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Original Research

Selected physicochemical analysis of groundwater in and nearby Nekemte town, East Wollega zone, Ethiopia

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Abstract

This study focused on the physicochemical analysis of groundwater samples obtained from Nekemte campus of Wollega University and Ifa Town of Diga district in Eastern Wollega zone. Most of the parameters were analyzed using DR/2400 Portable Spectrophotometere at Nekemte drinking water treatment plant. The results of the study are in the range of temperature (18.2-19.8ºC), turbidity (0.2-0.9 NTU), EC(136.3-180.2 µS/cm), pH (6.4-7.5), total solid (103.3-134.8 mg/L), total dissolved solid (99.9-131.8 mg/L), total suspended solid (2.9-3.9 mg/L), calcium hardness (0.2-2.4 mg/L), magnesium hardness (0.6-2.4 mg/L), total hardness (1.1-4.5 mg/L), aluminum (0.001-0.04 mg/L), chromium (0.01-0.04 mg/L), manganese (0.19-1.33 mg/L), iron (0.05-0.08 mg/L), potassium (1.5-2.8 mg/L), Nitrate (0.3-2.5 mg/L), Nitrite(0.004-0.011 mg/L), Phosphate (0.4-2.9 mg/L), sulfate(0.0.05-2.9 mg/L), fluoride (0.15-0.49 mg/L), dissolved oxygen (4.1-7.5 mg/L), total chlorine (0.01-0.16 mg/L), ammonia (less than 0.02 mg/L) and iodine (0.0-0.02 mg/L), for the deep well ground waters of the two sites. These values agree with WHO drinking water standards except that of manganese, dissolved oxygen and temperature. Based on the present study result it is possible to conclude that the ground waters of the two sites are suitable for drinking purpose.

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INTRODUCTION

Groundwater is stored in an aquifer, which typically is soil or rock that has a high porosity and permeability. Most groundwater is present within 90 m of the surface, but it can be as deep as 600 m. A well is a vertical hole that is extended into an aquifer to a certain depth (Zhang, 2007).

Groundwater is the most important source of domestic, industrial and agricultural water supply in the world (Kortatsi, 2007). It is considered as one of the purest forms of water available in nature and meets the overall demand of rural as well as urban population (Joarder et al*.,* 2008).Groundwater has more mineral composition than surface water (Mirribasi, et al., 2008).The domestic needs of more than 80 % rural and 50 % urban population besides irrigation is met by ground water (Anita & Gita, 2008).Exploitation of surface waters has reduced in Africa; there is an increasing reliance on groundwater due to increasing pollution with the concomitant rise in the cost of water treatment (Kortatsi, 2007).

Groundwater chemistry depends on a number of factors, such as general geology, degree of chemical weathering of the various rock types, and inputs from sources other than water rock interaction (Nosrat & Asghar, 2010). Groundwater quality also reflects inputs from the atmosphere as well as pollutant sources such as mining, land clearance, agriculture, acid precipitation, domestic and industrial wastes (Zhang, 2011). The ground water is made susceptible to contamination due to addition of waste materials with the growth of industry. Waste materials from the factories percolate with rain water and reach aquifer resulting in erosion of ground water quality (Mahananda, et al., 2010).

In Ethiopia, the common drinking water sources are limited to wells, springs, and taps. 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 & Samuel, 2011). The natural water analysis for physical and chemical properties is very important for public health studies (Arunabh, et. al., 2008). So basic monitoring on water quality has been necessitated to observe the demand and pollution level of ground water (Mitaliet, al., 2006).

The major sources of drinking water for Wollega University and Ifa town (Diga-District) community are Tinfa and Ifa bore hole well ground waters respectively. The two bore-hole wells at Tinfa were constructed 7 years ago; these are greater than 100 m deep. There is only one bore-hole well at Ifa town constructed 15 years ago; this is not greater than 60 m deep. Along these water sources, the main current anthropogenic activities are agriculture, including small scale farming and cattle breeding. So far, no study of the quality of these water sources has been carried out; hence the purpose of this project was to determine selected physicochemical parameters of Tinfa and Ifa bore hole well ground waters.

