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Physicochemical quality of drinking water sources in Ethiopia and its health impact: a retrospective study

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Abstract

Background: This retrospective study was aimed to examine the distribution of some physicochemical parameters and its health impact in selected drinking water sources of Ethiopia. The study used 983 water samples collected from different regions of the country, and have been tasted in the Environmental Health Laboratory, Ethiopian Public Health Institute, from 2003 to 2011. The samples were collected from eight regions plus two administrative cities of the country and classified based on the source type as spring, well, and tap water.

Methods: The physicochemical parameter analysis was executed based on standard method. Microsoft Excel and IBM SPSS Statistical software were used for the statistical analysis of median and graph.

Results: The median result indicates that some values are within the acceptable range (PH, magnesium, chloride and sodium from spring and tap water), but, there are some measured values in some regions which are out of the recommended limit, (total hardness and calcium in spring, tap and well water). On the other hand, very high Sodium and chloride concentration were recorded in spring, tap, and well water sources of the region such as Somali, Afar, and Oromia.

Conclusions: Those water sources that do not conform to National Standard will result in public health problem in long time exposure. Therefore, the local water authority shall strengthen local water quality monitoring and control system as well as risk assessment and management mechanisms.

Keywords: Physicochemical, Drinking water quality, Water sources, Health impact, Retrospective study

Background

Water is an essential component of human life and it is a universal solvent which has the ability to dissolve many substances of organic or inorganic compounds. With this outstanding property, nevertheless it is almost impossible to have water in its pure form since it cannot be held up in a vacuum (Bernard and Ayeni 2012). Water sources, including surface, ground and rain (in arid and some arid areas) are supporting drinking water supply, livestock needs, irrigation, industrial and many other commercial and domestic purposes. The quality of water sources depends on the various chemical constitutes and their concentration, which are mostly induce from natural and anthropogenic activities.

In Ethiopia, there is a rapid increase in population; however the common drinking water sources are limited to wells, springs, and taps. Now a day, these water sources are becoming contaminated and the contamination level is increasing, for example the expansion of industries in urban areas and agricultural practices in rural areas are the most common factors for water pollution. The study conducted in Ethiopia revealed that, the dominant sources of drinking water supply for major urban and rural communities are from wells and springs (Gebrekidan and Samuel 2011). Hence, Water quality is a key aspect of urban and rural water supply, which may influence community attitudes, thereby potentially

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affecting the sustainability of water supply systems. Perceived poor water quality influences the use of water, thus creating potentials of health risks through the development of unsafe alternative sources (Hoko 2008).

Water for human consumption must be free from living and non-living organisms, toxic elements and chemical substances in concentration large enough to affect health. The addition of various kinds of pollutants through sewage, industrial effluents, agricultural runoff, etc., into the water main stream brings about a series of changes in the physicochemical characteristics of the water, which have been the subject of several investigations (Bernard and Ayeni 2012). Likewise, human activities are a major factor that determines the quality of surface waters directly and indirectly by atmospheric pollution, effluent discharges and agricultural practice (Sillanpää et al. 2004). Hence, water, which infiltrates through the soil and accumulates in underground aquifers and this water have had lengthy exposure to calcium carbonate and sulfate are typically hard and alkaline (Von Gunten 2003).

Many chemicals found in drinking water sources may be the cause of adverse human health effects, affect the acceptability of water and lower the effectiveness of water treatment. The health impacts related to chemicals in drinking water are mainly those that cause adverse effects after long term exposure. The severity of this health effect depends upon the chemical; and its concentration, as well as the length of exposure. There are only a few chemicals that can lead to health problems after a single exposure, except through massive accidental contamination of a drinking water supply (WHO 2006). The main problems associated with chemical components of drinking water arise primarily from their ability to cause adverse health effects after prolonged periods of exposure, especially in the developing countries can be traced to lack of safe and wholesome water supply (WHO 2004). Then, the health impact associated with chemical elements of drinking water differ from microbial contamination, which arises from prolonged exposure to chemicals.

