0.00	ND	490.00±0.00
Babo Gaya Bore Hole	21.00±0.00	8.10±0.00	616.00±1.00	520.00±0.00	8.00±0.00	24.00±0.00	220.00±0.00	0.49±0.00	7.20±0.00	0.14±0.00	ND	624.00±0.00
Rosemary House Hold 1	24.00±0.00	7.90±0.00	639.33±5.51	473.00±1.41	5.00±0.00	20.00±0.00	220.00±0.00	1.63±0.00	7.50±0.00	0.21±0.00	ND	587.00±0.00
Shumbura Masa 7 Bore Hole	23.00±0.00	7.90±0.00	515.00±1.00	372.00±0.00	3.00±0.00	20.00±0.00	160.00±0.00	0.11±0.00	8.40±0.00	0.35±0.00	ND	474.00±0.00
Michael Around House Hold	22.00±0.00	8.10±0.00	601.00±0.00	479.00±1.41	5.00±1.00	20.00±0.00	220.00±0.00	1.20±0.00	5.90±0.00	1.29±0.00	ND	572.00±0.00
Zero 2 Kebele House Sold	22.00±0.00	7.87±0.06	583.33±1.53	505.00±1.141	5.00±0.00	30.00±2.83	220.00±0.00	0.48±0.00	7.80±0.00	0.36±0.00	ND	590.00±0.00
Babo Gaya 2 House Hold	24.00±0.00	7.80±0.00	495.33±2.52	367.00±1.41	5.00±0.00	22.00±2.83	140.00±0.00	0.07±0.00	8.80±0.00	0.48±0.00	ND	463.00±0.00
Babo Gaya 1 House Hold	22.00±0.00	7.80±0.10	487.67±1.53	362.00±0.00	8.00±0.00	26.00±2.83	140.00±0.00	0.21±0.00	8.20±0.00	0.30±0.00	ND	474.00±0.00
Kality Bore Hole	23.00±0.00	8.00±0.00	690.33±5.03	466.00±0.00	19.99±0.00	26.00±2.83	160.00±0.00	0.17±0.00	9.50±0.00	0.27±0.00	ND	656.00±0.00
Hora Ras Hotel Around House Hold	24.00±0.00	7.80±0.00	545.67±10.69	375.00±1.41	5.00±0.00	20.00±0.00	178.67±2.31	0.35±0.00	7.00±0.00	0.49±0.00	ND	475.00±0.00

ND - Not Detected*All parameters were analyzed in three replicates

Electrical Conductivity Measurement: 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 highest determined mean value of EC was 565.33 µS/cm at Bonaya house hold 2,459.33 µS/cm at Tafki reservoir, 1567.67 µS/cm at Dukam mandalo bore hole, 824 µS/cm at ada'a borehole hand pump and 1967 µS/cm at bishoftu gorgode borehole sites (Table 2, 3, 4, 5 and 6). According to WHO and Ethiopian compulsory standard guide values, the maximum EC of drinking water is 1000 µS/cm [9, 12]. However, the determine EC value at Dukam mandalo bore hole (1567.67 µS/cm) and at bishoftu gorgode borehole (1967 µS/cm) sites were above Ethiopian compulsory standard and WHO guide lines. Therefore, the EC determined at the mentioned above sites needs proper treatment and disinfection before distribution for the society.

Whereas, the lowest EC mean value obtained was 392.67 µS/cm at awash melkasa tap water 2, 392.67 µS/cm at Tafki mina bore hole, 442 µS/cm at Dukam tadecha nano Bekele gombore bore hole,712 µS/cm at ada'a borehole E-mass pump 3 and 412 µS/cm at bishoftu Lemlem 1 household sites.

From the determined pH and TDS value of this study, the electrical conductivity of the water depends on the number of ions present in water. Especially if the pH is higher or lower implies the ions present in water greater and the electrical conductivity is also high. As most of the salts in water are present in ionic forms, they make water capable for conducting electrical current [10].