MATERIALS AND METHODS

Description of the Study Area

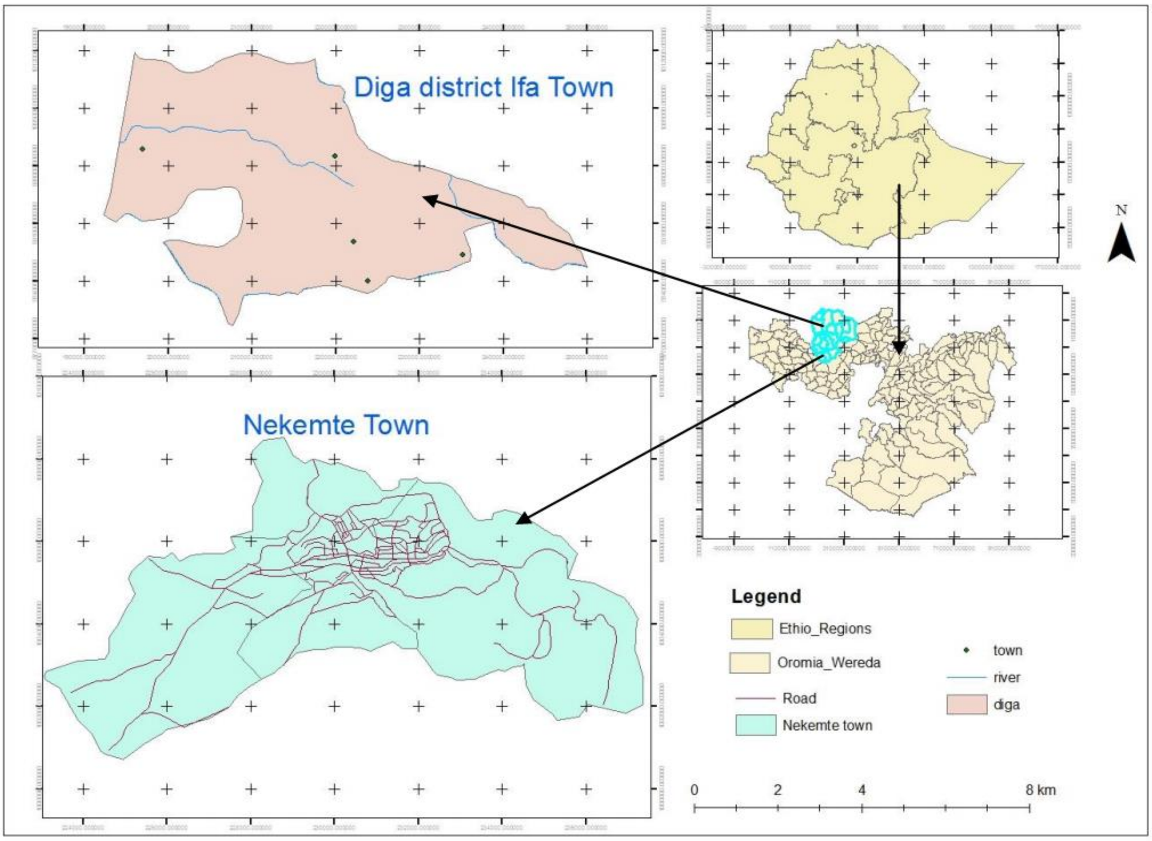

Figure 2.1 The map of location of the study areas

The study was conducted in and near Nekemte town, Ethiopia. Nekemte town is a town of North Western Oromia and the capital of East Wollega zone. It is 312 km far from Addis Ababa. The specific location is $9^0$5' North latitude, 36^0 33' East longitudes and has altitude range of 1960-2170 m above sea level. The climate of the area is a subtropical highland climate and gets rain six month per a year. The average temperature and rainfall range are between 13 to 15 ^{0}C and 1500-2200 mm respectively (WDKMMN, 2015). The geology of Nekemte area is generally covered by tertiary volcanic rocks such as upper volcanic rocks, lower volcanic rocks, sub-volcanic (hypabyssal) rocks, dome, and dykes (Shayaq & Asnakech, 2017).

