International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 15, Issue 3 (March 2019), PP.47-58

Evaluation of Ground water Quality and its Suitability for Drinking and Irrigation at Nekemte, East wollega zone, Oromia regional state, Ethiopia

Bilisa Bulti Emana[1], Vighneswara Rao.K[2]
[1&2] *Department of Chemical Engineering, Faculty of Technology,Wollega University, Shambu Campus, Oromia regional state, ETHIOPIA.*
Corresponding Author: Vighneswara Rao.K

ABSTRACT: *The study was conducted to evaluate the groundwater quality in order to analyze the suitability of the water for drinking and Irrigation uses in the Nekemte Town of Oromia Regional State, Ethiopia. Water samples were purposively collected from hand dug bore holes, hand dug wells, protected spring and pipe borne water and analyzed following standard methods for the examination of water quality (APHA, 2005). The study examined selected physical, chemical and biological qualities of water from hand dug bore holes, hand dug wells, protected spring and pipe borne. The water samples were analysised for Temperature, pH, turbidity, dissolved oxygen, conductivity, total dissolved solids, total alkalinity, bicarbonate, carbonate, total hardness and selected cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (Cl^{-} and SO_4^{2-}), heavy metals (Mn^{2+} and Fe^{2+}) and Coliforms (Total coliforms and Faecal coliforms),Water Salinity, Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC), Permeability index and Magnesium ratio between July 2018 and October 2018. Nonconservable water quality parameters such as Temperature, pH, turbidity, dissolved oxygen and conductivity were determined onsite immediately after sampling using handled portable water quality measuring instrumentation. These parameters were used to analyze the suitability of groundwater for drinking and domestic purpose by comparing with the WHO and Ethiopian standards. The results show that most of the studied physical, chemical and bacteriological parameters of the groundwater samples were above acceptable limits set by the WHO for drinking and domestic purpose. The results conclusively indicated that at the moment the groundwater and pipe borne water in the area is not safe for human consumption. Thus, some form of treatment is necessary to make the water suitable for drinking and domestic use. However, to meet the millennium development goal of potable water supply, efforts are required to improve water supply, sanitation coverage and it is important to regularly assess the pollution risks to water sources posed by improper on- site sanitation systems. Based on the classification of irrigation water according to Water Salinity, Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC), Permeability index and Magnesium ratio values, all sample locations are suitable for irrigation purposes.*

Keywords: *Composition, physical, chemical and biological Analysis, Domestic, Groundwater quality, Aquachem software, WHO and Ethiopian Standards*

Date of Submission: 20-10-2019 Date of acceptance: 03-11-2019

I. INTRODUCTION

Water is the most precious natural resource, vital for the existence of life and fundamental political issue . Water resources are harnessed for various purposes like drinking, agricultural, industrial, household, recreational and environmental activities etc. Groundwater refers to all the water stored underground occupying the pore spaces within bedrock and regolith that lay underneath the surface of the Earth (AWA, 2007). It is one of the most important sources of water for domestic, industrial, and Irrigation uses in every parts of the world (Bear, 1979). It is estimated that approximately one-third of the world's population rely on groundwater for drinking and other domestic uses (Nickson et al., 2005).

Many communities in Africa including our community depend heavily on groundwater and it is a very important source of water supply (Tilahun, 2010). More than 80% of the Ethiopia's drinking water supply comes from groundwater (Kebede et al., 2004). One of the advantages, unlike surface water resources, is being its existence everywhere within the country though there is a spatial variation in quantity and quality. In Ethiopia, hand pump boreholes, natural springs and wells are low-cost technology options for domestic water supply and are generally considered as 'safe' of drinking water sources. When properly constructed and maintained, they provide consistent safe drinking water supplies with minimum need for treatment before drinking (Amankona, 2010). Groundwater quality comprises the physical, chemical and microbiological qualities of groundwater (Meybeck et al., 1996). Temperature, turbidity, color, taste and odor make up the list of physical water quality parameters. Since groundwater is usually colorless, odorless and without specific taste, we are typically most concerned with its chemical and microbiological qualities.

II. MATERIAL AND METHODS

II.1 Description of the Study Area.

Nekemte town is a capital city of East Wollega Zone of Oromia regional state, Ethiopia. The geographical location of the town is extended over 9002’47”N to 9006’56” N latitudes and 36028’53”E to 36036’40”E longitudes. It is located at a distance of 331 km west of Addis Ababa and now administratively divided into six sub units. Its elevation ranges from 1960 to 2190 m.a.s. l dominated by steep slope and low lying areas. As meteorological data has shown that the climatic condition alternates with long summer rainfall (June to September), short rain season (March to April) and Winter dry seasons (December to February). The minimum and maximum annual rainfall and daily temperature ranges from 1450 to 2150 mm and 15 to 27^0c respectively (Firamye Garbi, Asamen et al, 2015). The central area of Nekemte is predominantly covered by commercial activities that range from retailing small items up to providing commercial function like banks, insurances and offices. The distribution of land use and land cover classification of the study area indicated that about 50% of the total area was covered by forest followed by built up areas which was accounted for 25%. The least land use types of the study area was water bodies which is nearly 0.3% of the total land cover of the town. A projection made by CSA in 2015 indicates that the town is about 110,640. The map of study area shown in Figure 1.