Temperature Measurement: The highest temperature measured value in this study was 24°C at public bono, Bonaya households (1, 2 and 3) and Tafki water supply site, 40°C at Dukam condominium bore hole and Dukam tadecha atlabachew bore hole, 23°C at ada'a dallo water pump and 34°C at bishoftu cheleleka 3 borehole sites (Table 2, 3, 4, 5 and 6). Since as the temperature increase the water characteristics also dramatically change and the water is not fit for drinking purpose. Especially, 40°C at sites Dukam condominium and atlabachew bore hole and 34°C bishoftu cheleleka 3 bore hole are very hot water.

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. High water temperature enhances the growth of microorganisms and may increase taste, odor, color and corrosion problems [11].

Turbidity Measurement: 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 [12].

In this study, the highest turbidity mean value was 3.31NTU at Bonaya reservoir, 13.20 NTU at Tafki house hold 8, 0.33NTU at Dukam mandala bore hole,43.7 mg/L at ada'a borehole deep well hand pump 4 and 1.63 NTU at bishoftu rosemary house hold sites (Table 2, 3, 4, 5 and 6).

Tafki house hold 8 (13.2 NTU) and ada'a bore hole deep well hand pump (43.7 NTU) was above Ethiopian compulsory standard and WHO guide line values (5 NTU) and the water at two sites needs further filtration and treatment in order to fit for domestic and drinking purpose. Especially Ada'a bore deep well hand pump were not protected properly which are open and dust and other pollutants were entered easily.

pH Measurement: The highest pH mean value was 7.60 at Bonaya house hold 3, 7.90 at Tafki households (1, 2, 3, 5, 6 and 8), 8.17 at Dukam water supply and sanitation office, 8.20 at ada'a Kanoria textile tap water and 8.13 at bishoftu cheleleka 1 kebele house hold sites (Table 2, 3, 4, 5 and 6). All values were slightly in the alkaline range and in the Ethiopian and WHO guide line range (6.5 up to 8.5).

Determination of 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 [11].

The highest total alkalinity mean value determined were 184 mg as $CaCO_3$/L at awash melkasa tap water 1, 152 mg as $CaCO_3$/L at Tafki water supply, 452 mg as

$CaCO_3$/L at dukam mandalo borehole, 297 mg as $CaCO_3$/L at ada'a borehole deep well hand pump 4 and 526 mg as $CaCO_3$/L at bishoftu gorgode bore hole sites (Table 2, 3, 4, 5 and 6). Bishoftu gorgode bore hole total alkalinity value were the most among the determine values. The total alkalinity value of dukam mandalo bore hole and Bishoftu gorgode bore hole were above the guideline value of Ethiopian standard and WHO standards (200mg as $CaCO_3$ per liter). The lowest total alkalinity from the overall sites, Tafki house hold 2 were 129 mg as $CaCO_3$ per liter.

Determination of 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 [10].

The highest total acidity mean value determined were 32 mg/L at Bonaya house hold 3, 20 mg/L at Tafki reservoir, mina bore hole, Tafki households (5, 6 and 7), 44 mg/L at dukam gogecha bore hole and dukam town agricultural center bore hole 2, 40 mg/L at ada'a borehole E-mass pump, 50 mg/L at bishoftu gorgode borehole sites (table 2, 3, 4, 5 and 6). The lowest acidity mean value determined were 8 mg/L at Tafki house hold water 2 site.

Determination of Chloride: The concentration of the chlorides determines the water quality. However, there was no any water treatment system took place in all sites we selected and the water supplied for community were directly distributed without storing in the reservoir and disinfection. The highest chloride mean value determined were10.33 mg/L at Bonaya hose hold 1, 23.33 mg/L at Tafki house hold 8, 40.99mg/L at dukam mandalo bore hole, 33.99 mg/L at ada'a Kanoria textile borehole, 164.95 mg/L at bishoftu gorgode borehole sites (Table 2, 3, 4, 5 and 6). From the determined values, the lowest chlorine had seen at bishoftu Lemlem 1 house hold water (2 mg/L). All the determined chlorine value at all sites was below the compulsory Ethiopian standard and WHO guide lines which is 250 mg/L.

High concentrations of chloride give a salty taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200–300 mg/liter for sodium, potassium and calcium chloride. Concentrations in excess of 250 mg/liter are increasingly likely to be detected by taste, but some consumers may become accustomed to low levels of chloride-induced taste. No health-based guideline value is proposed for chloride in drinking-water [11].