On the other hand, some chemicals in drinking water could be beneficial or detrimental health effects depending on its concentration, and total amount ingested. And yet, there is some evidence that magnesium can have protective effects against heart diseases or an inverse relation with cardiovascular diseases in general. The important effects of magnesium (Mg) on humans among the numerous study variables involved in the water story are that Mg appears preeminent. Also, its importance is both quantitative and qualitative intakes of water; magnesium (Mg) may palliate an "absolute" Mg deficit and its multiple consequences, particularly on the nephron-cardiovascular apparatus (Durlach et al. 1989). However, if the concentration of sodium exceeds from the recommended amount, it may cause to increase blood pressure (FDEP 2014). Though recent findings suggest that high sodium intake could result in high blood pressure (hypertension) that causes cardiovascular disease, stroke, and coronary heart disease, and mortality. Reducing salt intake lowers blood pressure and also reduces the incidence of cardiovascular diseases (Geleijnse et al. 2003; Bochud et al. n.d.; WHO 2012). So, Ethiopia as a country needs to have safe and adequate water supply at all levels to protecting public health in both intra and inter generations.

Physicochemical analysis of water quality would be expensive, difficult and need skilled personnel as well as sophisticated technology and referenced laboratory setting to test for all physicochemical parameters. Since, a country like Ethiopia have limited technical and financial resources for regular water quality assessment and has a constraint to conduct a national monitoring program for all water sources. Even though, this retrospective doesn't show temporal variations and some of the samples which not collected by professionals would result in deteriorate quality due to poor sample collection, preservation and transportation process and proportion of samples from some regions may not representative of the area. However, this retrospective study of physicochemical parameters of national referenced laboratory data have paramount importance to assess the national water quality status in all drinking water sources in the country. Hence, the aim of this retrospective study is to examine the distribution of selected physicochemical parameters and its health impact by comparing its values with the Ethiopian compulsory Standard for drinking water and to generate information which enables for health regulatory and water authorities to monitor water sources.

Methods

Country description

Ethiopia is found in the Horn of Africa and located between 33°E and 48°E longitudes and 3°N and 15°N of the equator. Ethiopia is a country with a great geographical variation. Its topography ranging from 4550 meters above sea level to 110 m below and bordered by five countries: on the north and northeast by Eritrea, on the east by Djibouti and Somalia, on the south by Kenya, and on the west and southwest by Sudan. Ethiopia is a Federal Democratic Republic composed of nine National Regional States namely: Tigray, Afar, Amhara, Oromia, Somali, Benshangul-Gumuz, Southern Nations, Nationalities and Peoples (SNNP), Gambella and Harari, plus two Administrative States (Addis Ababa and Dire Dawa City Administration) as indicated in Fig. 1. The national regional states as well as the two city Administrative councils are further divided in eight hundred woredas and around 15,000 Kebeles (5000 Urban and 10,000 Rural) (FDRE 1995).

Fig. 1 Map of Ethiopian regional and administrative city

Sample collection and analysis

This retrospective study used 179 springs, 551 well and 253 tap water samples collected across the country (Fig. 2). The data were generated from the year 2003 to 2011 in the Environmental Health Laboratory, Ethiopian Public Health Institute. The tested physicochemical parameter include: PH, Total Hardness, Total Silica (SiO_2), Sodium (Na^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Chloride (Cl^-) and Phosphate (PO_4^{3-}) in this retrospective investigation.

Quality control and quality assurance were checked for all parameters used in this study. We determined the linearity of calibration graphs with each batch analysis of the samples (approximately $R^2 > 0.999$) and calculating ion balances (cation and anion). There were also several in house standards analyzed together with samples to ensure quality of data.

All the analytical procedures used in the physicochemical analysis of the water samples were executed according to standard method of water and waste water analysis (APHA 1992). Details of the analytical methods for each parameter are listed below;

PH: It was determined by ion meter model 345 potentiometrically. The PH meter was calibrated before measurement with a buffer solution of PH 4.01 and PH 7.0 according to the manufacturer's calibration procedure.

Total Silica (SiO_2): The concentration of the Total Silica (SiO_2) was measured according to a Molybdosilicate method. The intensity of yellow color is measured by UV–VIS Spectrophotometric at 410 nm wave length, and the concentration was presented as mg SiO_2/L.

