مجله ایرانی شیمی تجزیه

دوره ۷، شماره ۱، فروردین ماه ۱۳۹۹ (۴۰-۳۰)

Physicochemical Characterization of Drinking Tap Water in Masha and Mizan-Aman Town, Southwest Ethiopia

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Abstract

Physicochemical characterization was carried out for the determination of the quality of drinking tap water from Masha, and Mizan-Aman town southwest Ethiopia. Known volume of tap water samples were digested by Standard Method 3030K microwave digestion system using 5 mL concentrated of HNO_3 for 20 minutes at variable temperature (160-170 °C). After digestion with microwave acid digestion, some selected metals (Mg, Ca, Cu, Mn, Fe, Zn, Cd & Pb) were determined by Flame Atomic Absorption Spectrophotometer and the common anions were determined as follows, Ortho phosphorous (PO_4^{3-}) by APHA4500-PC.Vanadomolybdphosphoric method, Chloride (Cl^-) by APHA4500-Cl-B. Argentometric method, Carbonate (CO_3^{-2}) by APHA 2330B.Titration method, Nitrate (NO_3^-) and ammonia (NH_3) by WTD photometer method (WAG PHOT-24).The concentration of these metals and common anions obtained in this study were found to be within the range of WHO and other international guideline lines except Cd. Levels of these metals concentration in this study was that, in all water samples, Mg was found in higher concentration followed by Ca, Fe, Mn, Zn, Cu and Cd respectively. Concentration of Pb was below the method detection limit in all water samples. Under this investigation, at p = 0.05, the physicochemical parameters of all water samples which were taken from different sites were significantly different among the distribution points and distribution systems. The concentrations of the selected metals and common anions were significantly different in between the distribution points and distribution systems except Zn in Mizan, Mn, Fe and Cd in Aman, NH_3 in Masha, and Aman sites and in respective of the physical parameters, temperature and electrical conductivity of all the water samples were significantly different except in Masha site. pH and total hardness of all water samples were not significantly different in all sites except total hardness in Masha site.

1. INTRODUCTION

Water is one of the most important and abundant compounds of the ecosystem. Most of the earth's water is undrinkable. Although 70% of the planet's surface is water, almost all of it is salt water in the oceans. Only 3% of the world's freshwater are safe for drinking, and 97% of that is frozen in glaciers. That leaves us with less than 1% usable water from lakes, rivers and underground sources. All living organisms on the earth need water for their survival and growth. Potable or water of good drinking quality is of the basic importance to human physiology and man's continued existence [1].The accessibility and availability of good quality drinking water plays the most important role in both social and economic development and; it is a basic factor in guaranteeing public health, the protection of the environment and sustainable development [2].Tap water is the major source of drinking water especially in urban areas. Due to natural phenomena and human made activities, it is highly polluted with different harmful contaminants. Therefore, it is necessary that the quality of drinking water should be checked at regular time interval, because due to use of

contaminated drinking water, human population suffers from varied of water borne diseases. According to WHO more than 80% of all the diseases in the world are attributed to unsafe drinking water or inadequate sanitation practices [3]. Although there are efforts and progress, many countries in the world met Millennium Development Goals target to water and a number of diversified and multipurpose international, regional and national governments, local and international NGOs exerted their efforts and invest huge capital every year at global scale in general and in developing countries in particular, access to improved water supplies and sanitation services in the world continues to be extremely marginal, and almost half of the world population is without access to improved sanitation facilities and more than one billion people still lack access to improved drinking-water supplies [4].The majority of the world's populations without access to improved water supply or sanitation services live in developing regions mainly in Africa and Asia[4]. In Ethiopia, access to improved water supply and sanitation was estimated at 54% for improved water supply (95% for urban areas and 45% for rural areas and

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12% for sanitation (29%in urban areas, 8% in rural areas).Unavailability of good quality drinking water is one of the worst problems in many parts of the developing nations including our country Ethiopia, particularly in rural areas, where many people lack enough water to stay healthy. Inhabitants of rural areas representing 84% of the global population use unimproved sources of drinking water, such as surface water, unprotected spring water, unprotected well water, and water from tanker trucks[5]. Clean, pure and safe water can exist only briefly in nature and immediately polluted by prevailing environmental factors aided by human activities. Water from most sources is therefore unfit for immediate consumption without some sort of treatment [6] and before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is potable and safe for drinking [7]. Potable water is defined as water that is free from disease producing microorganisms and chemical substances deleterious to health [8]. Hence treat, made safe and provision of portable water to rural and urban population is necessary to prevent health hazards associated with poor drinking water [9].