Determination of 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. Since most dissolved substances in water carry an electrical charge, the TDS concentration is usually, used as an estimate of the concentration of total dissolved solids in the water. Therefore, it has become common practice to use the total dissolved salts concentration, as a measure for the total dissolved solids [10].

The highest mean value of TDS determined were 532 mg/L at public bono, 461 mg/L at Tafki house hold 7, 1307 mg/L at dukam mandalo bore hole, 877 mg/L at ada'a bore hole deep well hand pump 4, 1764 mg/L at bishoftu gorgode bore hole sites (Table 2, 3, 4, 5 and 6). TDS value obtained at dukam mandalo deep well hand pump (1307 mg/L) and bishoftu gorgode bore hole (1764 mg/L) sites were above the Ethiopian compulsory standard and WHO guide line values. Therefore, the TDS value of water obtained at the two mentioned are need further treatment for drinking purpose. The lowest TDS value determined were yatu gudo bore hole and tadecha nano Bekele gombore bore hole.

The palatability of water with a TDS level of less than 600 mg/liter is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/liter. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances. No health-based guideline value for TDS has been proposed [11].

Determination of Total Hardness: The highest total hardness mean value determined were 238.67 mg as $CaCO_3$/L at Bonaya house hold 3, 166.67 mg as $CaCO_3$/L at Tafki household 2, 264 mg as $CaCO_3$/L at dukam town agricultural center bore hole 1, 284 mg as$CaCO_3$/L at ada'a bore hole hand pump, 450 mg as $CaCO_3$/L at bishoftu gorgode bore hole sites (Table 2, 3, 4, 5 and 6).

Except Tafki house hold 2, all the highest determined total hardness of water sampling sites test were above the Ethiopian compulsory standard and WHO guide line values (300 mg as $CaCO_3$ per liter). Whereas, the lowest total hardness determined were at site dukam condominium bore hole which was 112 mg as $CaCO_3$ per liter.

Determination of Fluoride: In all selected sites water sample were analyzed and recorded the extent of fluoride present within. Accordingly, the highest fluoride mean value determined were 1.27 mg/L at awash melkasa bore hole and tap water 2, 1.48 mg/L at Tafki house hold 7, 1.65 mg/L at dukam condominium bore hole, 1.10 mg/L at ada'a dallo water pump 5sites (Table 2, 3, 4, 5 and 6). Fluoride value at all bishoftu sites was higher than the instrumental measured capacity 1.65 mg/L at dukam condominium bore hole was above Ethiopian and WHO guide line values. Thus, the water at this site needs further treatments.

Determination of Nitrate: In all the sample water, the concentration of nitrates was quantified. The highest analyzed nitrate value was 4.47 mg/L at Bonaya reservoir, 2.26 mg/L at Tafki house hold 3, 21.0 mg/L at gogecha (1 and 2) bore holes, 22.0 mg/L at ada'a borehole hand pump and22.2 mg/L at bishoftu selam mender tap water (Table 2, 3, 4, 5 and 6). The lowest nitrate value was 0.14 mg/L at babogaya bore hole and bishoftu rose merry house hold site.

Determination of Potassium: The highest potassium mean value determined were 8.8, mg/L at awash melkasa tap water 2, 6.3 mg/L at Tafki water supply sites, Tafki reservoir, Tafki households (3, 7 and 9), 12.02 mg/L at dukam mandalo bore hole, 4.0 mg/L at ada'a Kanoria textile borehole and 12.02 mg/L at bishoftu gorgode borehole Sites (Table 2, 3, 4, 5 and 6). The determined potassium values at all sites were above the WHO and Ethiopian compulsory standard limit values (1.5 mg/L). Among the tested water sample, lowest potassium value determined were less than the instrumental detection limit at ada'a bore hole rope pump 2 site.

Determination of Sulfates: The highest sulfate mean value determined were 2.0 mg/L at awash melkasa public bono, 4 mg/L at Tafki house hold 7, 2.0 mg/L at dukam yatu gudo and gogecha bore hole 1 and 18.0 mg/L at ada'a borehole deep well hand pump 4 sites (annexes, Table 2, 3, 4, 5 and 6). All these values were below Ethiopian compulsory standard and WHO guide lines (250 mg/L). Therefore, the results indicate that all water sampling sites has no sulfate related problem. The least determined mean value of sulfate was seen in all bishoftu water samples.