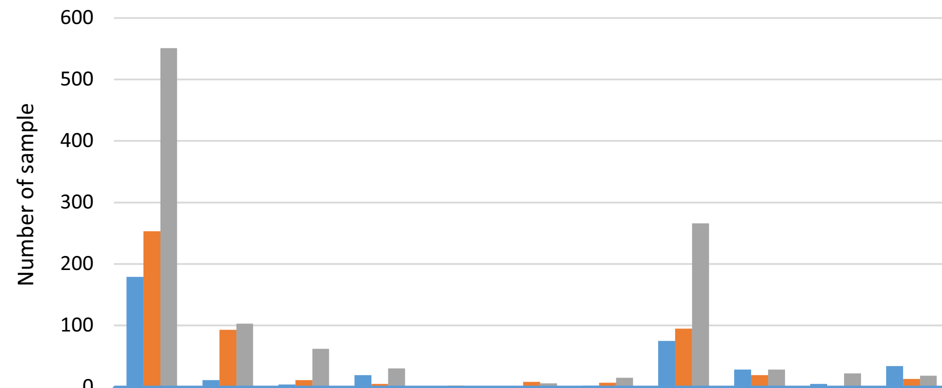
Sodium (Na^+): The concentration of Sodium (Na^+) was measured by the Flame photometric method.

Total hardness: EDTA titrimetric method was used to measure the concentration of total water hardness.

Calcium (Ca^{2+}): The concentrations of Calcium (Ca^{2+}) in the water sample were determined using EDTA titrimetric method.

Magnesium (Mg^{2+}): Magnesium (Mg^{2+}) concentration was determined by difference after analysis of Total Hardness and Calcium (Ca^{2+}).

Chloride (Cl^-): The concentration of Chloride (Cl^-) in the water sample was determined by Argentometric method.



	Total Number of Smples	Addis Ababa	Afar	Amhara	Benshangul Gumuz	Dire Dawa	Harari	Oromia	SNNP	Somali	Tigray
Spring water samples	179	11	4	19	1	0	2	75	28	5	34
Tap water samples	253	93	11	5	2	8	7	95	19	0	13
Well water samples	551	103	62	30	1	6	15	266	28	22	18

Fig. 2 Number of samples collected in regional and administrative city

Phosphate (PO_4^{3-}): The concentrations of Phosphate (PO_4^{3-}) in the water sample were measured using UV–VIS Spectrometric by Stannous chloride method at 690 nm wavelength.

Statistical analysis

Microsoft Excel and IBM SPSS 20 for windows software were used for the statistical analysis of the median and Percentage of the water sources out of the recommended limit (%WSORL).

Result and discussion

A summary of results for selected physicochemical parameters from spring, well, and tap water samples are shown in Tables 1, 2, and 3 as Median and %WSORL. Table 4 shows aggregated median value of each parameter, and this parameter is compared with the values set by the Ethiopian drinking water standard.

Measurement of PH is one of the most important and frequently used tests in water chemistry. Although, the Ethiopian Drinking water standard has set an allowable PH value ranges from 6.5 to 8.5 (ES 2001), it is known that PH is more important as operational water quality parameters than its impact on consumers. The median value of PH for the spring, tap, and well water samples collected from each region and administrative city of the country (Fig. 2), are among the Ethiopian standard for drinking water as indicated in Tables 1, 2, and 3, and an aggregated median PH value for spring, tap and well water are 6.93, 7.31, and 7.52 respectively as shown in Table 4. 63 % of samples collected from spring, 85 % from Tap, and 89 % from well water has a pH values in the middle of 6.5 and 8.5. Thus, the median PH value of water sample source are between the ranges and has not palatability or aesthetic problem. On the other hand, very low PH values were observed. For example, a spring water source from Oromia (Ambo Sekele-5) has a PH of 4.76 where as a tap water source from Addis Ababa showed a PH of 4.9. In contrast, very high PH values were also obtained in tap and well water sources. A tap water source from Tigray (Tsaeda Emba) and Addis Ababa (Nifas Silk Lafto sub city) has a PH of 9.7 and 11.80 respectively. Similarly, a PH of 10.35 was noted for a sample from a well water source from Amhara (Quarite). Likewise, a PH of 9.0, 9.1, and 9.5 for a well water source from Afar (Hamiltole School), Oromia (Meki Cattle Market) and Addis Ababa (Yeka) respectively were recorded.