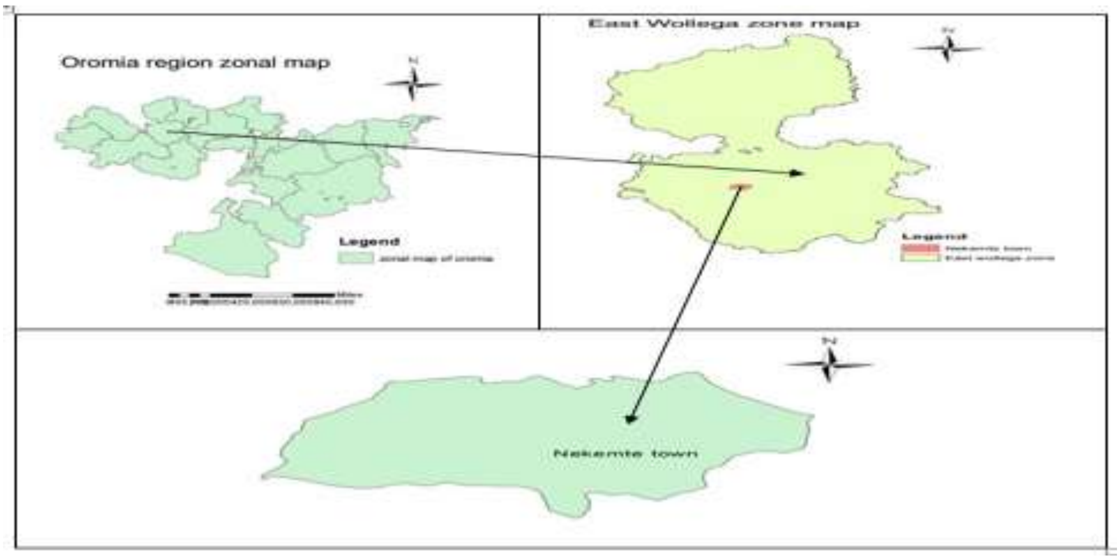

Figure 1: Map of the study area using Arc GIS version 10.1 software

II.2 Research design and Periods

The experimental research method was used to design the study. In this method, one can deliberately control and manipulate the conditions, which one have reason to believe determine the area in which one is interested. In other words independent variables are manipulated so as to watch the effects of the independent variables on the dependent variables. Experimental research takes place in the laboratory because it aims at finding out the relationship existing between two factors under controlled conditions. So that testing of water samples from the study area was used to determine its physical, chemical and biological characteristics. A experimental study was carried out from June to October 2018 in six sub-cities of Nekemte town, namely: Bake Jama, Burka Jato, Bakkanisa kesse, Darge, Keso and Chalalaki. The domestic water sources of protected spring, hand dug borehole hand dug well are illustrated in figure 2.

(a) Protected Spring (**b)** Hand Dug Borehole (**c)** Hand Dug Well

Figure 2 : Domestic water sources in the study area (Source: Field survey, March 25, 2018).

II.3 Study Variables Field Analysis**:** Temperature, conductivity, pH, Dissolved Oxygen and Turbidity (Direct measurement method)Laboratory Analysis**:** Chemical characteristics of sample were analyzed with standard methods water and wastewater (APHA, 2005): Total Hardness, Total Alkalinity, Calcium and Chloride (Titration method). Bicarbonate and Carbonate (calculation method), Sodium and Potassium (Calibration), Sulphate (Calibration), Iron and Manganese (Standard addition), TDS (Evaporation method), Magnesium (Difference method). Fecal and Total coliform were tested with Membrane. Filtration, Water Salinity, Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC), Permeability index and Magnesium ratio.

II.4 Water Sample collection The quality of any analytical system depends primarily on the samples collected for analysis. A total of 90 water samples (triplicate) were collected from hand dug bore hole, hand dug well, protected spring and pipe borne water for major ions and trace element components. EC, Turbidity, DO, pH and temperature were recorded in the field. A judgment sampling technique was used to select sampling points based on wells closer to pollution sources like garbage dumpsites, improper waste disposal sites. During the study period water samples were collected in 1 litre polypropylene bottles from hand dug bore hole, hand dug well and protected spring and pipe borne water. Prior to sampling the polyethylene bottles were cleaned by incubating them with 10 % (v/v) nitric acid (Analytical, Merck) solution for 48 hours in a hot water bath and then washed and rinsed with distilled and de-ionized waters. After taking each sample, the bottle was tightly capped to minimize contamination and escape of gases. The bottles were labeled according to the code numbers allotted to each sampling point and were then stored in a cool ice box for onward transfer to the Department of Environmental Health Laboratory (Jimma University) and Oromia Water Works Design and Supervision Enterprise Lab. The analysis was carried out within 24 hours after collection. The sample collection points at different locations shown in figure 3.