The presence of sulfate in drinking-water can cause noticeable taste and very high levels might cause a laxative effect in unaccustomed consumers. Taste impairment varies with the nature of the associated cation; taste thresholds have been found to range from 250 mg/liter for sodium sulfate to 1000 mg/liter for calcium sulfate. It is generally considered that taste impairment is minimal at levels below 250 mg/liter. No health-based guideline value has been derived for sulfate [11].

CONCLUSION

The study was conducted for selected Physico-chemical parameters of sebeta hawas and ada'a districts, bishoftu, dukam town water supplied for communities. Among the tested parameters, total hardness results shows that all the tested water sampling sites need further treatment. The turbidity value obtained at Tafki house hold and ada'a bore hole deep well hand pump was the highest and it needs further filtration and treatment processes. TDS value at site dukam mandalo bore hole and bishoftu gorgode bore hole were above the Ethiopian and WHO guide line value. Potassium and nitrates result shows that all the water sampling sites needs treatment or softening processes.

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REFERENCES

1. Urbansky, E.T. and M.L. Magnuson, 2002. Anaytical Chemistry, 74: 261A
2. Moyo, S., J. Wright, J. Ndamba and S. Gundry, 2004. Realising the maximum health benefits from water quality improvements in the home: a case from Zaka district, Zimbabwe. Physics and Chemistry of the Earth, 29: 1295-1299

3. Pruss-Ustun, A., J. Wolf, J. Bartram, T. Clasen, O. Cumming, M.C. Freeman, B. Gordon, P.R. Hunter, K. Medlicott and R. Johnston, 2019. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. International Journal of Hygiene and Environmental Health, 222(5): 765-777.
4. WHO, 2019. National systems to support drinking-water: Sanitation and hygiene: Global status report: UN-Water global analysis and assessment of sanitation and drinking water: GLAAS 2019 report. World Health Organization.
5. WHO, 2017. Guidelines for Drinking-Water Quality: First Addendum to the Fourth Edition, 4th ed. World Health Organization, Geneva, Switzerland.
6. WHO/UNICEF, 2017. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP). Available from: https://www.unwater.org/publication_categories/whounicef-joint-monitoring-programme-for-water-supplysanitation-hygiene-jmp (accessed 28 October 2020).
7. Beyene, A., T. Hailu, K. Faris and H. Kloos, 2015. Current state and trends of access to sanitation in Ethiopia and the need to revise indicators to monitor progress in the post-2015 era. BMC Public Health, 15(1): 451.
8. CSA, 2017. Drinking Water Quality in Ethiopia: Results from the 2016 Ethiopia Socioeconomic Survey. Report Central Statistical Agency of Ethiopia in Collaboration with the Ministry of Water, Irrigation and Electricity (MOWIE), Living Standards Measurement Study (LSMS), World Bank, UNICEF, WHO and WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), CSA, Addis Ababa, Ethiopia.
9. Compulsory Ethiopian Standard, 1st edition, 2013. Drinking water-specification.
10. UNICEF Ethiopia, 2018. Water, Sanitation and Hygiene (WASH) Improving Sanitation and Hygiene to Address Stunting, Diarrhea and Trachoma, Leveraging Resources for Access to Water and Sanitation in Schools and Health Facilities, Innovating to Improve Functioning of Water Supply. Available from: https://www.unicef.org/ethiopia/water, sanitation-and-hygiene-wash (accessed 28 October 2020).
11. Daniel, B., D. Tsehaye, S. Abdurahman, H. Tamene and H. Fetiya, 2022. Assessment of water quality by using Physico-chemical and microbiological parameters. The Case of Central Rift Valley Lakes, World Journal of Agricultural Sci., 18(2): 113-121.
12. WHO, 2004. Guidelines for Drinking-water Quality.
13. WHO, 1997. Guidelines for drinking-water quality, 2nd Edition, Volume 3, Surveillance and Control of Community Supplies.