2. EXPERIMENTAL

2.1. Description of the study area
Water samples were collected from Mizan - Aman, and Masha town which are located in southwest Ethiopia. Mizan - Aman is the administrative center of Bench Maji Zone, Southern Nations Nationalities and Peoples Region (SNNPR), it is located about 560 kilometers southwest of Addis Ababa. Mizan - Aman is located at 7°0′N 35°35′E latitude and longitude respectively and its elevation is 1451 meters above sea level. Masha town are located in Sheka Zone, Southern Nations Nationalities and Peoples Region (SNNPR) and far about 610 and 676 kilometers from Addis Ababa respectively. Masha, the administrative center of Sheka Zone, has a latitude and longitude of 7°44′N 35°29′E with an elevation of 2223 meters above sea level, which is highland as indicated in Fig. 1.
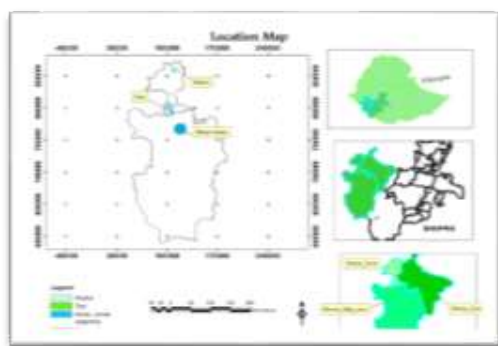

Fig.1. Location of study area.

2.2. Study design
A cross sectional and analytical study design were used to assess the physicochemical quality of water sources in the study area.

2.3. Apparatus
Flame Atomic Absorption Spectrometer, UV-Visible spectrometer, centrifuge, Volumetric flask, Conical flask, Electronic balance, Polypropylene bottles, Pipettes, Beakers, Thermometer, pH meter, Spectrophotometer, Glassware, Filtration apparatus and Filter paper are among the apparatuses which were used in this research.

2.4. Reagents and chemicals
The reagents and chemicals used in this study were: nitric acid, nitrate, nitrite, Phenolphthalein indicator, aqueous solution, HCl, H_2SO_4, $HClO_4$,Vanadate-molybdate reagent, Standard phosphate solution, Sodium carbonate solution, Standard hydrochloric acid, Standard solutions of Pb, Cu, Mg, Ca, Mn, Fe, Pb, Cd, deionized water and distilled water.Before the determination of metal cations, first 1000 mg/L stock solutions of each metal were prepared. From the stock solutions, working standard solutions were prepared for the calibration of the instruments.

2.5. Sample collection and Preparation
Representative water samples were collected from the selected sample sites. In this study, one reservoir was taken from Masha town and two reservoirs were taken from Mizan - Aman town. 10 distribution systems were selected randomly from each distribution point, two liter of tap water sample was taken from each reservoir and one liter of tap water sample was taken from each distribution system of the reservoir.

All the collected tap water samples of the distribution system from each distribution point was mix gently and two liter was taken as a composite sample of tap water of the distribution system. Tap water samples were packed in to polyethylene bottles which was rinsed with nitric acid and washed with distilled water and put in to ice box with ice packs, then tap water samples were labeled and transported to laboratory for further treatment after the sampling process were carefully completed.

2.6. Sample digestion
A method developed by standard method 3030K microwave digestion system was followed with slight modifications. Accordingly 10 mL of water samples were digested in 5 mL of concentrated nitric acid for 20 minutes. The digestion takes place in an inert polymeric microwave vessel that

is sealed and heated within the microwave system. The temperature profile of each sample was 160^0C within 10 minutes and 170^0C for 10 minutes which allows specific reactions to occur for digestion. The cooled analyte was allowed to settle and filtered before being analyzed by FAAS.

2.7. Determination of metal cations
For the determination of metal cations, the instrument (FAAS) was calibrated using four working standard solutions for each of metal interest. Working standards were prepared from the intermediate standard solutions containing 10 mg/L by diluting with double distilled deionized water. Intermediate standard solutions were prepared from the standard stock solution that contained 1000 mg/L for each metal interest. The parameters of flame atomic absorption spectrometer such as burner and lamp alignment, slit width and wavelength adjustment were optimized for maximum signal intensity of the instrument. The acetylene and air flow rates was manage to ensure suitable flame conditions. Hallow cathode lamp for each metal interest was operate at the manufacturer's recommended conditions used at its respective primary source line. Duplicate determinations were carried out for each sample.

2.8. Determination of common anions
Different methods were used for the determination of the common anions. These common anions were determined by the following methods.Ortho phosphorous (PO_4^{3-}) by APHA4500PC.Vanadomolybdphosphoric method, Chloride (Cl^-) by APHA4500-Cl B.Argentometric method, Carbonate (CO_3^{-2}) by APHA 2330B.Titration, Nitrate (NO_3^-) and ammonia (NH_3) by WTD photometer method (WAG PHOT-24).