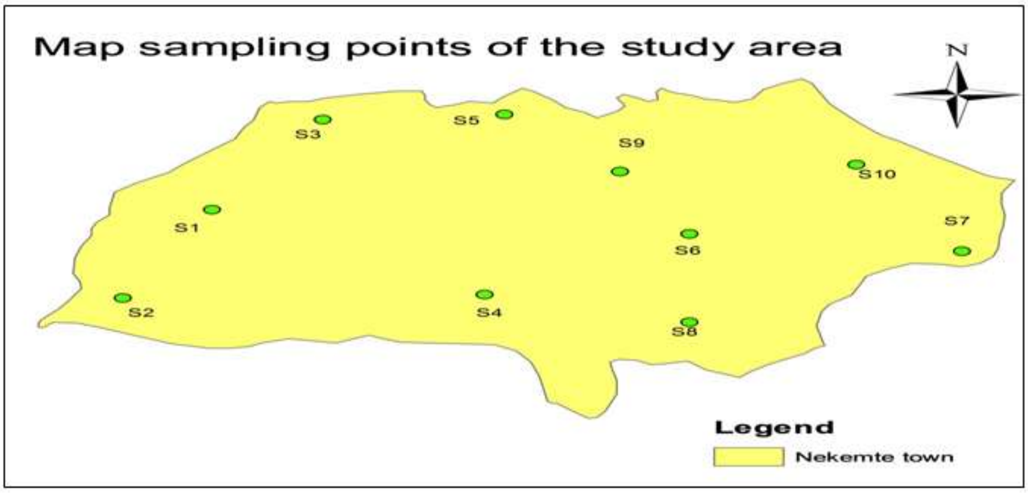

Figure 3 : Map of Nekemte town showing sample collection points using Arc GIS 10.1

II.5 Sample preservation

Water samples collected are susceptible to being changed between the time of sampling and the analysis as a result of physical, chemical or biological reactions (Dart and Stretton, 1980). The extent of these reactions is a function of the chemical and biological nature of the sample, its temperature, its exposure to light, the nature of the sample container and the time between sampling and analysis. Therefore, the sampling, handling and analysis have to be designed to minimize these reactions and in the case of many parameters, to analyze the sample with a minimum of delay (ISO, 1985).

III. RESULTS AND DISCUSSION

The evaluation of Groundwater quality for drinking, domestic and irrigation use is greatly very important due to its adversely effects on human welfare and agricultural productivity. The water to be used for drinking purposes fulfill the physical, chemical and biological standards of WHO (2004) and Ethiopian Standards published on Negarit Gazeta No. 12/1990 as cited in (Addisu, 2012 and Yonas, 2009). The analytical results have been evaluated to ascertain the suitability of groundwater in the study area for domestic and Irrigation uses. The all parameters results for the entire periods from 90 samples were averaged as shown in Table 1 and Table 2.

III. 1 Physical Parameters:

(i) Temparature. In the study area, the temperature of groundwater ranges from 24.86 - 26.78 °C with an average of 25.84°C, which greater than the specified range (Table 1). The highest temperature (26.78℃) was at location S_3 and the lowest (24.86 °C) at S_2 (Figure 4).Variations in solar energy received at the earth's surface create periodicities, both diurnal and annual, in temperature below ground surface (Todd 1995). The standard value recommended for groundwater temperature by WHO (2004) not exceeds 15^0c.

(ii) pH. it is a measure of the balance between the concentration of hydrogen ions and hydroxyl ions in water. The pH of water provides vital information in many types of geochemical equilibrium or solubility calculations (Hem, 1985). The limit of pH value for drinking water as specified by WHO (2004) and Ethiopian standards (1990) is 6.5–8.5. The pH value of the groundwater samples varies between 4.76 - 6.67, with an average of 5.53 which clearly shows that the groundwater in the study area is slightly acidic in nature(Table 1) and Figure 5.

(iii) Electrical conductivity (EC).

The electrical conductivity of water samples, is the ability to conduct an electric current which is influenced by the presence of ions dissolved in the water particularly HCO_3^-, SO_4^{2-}, Cl^-, Ca^{2+}, Na^+, Mg^{2+} and K^+ (Swennen, 2004). It depends upon temperature, concentration and types of ions present (Hem, 1985). The most desirable limit of EC in drinking water is prescribed as 250 μS/cm (WHO, 2004). The EC for groundwater samples analyzed during sampling period was varies from 69.97- 372.06 μS/cm, with a mean of 168.33 μS/cm (Table 1). All the samples were within the permissible limits of WHO standards for drinking water WHO (2004), stipulated range. The variation of electrical conductivity with samples shown in figure 6.

(iv) Total Dissolved Solids (TDS).

TDS concentration in the area varies from 46.87- 398.67 with an average value of 157.19 μS/cm, which less than the specified range as 500 mg/l (WHO, 2004) and 1,500 mg/l (Ethiopian Standards) (Table 1).The variation of total dissolved solids with all samples were shown in figure 7, the total groundwater samples are non-saline which desirable for domestic uses (TDS < 1000 mg/l).

(v) Turbidity.

The existence of turbidity in water affects its acceptability to consumers (EPA, 2001). Turbidity value in the area varies from 1.92 - 7.92 NTU, with an average value of 5.57 NTU (Table 1). The mean turbidity value of water samples obtained from Hand dug wells was above the maximum acceptable limits of 5 NTU recommended by both (WHO, 2004) and Ethiopian Standards (Figure 8). The high level of turbidity in water from the hand dug well is source of concern because the particles forming the turbidity could harbour and shield pathogenic organisms and hence escape the action of the disinfectant (EPA, 2001).

(vi) Dissolved Oxygen (DO).