Chemicals and reagents

Deionized water, distilled water, Buffer Solutions (pH 4.01±0.02, 7.00±0.02 and 10.01±0.02 at 25^{0}C), and Potassium Chloride (0.01M K.C. l). The reagents used in the spectrophotometric analysis are listed in Table 2.1.

Instruments and Equipments

DR/2400 Portable Spectrophotometer (Hach Company, 2002, Cat., No. 59400-45), pH/Temperature meter (Z-WAG-WE30020, Wagtech, Serial N0: 2075450), Portable Microprocessor Based Conductivity/TDS Meter (Model-1601), Portable Microprocessor Turbidity Meter (WZS-200).

Sample Collection and Preservation

The glass bottles used for sample collection were previous washed and it was sterilized by steam sterilizer at 125 ^{o}C (Rao & Mamatha, 2004). To avoid any kind of contamination during sampling extra-care was taken and the bottles were rinsed several times with the water being collected or filled. Before sample collection was carried out, the water pipe was opened for 3-5 minutes to allow the water flow out. In-situ analyses were made for temperature, electrical conductivity (EC) and pH. Then representative water samples were collected in sterilized glass bottles i.e., 2 L from selected area of interest (Wollega University = S1 and Ifa town Diga-District = S2) and was labeled accordingly. Sample collection was carried out in June 2016 (wet season). The collected samples were transported to the laboratory and kept at 4^{o}C prior the time of analyses.

Analysis of Samples

Table 2.1: Methods used for determination of physicochemical parameters

N	Parameters	Methods	Reagents
1.	Turbidity	Turbidity Meter	-
2.	Temperature	pH/Temperature meter	-
3.	pH	pH/Temperature meter	-
4.	Electrical conductivity EC	Conductivity meter	-
5.	Total solid (TS)	Filtration method	-
6.	Total dissolved solids (TDS)	Conductivity/TDS Meter	-
7.	Total suspended solids (TSS)	Filtration method	-
8.	Aluminum (Al^{3+})	Aluminon Method	Ascorbic acid, Aluver 3 aluminum reagent, bleaching 3 reagents
9.	Chromium (Cr^{6+})	1,5-Diphenylcarbohydrazide Method	Chromaver 3 reagent
10.	Manganese (Mn)	Periodate Oxidation Method	Buffer-citrate type and sodium periodate
11.	Iron (Fe)	FerroVer® Method	Ferrover iron reagent
12.	Potassium (K)	Tetraphenylborate Method	Potassium 2 solution potassium 1 and 3 powder pillow (PP)
13.	Nitrate (NO_3^-)	Cadmium Reduction Method	Nitraver 5 nitrate reagent
14.	Nitrite (NO_2^-)	Diazotization Method	Nitriver 3 nitrite reagent
15.	Phosphate (PO_4^{3-})	PhosVer® 3 (Ascorbic Acid) Method	Phosver 3 phosphate
16.	Sulfate (SO_4^{2-})	SulfaVer® 4 Method	Sulfaver 4 reagent (PP)
17.	Fluoride (F^-)	SPADNS Method	SPADNS Reagent
18.	Dissolved Oxygen (DO)	HRDO Method	High range dissolved oxygen
19.	Iodine (I_2)	DPD Method	DPD total chlorine (PP)
20.	Total chlorine	DPD Method	DPD total chlorine (PP)
21.	Ammonia (NH_3)	Salicylate Method	Ammonia salicylate, ammonia cyanurate reagent
22.	Hardness	Calcium and Magnesium; Calmagite Colorimetric Method	Ca and Mg indicator solution, alkali solution for Ca and Mg test, 1M EDTA solution, EGT solution

All the analytical procedures used in the physicochemical analysis of the ground 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 in Table 2.1.