2.9. Recovery analysis
The reliability and efficiency of the optimized procedure for the analysis of the ions from tap water samples were validated using spiking method, since there was no certified reference material. Accordingly the efficiency of the optimized procedure was checked by adding known concentration of each metal of interest in to the tap water samples.

2.9.1. Samples spiking
For spiking of samples, 1.25 mL of 0.1 mg/L Ca, Cu, Zn and Cd were spiked at once in to microwave digestion vessels that containing sample. 1.25 mL of 0.05 mg/L Mg, Mn and Fe were spiked at once in other microwave digestion vessels containing the same amount of sample. The spiked samples were digested in the same

manner and with the same reagents as described above for samples. For the recovery test of the common anions 2mg/L of PO_4^{3-} and 2mg/L of Cl^- were spiked to their respective samples.

2.10. Method detection limit
Method detection limits of the study were determined from the mean and standard deviation of the blanks. Eight blanks were digested in the same manner as described above for water samples, each blank was determined for each target analyte (Ca, Mg, Mn, Cu, Zn, Fe, Pb, and Cd). For each metal of interest, mean and standard deviation were calculated from the eight blank measurements to determine method detection limit.

2.11. Statistical data analysis
Statistical data analysis was made to check whether there was a significant difference in the physicochemical parameters between the samples taken from the study area. t – test and One way ANOVA were used to check whether there was a significant difference or not and the calculation was made using origin 6 software.

3. RESULTS AND DISCUSSION
3.1. Physicochemical characterization of water
3.1.1. Instrument calibration
The instruments were calibrated using five and four series of working standards. The working standards for each analyte of interest were used for external calibration running through FAAS. As it is shown from Table 1 the correlation coefficient obtained from the calibration curve of each metal was greater than 0.99 which indicates excellent correlation between the concentration and absorbance of each metal interest[10]. Concentrations of the working standards and value of correlation coefficient of the calibration graph for each metal is listed in Table 1.

Table 1. Concentrations of working standards and correlation coefficients of the calibration curve.

No	Metal	Concentration of working standards (mg/L)	Correlation coefficient
1	Ca	0.25, 0.5, 1.0, 2.0	0.999
2	Mg	0.5, 1.0, 1.5, 2.0, 2.5	0.999
3	Cu	0.25, 0.5, 1.0, 2.0	0.999
4	Zn	1.0, 2.0, 3.0, 4.0	0.997
5	Mn	0.1, 0.2, 0.3, 0.4, 0.5	0.999
6	Fe	1.0, 2.0, 3.0, 4.0, 5.0	0.998
7	Cd	0.25, 0.5, 0.75, 1.0	0.999
8	Pb	1.0, 2.0, 3.0, 4.0	0.999

3.1.2. Method detection limit
Method detection limit is the lowest analyte concentration that produces a response detectable above the noise level of the system or is the lowest concentration at which an analyte can be

detected at which no matrix interference; this means that the sample analyte can be distinguished from a blank with 99% certainty [11-12]. In the present investigation, replicate analyses for eight blank samples of the metals of interest were performed. Mean and standard deviation for each metal was calculated from the eight blanks. Accordingly method detection limit for water samples of each metal were above its instrumental detection limit. Method detection limit for water samples with respective instrumental detection limit for each metal is listed in Table 2.

Table 2. Instrumental and method detection limits for water samples.

No	Metal	Method detection limit for water samples (mg/L)	Instrument detection limit (mg/L)
1	Ca	0. 116	0.05
2	Mg	0.138	0.005
3	Cu	0.076	0.005
4	Zn	0.071	0.005
5	Mn	0.070	0.03
6	Fe	0.015	0.05
7	Cd	0.021	0.01
8	Pb	0.050	0.04

3.1.3. Analytical method validation

Validation of analytical method is the process used to confirm that the analytical procedure employed for a specific test is suitable for its intended use. Results from this evaluation of analytical method can be used to judge the quality, reliability and consistency of analytical results[13]. Spiking is among the methods for validation of analytical procedures. In this, it is essential to ensure that uniform chemical distribution is achieved between the material added and that originally present in the sample. The concentration of analyte in the spike should be sufficiently high so as to minimize disturbance by dilution of the matrix. Recovery of the method is determined from the values of spiked sample, non-spiked sample and the amount of known concentration added. Analysts are supposed to validate their analytical procedures and to estimate uncertainty associated to the results.