Silica in water is undesirable for a number of industrial uses because it forms difficult to remove silica and silicate scales in equipment, particularly on high pressure blades (APHA 1992). The median result of total silica is 41.36 mg/L for spring, 24.08 mg/L for tap, and 62.86 mg/L for well water samples observed nationally from the collected sample sources (Table 4). Yet, the Ethiopian drinking water Standard does not state the health effect of Silica and there are no recommended limit values (ES 2001).

Sodium is present in most natural waters. A recommended limit value for Sodium in drinking water set by the Ethiopian standard is 200 mg/L (ES 2001). The

Table 1 Median and %WSORL of selected physicochemical parameters of spring water samples

Region	Total number of sample	Selected physicochemical parameters							
		PH	Total Hardness mg/L as $CaCO_3$	SiO_2 (mg/L)	Na^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)
Addis Ababa	11	7.30 %WSORL = 0	56.0 %WSORL = 0	41.36	15.64 %WSORL = 0	16.03 %WSORL = 0	3.81 %WSORL = 0	4.20 %WSORL = 0	0.05
Afar	4	7.75 %WSORL = 50	76.0 %WSORL = 0	75.62	142.8 %WSORL = 50	21.64 %WSORL = 0	4.3 %WSORL = 0	60.58 %WSORL = 0	0
Amhara	19	7.0 %WSORL = 26.3	76.0 %WSORL = 0	37.07	12.58 %WSORL = 0	24.0 %WSORL = 0	5.28 %WSORL = 0	6.4 %WSORL = 0	0.06
Benshangul Gumuz	1	7.1 %WSORL = 0	80.0 %WSORL = 0	45.0	7.65 %WSORL = 0	16.03 %WSORL = 0	9.57 %WSORL = 0	3.99 %WSORL = 0	0.25
Dire Dawa	–	–	–	–	–	–	–	–	–
Harari	2	7.4 %WSORL = 0	303.0 %WSORL = 50	36.48	69.28 %WSORL = 0	79.76 %WSORL = 50	24.85 %WSORL = 0	32.09 %WSORL = 0	0.02
Oromia	75	6.6 %WSORL = 46.7	192.0 %WSORL = 45.3	49.54	85.0 %WSORL = 48	38.48 %WSORL = 38.7	11.47 %WSORL = 10.7	23.99 %WSORL = 1.3	0.04
SNNP	28	7.44 %WSORL = 25	46.0 %WSORL = 7.1	67.14	23.21 %WSORL = 25	12.03 %WSORL = 3.6	2.87 %WSORL = 0	4.06 %WSORL = 0	0.05
Somali	5	7.04 %WSORL = 0	700.0 %WSORL = 100	36.67	119.0 %WSORL = 40	200.4 %WSORL = 100	47.72 %WSORL = 40	119.96 %WSORL = 20	0.01
Tigray	34	6.58 %WSORL = 50	48.0 %WSORL = 0	17.05	7.48 %WSORL = 0	14.43 %WSORL = 2.9	3.82 %WSORL = 0	7.0 %WSORL = 0	0.08
ES (2001) (MPL)	–	6.5–8.5	300	–	200	75	50	250	–

%WSORL percentage of water source out of recommended limit, *MPL* maximum permissible limit, *ES* Ethiopian Standard

Table 2 Median and %WSORL of selected physicochemical parameters of tap water samples