RESULTS AND DISCUSSION

The water samples collected from the two sites (S1 = Wollega University and S2 = Ifa town-Diga district) were analyzed for different measurement parameters. A summary of values (mean with relative standard deviation) of different selected physical and chemical parameters (n=3) of the ground water samples have been presented in the following sections.

Physical Parameters

Tests under this category were carried out to examine water for temperature, pH, conductivity and turbidity (Table3.1).

Table3.1: Physical parameters of the groundwater samples

Parameters	Sampling sites/ Mean (RSD)		Maximum value	
	S1	S2	WHO	EPA
Turbidity (NTU)	0.3(1.7)	0.53(2.1)	5	1.0
Temperature (ºC)	18.8(4.3)	19.6(3.8)	15	25
pH	6.6(2.7)	7.2(2.4)	6.5-8.5	5.5-9
EC (µS/cm)	138.3(3.2)	176(5.7)	500	1000

Turbidity values showed that the study area has very low turbidity which was below the WHO limit for drinking water, 5 NTU. Similar findings are also reported at Gedio Zone, Ethiopia with turbidity value 3.78 – 40.2 NTU (Deguand, 2015). The temperatures values of the two sites (about 19 ºC) are considered higher than WHO maximum permissible limit. This result is also higher compared to the value reported at Jigjiga town within a range of 13.3 to 13.8 ºC (Adhenaet al., 2015). On the other hand, this result is less than the reported value by Ackah et al. (2011) from Ghana. Both the studied samples of S1 and S2 were found to be colorless, odorless and tasteless; particularly these ground waters have better taste than the treated surface water used in the town according to reputation from customers. pH values in both the water samples analyzed have concentration within the standard set by the ES and WHO. The electrical conductivity (EC) of the ground water samples studied is within the maximum acceptable concentration set by WHO. The recorded value is lower than 252 to 501µS/cm reported at East Wollega Zone, Western Ethiopia (Shayaqet al., 2015).

Chemical parameters

Selected Metals

Table 3.2: Chemical Parameters: Some metals in ground water samples

Parameters	Sampling sites /Mean (RSD)/		MAC*	
	S1	S2	WHO	EPA
Al^{3+} (mg/L)	0.033(4.8)	0.007(6.7)	0.2	0.2
Cr^{6+} (mg/L)	0.03(6.2)	0.02(5.4)	0.05	0.05
Mn (mg/L)	0.31(3.8)	0.83(1.6)	0.5	1.0
Fe (mg/L)	0.07(4.9)	0.07(4.4)	0.3	2
K (mg/L)	1.67(1.4)	2.63(5.6)	12	-

MAC* =Maximum Acceptable Concentration

The level of selected metals is shown in Table 3.2. Manganese in Diga-district ground water is found above the maximum acceptable concentration permissible level set by WHO. This value is also greater than the reported mean value by Ackah et al. (2011) from Ghana.

On the other hand, it is clear from the results that Al, Cr, Cu, Fe and K in all the area selected samples were found below the permissible limit as prescribed by EPA and WHO. The values recorded for K and Fe are also less than the average reported value by Ackah et al. (2011) from Ghana.

Selected anions

The values determined for selected anions are shown in Table 3.3. The values recorded for nitrate and phosphate are less than the mean value reported by Ackah et al. (2011) from Ghana. On the other hand, high phosphate value is recorded in S1 than S2. The value of nitrate concentration in this study is greater than the average value reported by Shayaq et al. (2015). The nitrate, nitrite, sulfate and fluoride content in ground water samples of the study areas are found under the maximum acceptable concentration set by EPA and WHO

.

Table 3.3: Some anions in ground water samples

Parameters	Sampling sites/Mean (RSD)/		MAC*	
	S1	S2	WHO	EPA
NO_3^-(mg/L)	1.93(2.4)	0.73(6.7)	50	50
NO_2^-(mg/L)	0.007(5.5)	0.005(1.9)	1	0.03
PO_4^{3-} (mg/L)	2.30)3.1)	0.45(5.6)	-	0.7
SO_4^{2-} (mg/L)	0.33(5.2)	2.33(1.6)	250	200
F^- (mg/L)	0.22(4.2)	0.39(1.8)	2	1.7

MAC* =Maximum Acceptable Concentration

Selected free molecules

The level of selected free molecules is shown in Table 3.4.