As shown in Table 3 the percentage recovery for water sample was 88 – 95 %, which is within the acceptable range for all metals and the percentage recovery of PO_4^{3-} was 96.7% and percentage recovery of Cl^- was 91.81% [14].

Table 3. Recovery test for water samples.

No	Metal	Concentration before spiking (mg/L)	Amount added (mg/L)	Concentration after spiking (mg/L)	% of recovery
1	Ca	8.776 $\pm$ 0.086	0.10	8.866$\pm$ 0.057	90.23$\pm$ 0.043
2	Mg	0.515 $\pm$ 0.001	0.25	0.745$\pm$ 0.002	92.05$\pm$ 0.026
3	Cu	0.108 $\pm$ 0.0002	0.10	0.197$\pm$ 0.001	89.14$\pm$ 0.015
4	Zn	0.750 $\pm$ 0.008	0.10	0.843$\pm$ 0.005	93.06$\pm$ 0.035
5	Mn	0.011$\pm$ 0.002	0.25	0.249$\pm$ 0.001	95.14$\pm$ 0.036
6	Fe	0.016 $\pm$ 0.004	0.25	0.249$\pm$ 0.002	93.26$\pm$ 0.014
7	Cd	0.01$\pm$ 0.001	0.05	0.055$\pm$ 0.003	91.04$\pm$ 0.005
8	Pb	0.017 $\pm$ 0.002	0.05	0.061$\pm$ 0.001	88.05$\pm$ 0.026
9	PO_4^{3-}	0.47$\pm$ 0.001	2.00	2.404$\pm$ 0.003	96.70$\pm$ 0.001
10	Cl^-	24.82$\pm$ 0.002	2.00	26.656$\pm$ 0.001	91.81$\pm$ 0.002

3.1.4. Physicochemical parameters

In this study physicochemical parameters such as temperature, pH, electrical conductivity and total hardness water samples determined in both distribution point and their respective distribution systems. As indicated from the Table 4, the mean temperature of all water samples was ranged between 20.76$\pm$0.05 ^{O}C to 27.2$\pm$0.05^{O}C. The minimum temperature was recorded from Masha distribution point while the maximum value was observed from Mizan distribution system. Concerning the pH of water samples of, it was lied between 7.18$\pm$0.04 to 7.83$\pm$0.06 recorded from Mizan site distribution point and Masha site distribution system respectively. The recorded pH values were found significantly different among distribution points and distribution systems in all study sites at P=0.05.This shows that water sample of pH values of all other samples were pH value within the prescribed recommended limits of WHO guideline [3].The Electrical conductivity (EC) values of all water samples were ranged between 55.7$\pm$1.7 - 87.2$\pm$0.3 μs /100mL the lowest and highest value is correspond to Masha site distribution point and Mizan distribution systems respectively. The recorded electrical

conductivity (EC) values were found significantly different among distribution points and distribution systems in all study sites at P=0.05.

The lowest and highest value EC of Masha site distribution point and Mizan distribution system respectively is might be the nature of source which is surface water and ground water. As per the electrical conductivity results of study site it is confirmed that, water source from bore well found higher conductivity than the surface water which is mainly due to higher concentration of dissolved solids in the ground water [15].The total hardness value of all water samples were found above the recommended value, which ranged from 383 ± 0.35 mg/L to 674 ± 1.84 mg/L from Masha site distribution system and Mizan distribution point respectively. This might be due to the presence of Ca, Mg, SO_4^{2-} & Cl^- in the study sites[16].The pattern of most physicochemical parameters was shifted up as the water flow from the distribution point to the distribution systems as indicated from Table 4.The independent t-test value shows that the temperature, pH, and electrical conductivity values of water samples from distribution systems were significantly higher than distribution points. The recorded total hardness values were not significantly different between distribution points and systems except in Masha site.

3.2. Chemical parameters
3.2.1.Determination of major, minor-essential and toxic metals
The concentrations of the eight elements in the digested and diluted solutions of water samples are shown in Table 5.

The present investigation shows that, these selected major, minor-essential metals were present in the water samples. From the toxic metals Pb was not detected in all water samples but Cd was detected in water samples.

As it is shown from Table 5 the concentration of Mg(98.4 ± 0.021 mg/L) was higher followed by Ca (9.686 ± 0.009 mg/L) in water samples. The levels of minor – essential metals in this sample, Fe (4.830 ± 0.009 mg/L) was higher followed by Mn (6.230 ± 0.001 mg/L), Zn (1.277 ± 0.016 mg/L) and Cu (0.111 ± 0.001 mg/L) respectively. Cd was detected in water samples with a maximum concentration (0.047 ± 0.002 mg/L) and the concentration of Pb was below the method detection limit.