Region	Total number of sample	Selected physicochemical parameters							
		PH	Total hardness mg/L as $CaCO_3$	SiO_2 (mg/L)	Na^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)
Addis Ababa	93	7.33 %WSORL = 8.6	56.0 %WSORL = 2.2	16.3	6.8 %WSORL = 1.1	14.43 %WSORL = 2.2	3.82 %WSORL = 1.1	7.2 %WSORL = 0	0.02
Afar	11	7.68 %WSORL = 27.3	96.0 %WSORL = 0	28.0	56.52 %WSORL = 36.4	25.65 %WSORL = 0	4.78 %WSORL = 0	16.0 %WSORL = 9.1	0.12
Amhara	5	7.43 %WSORL = 0	84.0 %WSORL = 0	5.45	21.08 %WSORL = 0	27.25 %WSORL = 0	3.81 %WSORL = 0	7.6 %WSORL = 0	0.04
Benshangul Gumuz	2	7.26 %WSORL = 0	74.0 %WSORL = 0	71.17	14.79 %WSORL = 0	18.44 %WSORL = 0	6.7 %WSORL = 0	2.8 %WSORL = 0	0.07
Dire Dawa	8	7.47 %WSORL = 0	600.0 %WSORL = 75	44.55	45.9 %WSORL = 12.5	172.38 %WSORL = 87.5	43.42 %WSORL = 25	120.98 %WSORL = 0	0
Harari	7	7.54 %WSORL = 0	280.0 %WSORL = 28.6	41.60	58.7 %WSORL = 0	80.2 %WSORL = 57.1	19.06 %WSORL = 14.3	37.0 %WSORL = 0	0
Oromia	95	7.17 %WSORL = 22.1	96.0 %WSORL = 12.6	30.0	27.88 %WSORL = 13.7	25.65 %WSORL = 12.6	5.74 %WSORL = 6.3	6.0 %WSORL = 1.1	0.05
SNNP	19	7.0 %WSORL = 15.8	60.0 %WSORL = 0	50.24	52.7 %WSORL = 0	16.03 %WSORL = 0	4.78 %WSORL = 0	2.4 %WSORL = 0	0.02
Somali	–	–	–	–	–	–	–	–	–
Tigray	13	7.5 %WSORL = 23.1	100.0 %WSORL = 23.1	21.3	28.9 %WSORL = 7.7	24.04 %WSORL = 23.1	9.57 %WSORL = 0	5.2 %WSORL = 0	0.09
ES (2001) (MPL)	–	6.5–8.5	300	–	200	75	50	250	–

%WSORL percentage of water source out of recommended limit, *MPL* maximum permissible limit, *ES* Ethiopian standard

Table 3 Median and %WSORL of selected physicochemical parameters of well water samples

Region	Total number of sample	Selected physicochemical parameters							
		PH	Total hardness mg/L as $CaCO_3$	SiO_2 (mg/L)	Na^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/)
Addis Ababa	103	7.34 %WSORL = 12.6	154.0 %WSORL = 8.7	50.73	27.2 %WSORL = 2.9	41.68 %WSORL = 11.7	10.5 %WSORL = 0	12.0 %WSORL = 1	0.03
Afar	62	7.72 %WSORL = 6.5	182.0 %WSORL = 32.3	80.0	391.0 %WSORL = 69.4	42.49 %WSORL = 25.8	19.4 %WSORL = 16.1	130.46 %WSORL = 33.9	0.05
Amhara	30	7.38 %WSORL = 10	96.0 %WSORL = 16.7	56.12	49.3 %WSORL = 26.7	28.05 %WSORL = 16.7	6.69 %WSORL = 6.7	8.0 %WSORL = 0	0.05
Benshangul Gumuz	1	7.4 %WSORL = 0	112.0 %WSORL = 0	41.22	12.24 %WSORL = 0	30.46 %WSORL = 0	8.6 %WSORL = 0	1.0 %WSORL = 0	0.08
Dire Dawa	6	7.26 %WSORL = 16.7	590.0 %WSORL = 66.7	44.55	47.6 %WSORL = 16.7	150.3 %WSORL = 66.7	44.17 %WSORL = 33.3	137.23 %WSORL = 0	0
Harari	15	7.22 %WSORL = 0	290.0 %WSORL = 40	43.7	74.8 %WSORL = 6.7	72.14 %WSORL = 46.7	22.0 %WSORL = 6.7	39.32 %WSORL = 0	0.01
Oromia	266	7.66 %WSORL = 13.5	104.0 %WSORL = 6.4	67.27	54.5 %WSORL = 24.8	27.25 %WSORL = 7.9	8.57 %WSORL = 1.5	8.04 %WSORL = 1.5	0.08
SNNP	28	7.58 %WSORL = 14.3	84.0 %WSORL = 14.3	79.81	68.0 %WSORL = 21.4	24.05 %WSORL = 10.7	4.78 %WSORL = 0	6.45 %WSORL = 0	0.04
Somali	22	7.3 %WSORL = 0	865.0 %WSORL = 72.7	47.59	224.4 %WSORL = 59.1	160.32 %WSORL = 77.3	66.46 %WSORL = 59.1	234.93 %WSORL = 40.9	0.02
Tigray	18	7.38 %WSORL = 11.1	202.0 %WSORL = 33.3	35.0	41.65 %WSORL = 11.1	55.31 %WSORL = 38.9	15.3 %WSORL = 11.1	10.99 %WSORL = 0	0.09
ES (2001) (MPL)	–	6.5–8.5	300	–	200	75	50	250	–