The DO values indicate the degree of pollution in water bodies (Balamurugan et al., 2012). In present study the DO values of different water samples ranged from 6.06 - 6.52 mg/l, with an average value of 6.29 mg/l respectively (Table 1). The mean DO value of water samples obtained from the all water sample was below the 7.5 mg/l , but WHO (2004) Standards recommended is 7.5 and above (Figure 9).

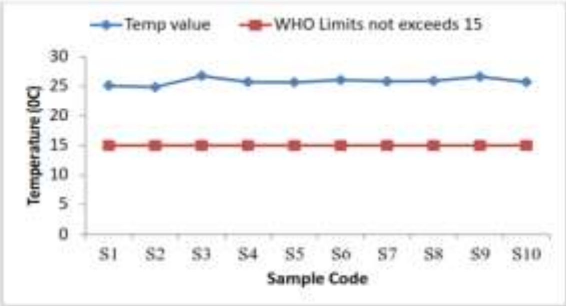

Figure 4: Temperatures at Different Locations

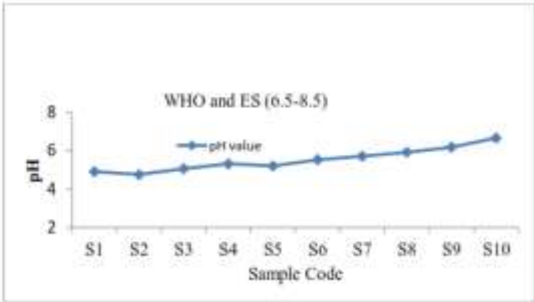

Figure 5: pH at Different Locations

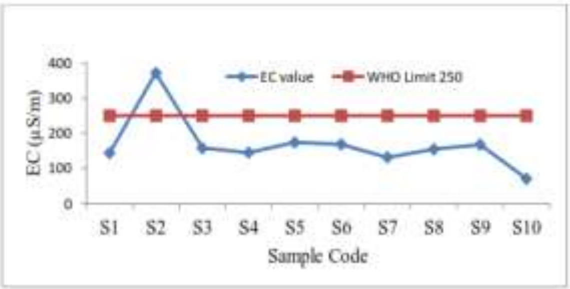

Figure 6: Electrical Conductivity at Different Locations

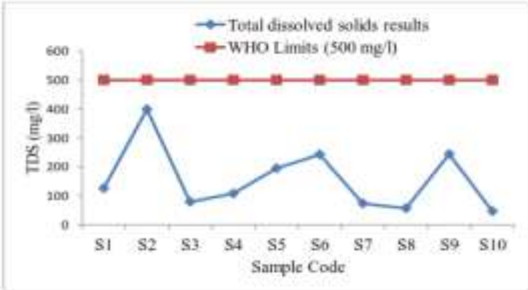

Figure 7: TDS at Different Locations

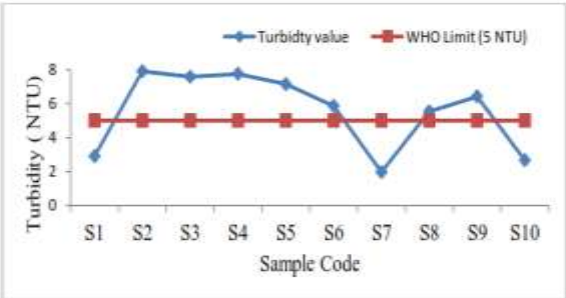

Figure 8: Turbidity at Different Locations

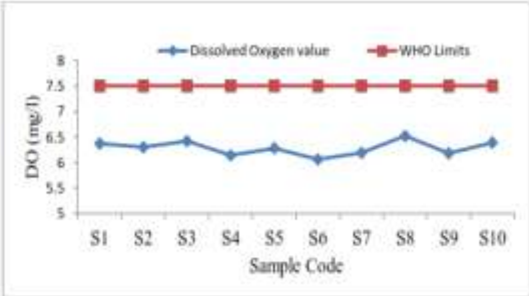

Figure 9: Dissolved Oxygen at Different Locations

III.2 Chemical Parameters:

(i) Chloride.

The chloride concentration serves as an indicator of pollution by sewage (Balamurganet al.2012). Chlorides in water are more of a taste than a health concern, although high concentrations may be harmful to people with heart or kidney problems (Weiner, 2000). In the present analysis, chloride concentration in the groundwater samples was found in the ranges from 10.58 - 58.90 mg/l, with a mean value of 23.83 mg/l, which less than the specified range as 250 mg/l (WHO, 2004) and 533 mg/l (Ethiopian Standards) (Table 2) and figure 10.

(ii) Total Hardness.

Total hardness of water is a measure of dissolved Ca and Mg in water expressed as $CaCO_3$ (Mitra et al. 2007). The mean hardness of the groundwater samples ranged from 0 - 26.0 mg/l with an average of 1.92mg/l, which less than Standard limit prescribed by WHO (2004) and Ethiopian Standards as 200 and 500 mg/l respectively (Table 2 or Figure 11). All the groundwater samples in the study area are soft due to the low existence of alkaline earths such as calcium and magnesium and the groundwater samples analyzed were suitable for domestic use.