3.2.2. Determination of common anions
Regarding the common anions, PO_4^{3-}, Cl^- and NH_3 were detected and ranged as, $0.21\pm0.023 - 1.91\pm0.019$ mg/L,$7.80\pm0.002 - 14.89\pm0.031$ mg/L and $0.023\pm0.006 - 0.350\pm0.350$ mg/L respectively. But the concentration of NO_3^- and CO_3^{2-} were found below the detection limit in all water samples as indicated from Table 6.

Table 4. Physicochemical parameters of water samples.

Sampling site	Physical parameter of distribution points			
	Temperature (ºC)	pH	Electrical conductivity ((μs/100cm³)	Total hardness (mg/l CaCO₃)
Mizan DP	24.4 ± 0.05	7.18 ± 0.04	81.7 ± 1.85	674 ± 1.84
Aman DP	23.3 ± 0.05	7.50 ± 0.08	57.5 ± 0.36	645 ± 0.78
Masha DP	20.76 ± 0.05	7.74 ± 0.13	55.7 ± 1.7	468 ± 0.14
Sampling site	Physical parameter of distribution systems			
	Temperature (ºC)	pH	Electrical conductivity (μs/100 cm³)	Total hardness (mg/l)
Mizan DS	27.2 ± 0.05	7.20 ± 0.05	87.2 ± 0.3	663 ± 0.49
Aman DS	25.3 ± 0.17	7.55 ± 0.025	58.8 ± 0.43	650 ± 0.00
Masha DS	22.06 ± 0.9	7.83 ± 0.06	57.4 ± 1.16	383 ± 0.35

Key: - DP: Distribution point, DS: Distribution system

Table 5. Mean concentration (X ± SD, n=2, mg/l) and relative standard deviation (% RSD) of Metals in tap water samples from different sites.

Sample	Ca (mg/L)	%RSD	Mg (mg/L)	%RSD	Cu (mg/L)	%RSD	Zn (mg/L)	%RSD	Mn (mg/L)	%RSD	Fe (mg/L)	%RSD	Cd (mg/L)	%RSD	Pb (mg/L)
											Metals				
Masha	8.981±0.013	0.14	90.11±0.003	0.003	0.045±0.001	2.22	1.277±0.016	1.25	3.490±0.00	0	4.830±0.009	0.18	0.01±0.001	10	ND
Masha	7.178±0.031	0.43	98.4±0.021	0.02	0.053±0.001	1.88	0.618±0.003	0.48	6.230±0.001	0.016	1.744±0.013	0.74	0.025±0.001	0.04	ND
Mizan DP	8.777±0.009	0.102	51.5±0.001	0.0019	0.108±0.001	0.92	0.750±0.008	1.06	1.155±0.002	0.17	0.162±0.004	2.46	0.032±0.005	15.6	ND
Mizan DS	9.686±0.009	0.092	82.1±0.019	0.023	0.062±0.001	1.61	0.881±0.066	7.49	1.87±0.001	0.05	0.296±0.044	14.8	0.047±0.002	4.25	ND
Aman DP	7.468±0.134	1.79	49.9±0.002	0.004	0.111±0.001	0.90	0.512±0.002	0.39	2.25±0.001	0.044	2.420±0.001	0.041	0.045±0.005	11.1	ND
Aman DS	5.678±0.040	0.70	69.8±0.001	0.001	0.072±0.001	1.38	0.329±0.003	0.91	2.36±0.001	0.042	2.117±0.022	1.039	0.046±0.001	2.17	ND

Key: - DP: Distribution point, DS: Distribution system, ND: Not Detected.

Table 6. Mean concentration (X ± SD, n=2, mg/l) and relative standard deviation (% RSD) of common anions in tap water samples from different sites.

Sample	PO_4^{3-} (mg/L)	%RSD	Cl^- (mg/L)	%RSD	NO_3^- (mg/L)	NH_3 (mg/L)	%RSD	CO_3^{2-} (mg/L)
Masha DP	0.33±0.015	4.5	8.51±0.015	0.2	ND	0.030±0.006	20	ND
Masha DS	1.85±0.001	0.2	7.80±0.002	0.03	ND	0.023±0.006	26	ND
Mizan DP	0.51±0.003	0.6	14.18±0.034	0.24	ND	0.056±0.006	10.7	ND
Mizan DS	0.47±0.001	0.2	8.51±0.012	0.14	ND	0.350±0.0350	10	ND
Aman DP	1.91±0.019	0.1	10.64±0.002	0.02	ND	0.060±0.001	1.66	ND
Aman DS	0.21±0.023	10.95	14.89±0.031	0.2	ND	0.083±0.006	7.2	ND

Key;- DP: Distribution point, DS: Distribution system, ND: Not Detected.