Table 3.4: Some anions in ground water samples

	S1	S2	WHO
Total chlorine (mg/L)	0.04(0.9)	0.03(2.4)	-
Iodine (mg/L)	0.01(1.5)	0.01(3.1)	-
NH_3 (mg/L)	ND	0.01(3.7)	1.5
DO (mg/L)	4.6(3.7)	7.37(5.9)	5

The concentrations of total chlorine in ground water of studied areas are lower than the reported value from Western Ethiopia (Shayaqet al.,2015), Ghana (Ackah et al., 2011) and Indonesia (Mohamad et al., 2015). The origin of chloride in groundwater may be from diverse sources such as weathering, leaching of sedimentary rocks and soils, intrusion of saltwater, windblown salt in-precipitation, domestic and industrial waste discharges, municipal effluents, etc. It shows that the studied areas have a low concentration of chloride since the region is far away from sea water intrusion and has a high level of resistance to weathering of rocks (Mohamad et al., 2015).

The DO values of the water sources of study area are considerably high; this is due to the capacity of water to hold oxygen. The DO value of S1 is within permissible value; however, it is slightly low indicating that it is contaminated by organic matter. In the present study, the measured values of ammonia concentrations is lower than the permissible level of NH_3 for safe drinking water set by WHO. The ammonia concentration of the present study is comparable with the values (0 to 0.05 mg/L) reported from Iran (Nosrat & Asghar, 2010).

Hardness and dissolved solids

The values recorded for hardness and dissolved solids in this study are shown in Table 3.5.

Table 3.5. Chemical Parameters: Dissolved solids and hardness.

Parameters	Sampling sites /Mean (RSD)/		MAC
	S1	S2	WHO
TH (mg/L)	4.1(7.7)	1.2(4.6)	500
MgH (mg/L)	1.9(1.8)	0.8(6.5)	200
CaH(mg/L)	2.2(5.8)	0.4(7.3)	150
TS (mg/L)	103.7(4.9)	134.1(3.9)	-
TSS (mg/L)	3.8(2.9)	3.1(4.7)	-
TDS (mg/L)	100.7(5.1)	131.1(5.5)	1000

In the present study the values of total hardness as well as calcium and magnesium hardness are within the acceptable concentration set by WHO and hence the groundwater in part of study area is soft.

The values of total solids (TS) were recorded maximum at S2 and minimum at S1. Since, the two studied areas are in rural areas there are no industrial sewage activities that cause runoff to the site; hence, low value of TS concentration recorded in the sites is reasonable. The total suspended solids (TSS)values of studied area are in agreement with this explanation. The total dissolved solids (TDS) recorded in the current study is within the maximum acceptable concentration set by WHO. This result is also lower compared to other studies reported at East Wollega Zone (Shayaqet al.,2015) and Jigjiga in Western Ethiopia (Adhenaet al., 2015). On the other hand, the value is comparable with the one reported (94-808 mg/L) by a study conducted in West Java, Indonesia (Mohamad et al., 2015).

CONCLUSION AND RECOMMENDATIONS

The physicochemical parameters values recorded in the current study are in line with World health organization (WHO) guidelines except for Mn in Ifa town of Diga, DO in Nekemte campus of Wollega University and temperature in both sites. Furtherer more, the content of EC and TS are higher in Ifa town of Diga than Nekemte campus of Wollega University; however, the values are less than the maximum permissible values recommended by WHO. In general, the ground waters at the two locations are safe for drinking according to the analysis of the current study. For more detail quality monitoring, seasonal characterization is required. DR/2400 Portable Spectrophotometere used in the current study for the analysis of selected metals could be helpful to get primary data as presented in the foregoing discussion. However, advanced analytical instruments and methods are required to generate more accurate data regarding the level of the metals studied.

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