(iii) Total Alkalinity

The concentration of total alkalinity is ranged from 5.13- 37.73 mg/l, with average value of 12.8 mg/l (Table 2). The highest desirable limit of total alkalinity of WHO (2004) and Ethiopian Standards is 200 and 600 mg/lrespectively (Table 2). The highest value was observed at S_7 and the lowest at S_1 (Figure 12). Lower alkalinity is due to dilution (heavy rainfall) (Sisodia, R. et al. 2006). In study area all the values are within the permissible limit, therefore the groundwater samples analyzed were suitable for domestic use.

(iv) Bicarbonate (HCO_3^-).

Bicarbonate (HCO_3^-) in the study area ranges from 5.13- 37.73 mg/l, with average value of 12.8 mg/l (Table 2). Higher Bicarbonate concentration 37.73 mg/l at S_7 and lower 5.13 mg/l at S_1 (Figure 13). The acceptable drinking water limit for bicarbonate is 200 mg/L (WHO, 2004).

(v) Carbonate (CO_3^{2-})

From the observed results no Carbonate concentration in the study area might be due to the absence of Magmatic, volcanic rock and Carbonate-rich sedimentary rocks, principally formed from deposition of biogenic marine materials (Wedepohl 1978). Also no anthropogenic sources of carbonate such as limestone applied to fields to increase soil pH and effluents of wastewater from industry etc.Therefore, the results showed that the water samples are suitable for drinking and domestic uses.

(vi) Sulphate.

Industrial wastewater represents a source of SO_4^{2-} (Barrett et al., 1999). The low concentration level of Sulphate in the water most probably due to the removal of SO_4^{2-} by the action of bacteria (Amadi et al., 1989). There is no Sulphate concentration in the study area might be due to the absence of any abuse of the water by septic tanks,. Therefore no groundwater quality problem for the concentrations of Sulphate. These results show that the water samples are suitable for domestic uses.

(vii) Calcium and magnesium.

According to S. V. Sarath Prasanth, N. S. Magesh, et al. (2012), Calcium and magnesium are the most abundant elements in the natural surface and groundwater and exist mainly as bicarbonates and to a lesser degree in the form of sulfate and chloride. Ca^{2+} concentrations are varying from 49.7- 307.7 mg/l, with an average value of 153.55 (Table 2 or figure 14)

Magnesium content is varying from 1.48 - 6.35 mg/l, with an average value of 3.65 mg/l (Table 2). The maximum permissible limit of Mg^{2+} concentration of drinking water is specified by WHO (2004) and Ethiopian Standards is 50 and 150 mg/l respectively (Figure 15). Therefore, the results of Magnesium show that the water samples are suitable for domestic uses.

(viii) Sodium and potassium.

According to S. V. Sarath Prasanth, N. S. Magesh, et al. (2012), Sodium is generally found in lower concentration than Ca^{2+} and Mg^{2+} in freshwater. The concentration of Na^+ is varied from 1.45- 4.9 mg/, with an average value of 2.91mg/l (Table 2)

According to S. V. Sarath Prasanth, N. S. Magesh, et al. (2012), Potassium is a naturally occurring element; however, its concentration remains quite lower compared with Ca, Mg and Na. The concentration of K^+ is observed between 0.4 - 2.4 mg/l, with an average value of 1.46 mg/l respectively (Table 2).

(ix) Iron and Manganese.

The level of Fe and Mn metals in the environment has increased as a result of increase in human activities (Prater, 1975: Marian, 1991). The iron concentration was recorded in water samples from 0 - 0.72 mg/l, with an average value of 0.21 mg/l (Table 2). Samples from S_3, S_5, S_6 (wells) and S_{10}(pipe borne water) were recorded high levels of Iron exceeding WHO limit (Figure 16).

The mean level of manganese in water samples for the entire period ranged from 0 - 1.61 mg/l, with an average value of 0.62 mg/l (Table 2). The desirable limit of manganese concentration for drinking water is specified as 0.1 mg/l (WHO 2004), which shows that all water samples above the permissible limit except S_7 (Figure 17).