3.3. Comparison level of metals and common anions between distribution points and distribution systems

During the flow of water from the distribution point through the pips to the distribution systems there is some chemical and physical changes on the nature of the water due to different chemical interactions and physical phenomena with pipes in which the water supply flow. Under this investigation, at $p = 0.05$, the concentrations of

these selected metals and common anions were significantly different in between the distribution point and distribution systems except Zn in Mizan, Mn, Fe and Cd in Aman, NH_3 in Masha, and Aman sites. For the level of metals in which their concentration at the distribution point is greater than at the distribution systems with a significant difference is might be due to weight of the metals and/or different chemical and physical interaction with the pipe of the system that hinders for the mobility of the metals. On the other hand the level of metals in which their concentration at the distribution system is greater than at the distribution point with a significant difference is might be due the chemical composition of the pipes then additional amount is leach from the pipes to the water system during the flow.

3.4. Comparison level of metals and common anions between distribution points of different sites

Availability of metals in water from soil through different mechanisms such as: ionic exchange, redox reactions and precipitation. The solubility of metals in the soil depends also on the nature of soil (carbonates, oxide, hydroxide etc.), soil organic matter (humic acids, fulvic acids, polysaccharides and organic acids), soil pH, redox potential, soil temperature and humidity. From all metals in soil, only the metals that are mobile are transferred to the water body. These factors are widely different from one geographical location to another. Chemical compositions of water bodies which are located in different geographical location might be differing due these and other factors[17].

As it is shown from Table 7, the concentrations of these selected metals were significantly different (at p = 0.05) in between the distribution points. The concentration of Ca was significantly different in all water samples with the highest concentration of 8.981 ± 0.013 mg/L in Masha and lowest concentration of 7.468 ± 0.134 mg/L in Aman and the concentration of Mg was

significantly different in all water samples with the highest concentration of 90.11±0.003 mg/L in Masha and lowest concentration of 49.9 ± 0.002 mg/L in Aman.

For minor-essential metals, Cu(0.111±0.001 mg/L, Aman) - (0.108 ± 0.001 mg/L, Mizan), Zn(1.277±0.016mg/L ,Masha) - (0.512±0.002 mg/L, Aman), Mn (3.490 ± 0.001 mg/L, Masha) - (1.155 ±0.002 mg/L, Mizan), and Fe (4.830±0.009mg/L, Masha) - (0.162±0.004 mg/L,Mizan) with their highest and lowest values respectively. The concentration of Cd was significantly different in all water samples with the highest concentration of 0.045±0.005 mg/L in Aman and lowest concentration of 0.01± 0.001 mg/L in Masha.

As it is shown from Table 7, the concentration of all the common anions were significantly different in the entire sites at p = 0.05. Accordingly the concentrations of PO_4^{3-}, Cl^- and NH_3 were significantly different in all the water samples with the highest concentration of 1.91±0.019 mg/L, 14.18±0.034 mg/L and 0.060±0.001 mg/L in Aman site, Mizan site & Aman site respectively and lowest concentration of 0.33±0.015mg/L, 8.51±0.015 mg/L and 0.030±0.006 mg/L in Masha respectively.

3.5. Comparison level of metals and common anions between distribution systems of different sites.

The distribution points are the sources for water supply of households, therefore the distribution system water supply contain some physicochemical parameters as the distribution points water. Therefore, the distribution systems which are located at different geographical location and different climates have different chemical composition and different physical parameters. As it is shown from Table 8, the concentrations of these selected metals were significantly different (at p = 0.05), this is because of the difference of geographical location and climate of the sites.

Table 7. Comparison level of metals and common anions between distribution points of different sites

Metal/anion (mg/L)	Sites		
	Masha	Mizan	Aman
Ca	8.981±0.013	8.777±0.009	7.468±0.134
Mg	90.11±0.003	51.5±0.001	49.9±0.002
Cu	0.045±0.001	0.108±0.001	0.111±0.001
Zn	1.277±0.016	0.750±0.008	0.512±0.002
Mn	3.490± 0.001	1.155±0.002	2.25±0.001
Fe	4.830±0.009	0.162±0.004	2.420± 0.001
Cd	0.01±0.001	0.032±0.005	0.045±0.005
PO_4^{3-}	0.33±0.015	0.51±0.003	1.91±0.019
Cl^-	8.51±0.015	14.18±0.034	10.64±0.002
NH_3	0.030±0.006	0.056±0.006	0.060±0.001

Table 8. Comparison level of metals and common anions between distribution systems of different sites.