%WSORL percentage of water source out of recommended limit, *MPL* maximum permissible limit, *ES* Ethiopian standard

Table 4 Median and %WSORL of selected physicochemical parameters of spring, tap, and well water samples

Source of water samples	Total number of sample	Selected physicochemical parameters							
		PH	Total hardness mg/L as $CaCO_3$	SiO_2 (mg/L)	Na^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)
Spring water	179	6.93 %WSORL = 36.9	72.0 %WSORL = 23.5	41.36	25.50 %WSORL = 26.3	19.24 %WSORL = 20.7	5.70 %WSORL = 5.6	7.6 %WSORL = 1.1	0.05
Tap water	253	7.31 %WSORL = 15.0	76.0 %WSORL = 9.9	24.08	20.40 %WSORL = 7.9	20.84 %WSORL = 11.1	4.78 %WSORL = 3.9	7.2 %WSORL = 0.8	0.04
Well water	551	7.52 %WSORL = 11.4	140.0 %WSORL = 15.8	62.86	54.4 %WSORL = 25.9	35.27 %WSORL = 16.7	10.50 %WSORL = 6.2	12.0 %WSORL = 6.4	0.06
ES (2001) (MPL)	–	6.5–8.5	300	–	200	75	50	250	–

%WSORL percentage of water source out of recommended limit, *MPL* maximum permissible limit, *ES* Ethiopian standard

number of samples from well water with high sodium concentration is higher than the tap and spring water samples. As well, very high Sodium concentration was recorded in spring water sources, 1020 mg/L from Somali (Afder, Bari) and 5304 mg/L from Oromia (North Shoa Ejere). In tap water sources, 1088 mg/L from Oromia (Ethiopia Cutting Mojo-1) and 1190 mg/L from Oromia (Koka Dam outlet) were noted extremely high in Sodium concentration. In addition, well water sources, 1842.8 mg/L from Afar (Handeg village), 4986.67 mg/L from Afar (Hamiltole School) and 6006.7 mg/L from Afar (Dubty, magenta) were very high sodium concentration recorded. The ratio of sodium to total cations is important in agriculture and human pathology. But, persons afflicted with certain diseases require water with low sodium concentration. Though, the state of Florida Department of Environmental Protection (FDEP) has set the drinking water standard for sodium at 160 mg/L to protect individuals that are susceptible to sodium sensitive hypertension or diseases that cause difficulty in regulating body fluid volume (FDEP 2014). Although, no health based guideline value is proposed for sodium in drinking water, the concentrations in excess of 200 mg/L may give rise to unacceptable taste (WHO 2011; ES

2001). While, recent finding reports that reducing salt intake lowers blood pressure and also reduces the incidence of cardiovascular diseases (WHO 2012). Similarly, for all those water sources extremely high in sodium concentration may rise cardiovascular diseases and this will increase the mortality rate.

This result indicated that relative maximum total hardness value was recorded in spring water samples from Oromia (1100 mg/L); tap water from Addis Ababa (1600 mg/L), and well water samples from the Afar region (12,800 mg/L). Forty-two of spring water, twenty-five of tap water and eighty-seven of the well water samples were exceeded the national recommended limit for total hardness (ES 2001). Hard water can affect acceptability of drinking water above a certain limit. However, Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions (WHO 1993). The need for softening of domestic supplies depends on reasons of convenience and economy rather than of health concern, since even at very high concentrations of up to 1000 mg/L hardness is quite harmless. Similarly, there is some evidence that Total Hardness can have a protective effect against heart disease or an inverse relation with cardiovascular diseases in general. Indeed, there is some statistical evidence to suggest that artificially softened water may increase the incidence of some forms of heart disease (Tebbutt 1998).