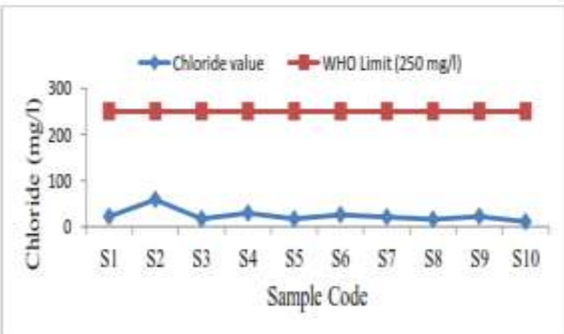

Figure 10: Chloride at Different Locations

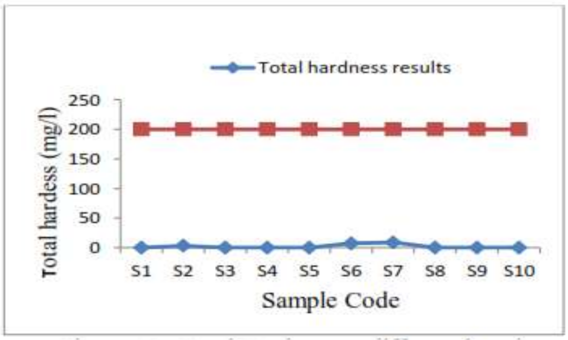

Figure 11: Total Hardness at Different Locations

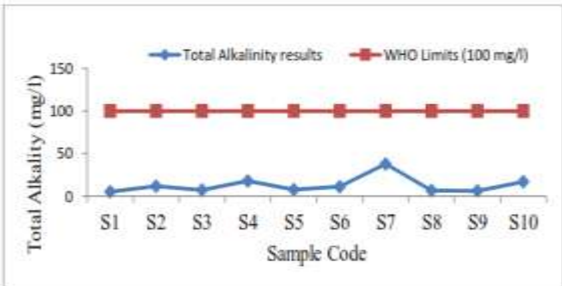

Figure 12: Total Alkalinity at Different Locations

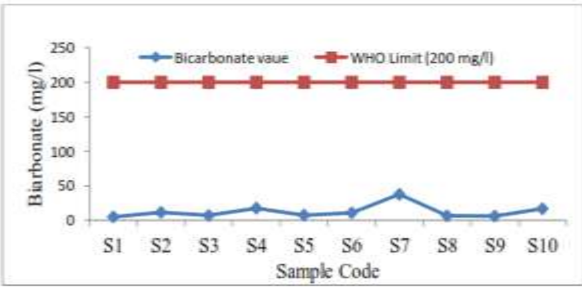

Figure 13: Bicarbonate at Different Locations

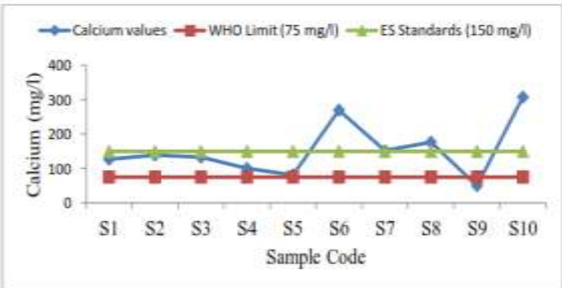

Figure 14: Calcium at Different Locations

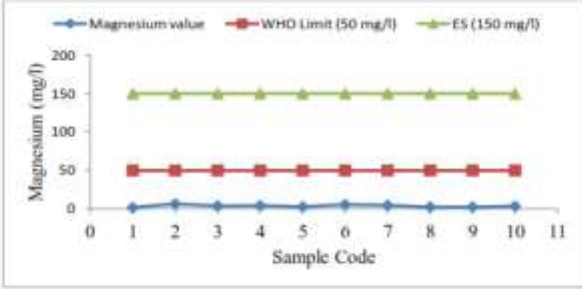

Figure 15: Magnesium at Different Locations

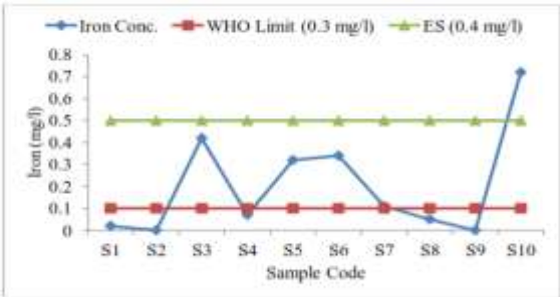

Figure 16: Iron at Different Locations

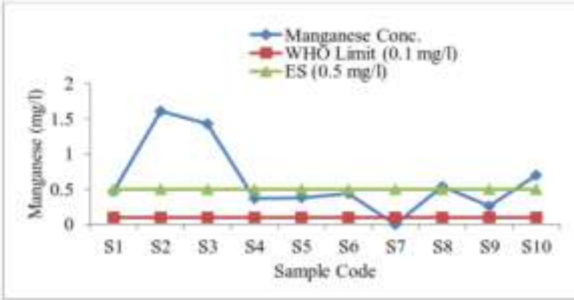

Figure 17: Manganese at Different Locations

III.3 Biological Parameters:

(i) Fecal Coliform (FC).

The results of analysis indicated that the values of fecal coliform (FC) ranged from 11 - 530 cfu/100 ml, with an average value of 150.89 cfu/100 ml (Table 1). In drinking water, TC and FC should be absent (WHO, 2004). The highest value was observed at S_4 and the lowest at S_1. Most often, in the rainy season, number of total and faecal coliform in water sources increases as faeces of human and/or animal are washed into creeks, rivers, streams, lakes or ground water. However, in the dry season, the number of FC is higher due to concentration of the organism during the dry season (Obi et al.,1998). The concentration of FC obtained from the water samples exceeds the acceptable limits (0 cfu/100ml) in all the investigated wells, bore holes, protected spring and pipe borne water(Figure 18). From the result, it may be concluded that drinking water samples collected from all the water sources are not safe for human consumption. The Researcher concluded that faecal matter of wild (rodents, birds etc.), domesticated animals (cows, goats, chickens, dogs etc.), water source being few meters away from toilet and solid waste dumps and scattered waste around each water sources were some of the main sources of faecal pollution of shallow groundwater sources after precipitation events (urban runoff).

(ii) Total Coliform (TC).