Metal/anion (mg/L)	Sites		
	Masha	Mizan	Aman
Ca	7.178±0.031	9.686 ±0.009	5.678 ±0.040
Mg	98.4±0.021	82.1±0.019	69.8±0.001
Cu	0.053± 0.001	0.062±0.001	0.072± 0.001
Zn	0.618±0.003	0.881±0.066	0.329±0.003
Mn	6.230±0.001	1.87± 0.001	2.36±0.001
Fe	1.744±0.013	0.296±0.044	0.046±0.001
Cd	0.025±0.001	0.047±0.002	0.046±0.001
PO_4^{3-}	1.85±0.001	0.47±0.001	0.21±0.023
Cl^-	7.80±0.002	8.51±0.012	14.89±0.031
NH_3	0.023±0.006	0.350±0.0350	0.083±0.006

Table 9. Comparison of present study with different national and international guidelines.

Physico-chemical properties	Canada (2007)	USEPA (1998)	WHO (2003)	Ethiopian guideline	Present study
Temperature (^{0}C)	15	-	15	-	20.76-27.2
Conductivity	-	300µmho/cm	300µmho/cm	1,000 µS/cm	55.7-87.2 µS/100ml
pH	6.5 to 8.5	6.5 - 8.5	6.5–8.5	6.5–8.5	7.18-7.83
Total Hardness	0-75	-	300-600	-	383- 674
Ca (mg/L)	-	100	2–80	200	5.678-9.686
Mg (mg/L)	50	30	5–235.6	50	49.9-98.4
Cu (mg/L)	≤1	1	2	2	0.045-0.111
Zn (mg/L)	≤5	5	3	6	0.329-1.277
Mn (mg/L)	-	0.05	<5	-	1.155-6.230
Fe (mg/L)	≤0.3	-	0.5–10	0.4	0.162-4.83
Cd (mg/L)	0.005	0.005	0.005	0.003	0.01-0.047
PO_4^{3-} (mg/L)	-	-	0.1	-	0.21-1.91
Cl^- (mg/L)	≤ 250	250	250	30	7.80-14.89
NH_3 (mg/L)	45	10	0.5	0.15	0.023-0.083

Note:-USEPA = United States Environmental Protection Agency Maximum Contaminant Level (MCL) (1998); WHO=World Health organization(2003)

Depending on this, the concentration of Ca was significantly different in all the water samples with the highest concentration of 9.686±0.009 mg/L in Mizan site and lowest concentration of 5.678 ±0.040 mg/L in Aman site, the concentration of Mg was significantly different in all the tap water samples with the highest concentration of 98.4±0.021 mg/L in Masha site and lowest concentration of 69.8±0.001 in Aman site. For the minor-essential metals, Cu 0.053±0.001 mg/L (Masha) - 0.072± 0.001 mg/L (Aman), Zn 0.329±0.003 mg/L (Aman) - 0.881±0.066 mg/L (Mizan), Mn 1.87±0.001 mg/L (Mizan) -6.23±0.001mg/L(Masha) and Fe 0.046±0.001 mg/L(Aman) - 1.744±0.013 mg/L (Masha) with their lowest and highest values respectively. The concentration of Cd was significantly different in all the tap water samples with the highest concentration of 0.047±0.002 mg/L in Mizan. As it is shown from Table 8, the concentrations of PO_4^{3-} , Cl^- and NH_3 were significantly different in all the water samples

with the highest concentrations of 1.85±0.001 mg/L (Masha), 14.89 ± 0.031 mg/L (Aman) and 0.350 ± 0.0350 mg/L (Mizan) and lowest concentrations of 0.21±0.023 mg/L (Aman), 8.51 ± 0.012 mg/L (Mizan) and 0.023±0.006 mg/L (Masha) respectively.

3.6.Comparison of present study with different international guidelines lay down by various international monitoring and regulatory bodies
The accumulation of metals especially the heavy metals in the environment is of increasing concern due to the food safety issues and potential health risk. Different international organizations have been developing regulatory frameworks and guidelines for metals level in the environment, drinking water and foodstuffs. As it is shown from Table 9, the present study shows that, the concentration of the major and minor-essential metals and common anions in water samples are in the safe side except for Cd**.**

3.7.Comparison of the present study with different reported literature values

Some researchers have reported the concentrations of some major and minor-essential, toxic metals and some common anions in water. The comparative study of the metals and anions concentration in water samples determined in this study and reported values of other researchers were presented in Table 10.

Under this investigation, the levels of the metals and anions except Ca and Mn were not significantly different from the levels of the same metals and anions reported by different scholars who have been conducted different researches on physicochemical parameters of tap water in Ethiopia. The difference for the two metals might be due to the difference in geographical locations of the areas and/or the analysis methods.