However, 167 and 54 water samples were in compliance with national standards for calcium and magnesium respectively for all water sources. Ethiopian Standard sets its maximum limit of 50 mg/L of magnesium in drinking water. Magnesium is a common constituent of natural water and it is an important contributor to the hardness of water, magnesium salts break down when heated, and forming scale in boilers. Coand economy rather than of health concern, since evenncentration greater than 125 mg/L also can have a cathartic and diuretic effect (APHA 1992). The long term magnesium exposure in mineral water consumption can contribute to a sufficiently high urine volume and consequently to a decline in the concentration of lithogeny substances and the risk of calcium oxalate crystallization, counterbalancing increased calcium excretion (Siener et al. 2004). In general, aggregated median concentration of calcium, magnesium, and total hardness in all water samples conformed to the national standard.

Chloride, in the form of chloride (Cl^-) ion, is one of the major inorganic anions in water and wastewater. It can originate from natural and anthropogenic activities, such as sewage and industrial effluents. Ethiopian Standard sets the Chloride limit of 250 mg/L Chloride for drinking water (ES 2001). Although, a total of 39 samples has exceeded the standard limit of 250 mg/L, a higher number of well water samples have contributed to this divergence. The regional distribution as shown in Table 1, 2, and 3 puts Afar region at the top having 21 samples in compliance to the national standard. Relatively, chloride concentration was detected higher in well water samples than spring and tap water samples. The very high Chloride value of spring water sources, 1399.6 mg/L from Somali (Afder, Bare) and 5598 mg/L from Oromia (North Shoa Ejere) were recorded. Additionally, in the well water sources extremely high chloride concentration of 3338.96 mg/L from Somali (Gilfega village), 12,995.97 mg/L from Afar (Dubty, magenta), and 13,195.91 mg/L from Afar (Hamiltole School), were recorded. The high chloride content may harm metallic pipes and structures (Terrence et al. 2007) and chloride concentrations in excess of about 250 mg/L can give rise to detectable taste in drinking water. On the other hand, no health based guideline value is proposed for chloride in drinking water.

Water may contain PO_4^{3-} derived from contact with natural minerals or through pollution from an application of fertilizer, sewage and industrial waste. Hence, ground water is more likely to have higher PO_4^{3-} concentration (Maiti 2004). The median concentration of Phosphate nationally for spring, tap, and well water samples were 0.05, 0.04, and 0.06 mg/L, respectively as indicated in Table 4. However, the extremely high phosphate value was recorded in well water sources than spring and tap water sources. And yet, the WHO guideline and Ethiopian Standard could not state its health effect and also does not consider its guideline standard value for drinking water quality.

Conclusions

Quality of water sources in Ethiopia is subjected to contamination and pollution resulting from anthropogenic activities and natural sources. The result in this study indicates that, some of the physicochemical parameters analyzed values do not conform to either the Ethiopian compulsory Standard or WHO guideline values. The water sources that do not conform to National Standard will result to the public health problem in long time exposure. However, some of parameters like sodium and chloride in high concentration have negative health effects, particularly to those with high blood pressure and chronic kidney disease. On the other hands, total hardness and magnesium as parameters has not any notify health effects on human being rather has positive health effect in high concentration for cardiovascular and heart diseases.

In general, consuming water with above of permissible limit value could cause serious health problem. Those water sources that do not conform to National Standard will result in public health problem in long time exposure. Therefore, the local water authority shall strengthen local water quality monitoring and control system as well as risk assessment and management mechanisms.

Abbreviations
ES: Ethiopian standard; Mg/L: milligram per liter; WHO: World Health Organization; MPL: maximum permissible limit; EPHI: Ethiopian Public Health Institute; SNNP: Southern Nation, Nationality People; FDRE: Federal Democratic Republic of Ethiopia; FDEP: Florida Department of Environmental Protection; %WSORL: percentage of water source out of recommended limit.

Authors' contributions
ZA the main investigator and performed the study design, data entry, statistical analysis of results, data interpretation and writing the manuscript. KT has helped to edit the manuscript and participated in Laboratory analysis. TA involved in data entry and participated in Laboratory analysis. KH are participated in Laboratory analysis and editing the manuscript. SD helped to draft and edits the manuscript. All authors read and approved the final manuscript.

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Competing interests
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