Bacteriological pollution of TC were found in water samples analyzed ranged from 264.11- 7802.67 cfu/100 ml, with an average value of 3341.61 cfu/100 ml, which exceeds the acceptable limits (0 cfu/100ml) (Table 1). The highest value was observed at S_7 and the lowest at S_{10} (Figure 19). The highest level of Total coliform bacteria contamination of protected spring (S_7) in water samples may be as a result of the location of the spring water, refuse dump, human faeces scattered nearby the spring in the forest, dog excrement, decomposition of plant material by the action of microbial washed down into the soil and domestic animals that normally visit the site to drink and defecate around the water source.

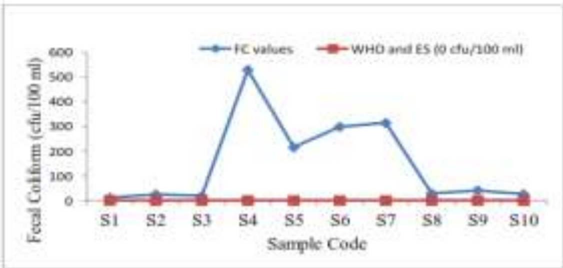

Figure 18: Fecal Coliform at Different Locations

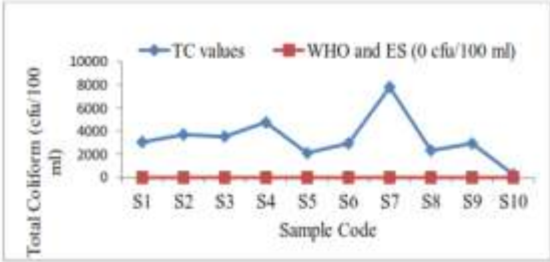

Figure 19: Total Coliform at Different Locations

Table 1: Study area Physical and Biological Parameters comparisons with guidelines of WHO (2004) and Ethiopian Standards of all the entire period.

S.C	Sample Location	Temp (^0C)	EC (µS/cm)	PH	Turbid ity (NTU)	DO (mg/l)	TDS (mg/l)	FC (cfu/100 ml)	TC (cfu/100m l)
S_1	Bake Jama	25.13	143.59	4.91	2.90	6.37	126.20	11.00	3054.87
S_2	Bake Jama	24.86	372.06	4.76	7.90	6.30	398.67	24.67	3705.10
S_3	Bakkanis a kesse	26.78	157.69	5.07	7.57	6.42	79.13	19.11	3539.00
S_4	Darge	25.73	144.86	5.32	7.75	6.14	108.00	530	4749.00
S_5	Keso	25.69	173.70	5.21	7.14	6.28	194.93	215.89	2105.90
S_6	Burka Jato	26.06	168.45	5.54	5.85	6.06	242.93	298.78	2936.43
S_7	Burka Jato	25.83	131.13	5.72	1.96	6.19	73.80	314.78	7802.67
S_8	Darge	25.92	154.27	5.93	5.54	6.52	57.13	28.33	2333.33
S_9	Chalalaki	26.63	167.57	6.19	6.42	6.18	244.20	40.89	2925.67
S_{10}	Chalalaki	25.73	69.97	6.67	2.66	6.39	46.87	25.44	264.11
Minimum		24.86	69.97	4.76	1.96	6.06	46.87	11	264.11
Maximum		26.78	372.06	6.67	7.90	6.52	398.67	530	7802.67
Mean		25.84	168.33	5.53	5.57	6.29	157.19	150.89	3341.61
WHO (2004)		≤ 15	250	6.5-8.5	5	Not <7.5	500	0	0
Ethiopian Standards(ES)		NA	NA	6.5-8.5	5	NA	1,500	0	0

Table 2 : Study area Chemical Parameters comparisons with guidelines of WHO (2004) and Ethiopian Standards of all the entire period.

S.C	TH	TA	HCO^-3	$CO^{2-}{}_3$	Cl^-	Ca^{2+}	$Mg^{2}+$	Na^+	K^+	Mn^{2+}	Fe^{2+}	SO_42-
S_1	0	5.13	5.13	0	21.91	126.65	1.48	1.6	1.2	0.47	0.02	0
S_2	3.3	11.67	11.7	0	58.90	139.1	6.35	3.65	1.55	1.61	0.0	0
S_3	0	7.20	7.20	0	16.72	132.95	3.75	2.5	1.5	1.43	0.42	0
S_4	0	17.77	17.8	0	29.17	100.15	4.17	4.6	2.1	0.37	0.07	0
S_5	0	7.60	7.60	0	16.67	81.25	2.75	3.75	1.15	0.38	0.32	0
S_6	7.17	11.00	11.0	0	25.50	269.8	5.43	4.9	1.75	0.44	0.34	0
S_7	8.67	37.73	37.7	0	20.88	151.8	4.5	2.6	0.9	0.0	0.11	0
S_8	0	6.60	6.60	0	15.55	176.35	2.36	2.05	2.4	0.54	0.05	0
S_9	0	6.27	6.27	0	22.38	49.7	2.35	2	1.65	0.26	0.0	0
S_{10}	0	16.9	16.9	0	10.58	307.7	3.36	1.45	0.4	0.7	0.72	0
Min	0	5.13	5.13	0	10.58	49.7	1.48	1.45	0.4	0	0	0
Max	8.67	37.73	37.7	0	58.90	307.7	6.35	4.9	2.4	1.61	0.72	0
Mean	1.92	12.8	12.8	0	23.83	153.55	3.65	2.91	1.46	0.62	0.21	0
WHO ,2004	200	100	200	NA	250	75	50	200	10	0.1	0.3	250
ES	500	600	NA	NA	533	200	150	358	50	0.5	0.4	483