Table 10, Comparison of present study with other reported literature values.

Metal	Present study (mg/L)			Related study (ppm)	
Ca	5.678-9.686	12.03 – 200.4	[18]	67.54 – 72.81	[19]
Mg	49.9-98.4	2.87 – 66.46		59.23 – 65.55	
Cu	0.045-0.111	0.03 – 0.09	[20]	1.114	[21]
Zn	0.329-1.277	0.05 – 0.62		0.104	
Mn	1.155-6.230	0.061 – 0.092	[22]	0.924	
Fe	0.162-4.83	0.163 – 0.247		0.60	[23]
Cd	0.01-0.047	0.031 – 0.065		0.05 – 0.108	[24]
PO_4^{3-}	0.21-1.91	3.21 – 3.85	[25]	0.28 - 1.88	[26]
NH_3	0.023-0.083	2.15 - 4.51		0.95	[21]
Cl^-	7.80-14.89	4.2 – 60.58	[18]	260 - 271	[19]

4. CONCLUSION

4.1. Conclusion

In this study physicochemical parameters such as pH, temperature, electrical conductivity, total hardness, Cl-, PO_4^{3-} , CO_3^{2-} NO_3^- , NH_3 Ca , Mg, Fe, Cu, Zn, Mn, Cd and Pb were measured. The physicochemical parameters of all water samples met both national and international standards except Temperature, total hardness, Mg and Cd. The temperature records from all tap water samples showed a range from 20.76ºC up to 27.2ºC, compared to the standard of <15ºC.Total hardness recorded was ranged between 383 – 674 mg/l compared to 300 - 600 mg/L WHO standard allowable limit [3].In respective to metals, Cd was recorded 0.047 mg/L in Aman site which is above the recommended values set by WHO[27].

4.2. Recommendations

Even though all tap water samples met international and national physicochemical parameter standards, for those parameters above the guidelines need to come up with protection strategies for the study areas. The present study was considered some selected physicochemical parameters. So, other water quality parameters which weren't investigated should be undertaken.
By accounting the physicochemical analysis, researcher recommend the essence water source protection, installation of standardized and efficient treatment process in the distribution points and stringent control and management of distribution systems to avoid cross contamination.

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بررسی خواص فیزیکوشیمیایی آب آشامیدنی شهرهای ماشا و میزان-آما در جنوب اتیوپی

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چکیده

خواص فیزیکوشیمیایی آب آشامیدنی شهرهای ماشا و میزان-آما در جنوب اتیوپی برای بررسی کیفیت آب تعیین گردید. حجم مشخصی از نمونه های آب شیر با روش استاندارد هضم میکرو ویو $3030K$ توسط ۵ میلی لیتر اسید نیتریک غلیظ به مدت ۲۰ دقیقه در دمای متغیر (۱۷۰-۱۶۰) صورت گرفت. بعد از هضم به روش هضم اسیدی میکرو ویو، تعدادی از فلزات از جمله منگنز، کلسیم، مس، منیزیم، آهن، روی، کادمیم و سرب توسط اسپکترومتری جذب اتمی شعله و آنیون های متداول آب با روش های زیر تعیین گردیدند. PO_4^{3-} به روش وانادومولیبدوفسفریک، یون کلرید به روش آرژنومتری، یون کربنات به روش تیتراسیون و نیترات و امونیاک به روش فتومری WTD. غلظت همه این آنیون ها و فلزات بجز کادمیوم در محدوده استانداردهای بین المللی و سازمان بهداشت جهانی بود. در همه نمونه های آبی، منگنز غلظت بالاتری نسبت به سایر فلزات داشت و سپس کلسیم، آهن، منیزیم، روی، مس و کادمیم به ترتیب بیشترین غلظت ها را داشتند. در این تحقیق، در P=۰.۰۵، پارامترهای فیزیکوشیمیایی همه نمونه های آبی که از مناطق مختلف نمونه برداری شده بود، بطور محسوسی در بین نقاط توزیع و سیستم های توزیع متفاوت بود. غلظت فلزات و آنیون های انتخاب شده در بین نقاط و سیستم های توزیع کاملاً متفاوت بود بجز روی در شهر میزان و منیزیم، آهن و کادمیم در شهر آمان و نیز نیترات آمونیاک در شهر ماشا، در بین خواص فیزیکی دما و هدایت الکتریکی همه نمونه های آبی در همه، بجز منطقه ماشا کاملاً متفاوت بود. pH و سختی کل همه نمونه های آبی بجز منطقه ماشا یکسان بود.

واژه‌های کلیدی

آب شیر، فلز، آنیون، نفاط توزیع، سیستم توزیع.