III.4 Chemical analysis of groundwater composition using AquaChem Software Depth Profile

The EC of water samples was plotted against depth in AquaChem for evaluation of vertical variation in groundwater quality as shown in Figure 20. The plot indicates that most of the investigative wells are falling in freshwater zone and EC varied with depth may due to rainfall fluctuation and topographic level of study area

Piper Diagram: The linear plots are most suitable for the representation of groundwater composition. The diagram consists of three distinct fields; two triangular fields and one diamond shaped field. Different groundwater can be identified by their position in the diamond field. Cations expressed as percentages of total cations in meq/l plot as a single point on the left triangle while anions plot in the right triangle. Similarities and differences among groundwater samples can be revealed from the trilinear because water of similar qualities will tend to plot together as groups. The output of Piper as shown in Figure 26 and Table 9 indicates that prominent hydrochemical facies in Nekemte Aquifer are; Ca^{2+} – Cl^{-} and Ca^{2+} type.

Durov Diagram: In Piper Diagram some information are lost during transformation from triangular to diamond- shaped part of the diagram. In this plot magnesium and calcium are combined in cations whereas chloride and sulfate are combined in anions. The advantage of Durov diagram is that it can display some possible geochemical processes that could help in understanding quality of groundwater and its evolution. In Durov it is possible to depict pH and EC in addition to cations and anions. The description of water quality by marked fields yields that Pipe borne water (S_{10}) is along ion- exchange line in zone 3 and along mixing or dissolution line. All wells are falling along reverse ion exchange and endpoint of aquifer. On pH plot the concentration of wells and pipe borne water (S_{10})reveals acidic groundwater as pH of the samples is below 7.1.

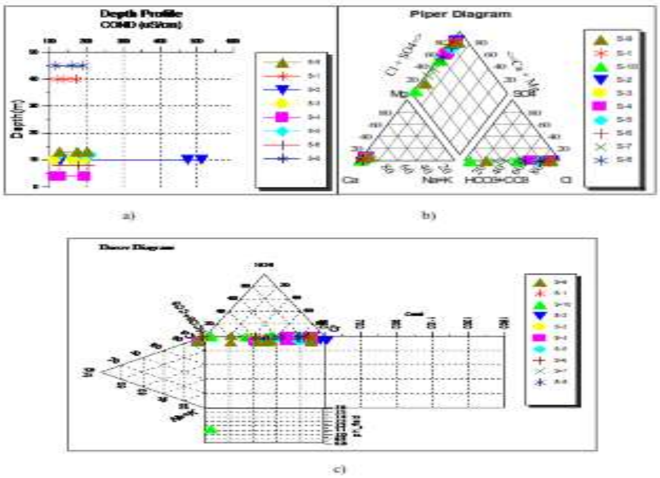

Figure 20: Chemical analysis of groundwater a) Depth profile b) Piper and c) Durov diagram

III.5 Groundwater Suitability for Irrigation Purposes.

The water quality parameters of water salinity, sodium absorption ratio, residual sodium carbonate, permiability index and magnesium ratio are very important for irrigation. The water quality parameters of all samples were calculated and given in table 3.

(i) Water Salinity(TDS and EC)

Water salinity can be assessed based on TDS or EC. High salt content in irrigation water causes osmotic pressure in soil solution (Thorne and Peterson, 1954). According to the USEPA (1976) classification of water TDS for arid and semi-arid regions (Table 4), only 1 samples of class II and the rest of samples are of class I.

Table 4a :Dissolved solids for irrigation water (USEPA, 1976)

Cl.No	TDS (mg/l)	Effects on plants	Sp.No
I	<500	No detrimental effects usually noticed	All
II	500-1000	Detrimental effects on sensitive crop	-
III	1000-2000	Adverse effects on many crops, requiring careful management practices	-
IV	2000-5000	Only for tolerant plants on permeable soils with careful management practices	-

EC µS /cm	Class	Samples (S)
<250	Excellent (C1)	$S_1, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}$
250 – 750	Good (C2)	S_2
750 – 2250	Permissible (C3)	-
>2250	Unsuitable (C4)	-

Table 4b. Classification of groundwater samples for Irrigation use based on EC (Richards, 1954).

(ii) Sodium adsorption ratio (SAR)

SAR is a measure of the suitability of water for use in agricultural irrigation, because sodium concentration can reduce the soil permeability and soil structure (Todd, 1980). The excess sodium or limited calcium and magnesium are evaluated by SAR (Kalra and Maynard, 1991) expressed as:SAR = Na^+ / $[(Ca^{2+}+Mg^{2+})/2)]^{1/2}$. The classification of water based on SAR and sodium hazard classes shown in table 5.

Table 5: Classification of waters based on SAR values(Todd, 1959; Richards, 1954) and sodium hazard classes.

SAR value	Sodium hazard class	Remark on quality	Samples (S)	Percent (%)
<10	S_1	Excellent	All samples	100
10 – 18	S_2	Good	-	
19 – 26	S_3	Fairly poor	-	
>26	S_4 and S_5	Unsuitable	-	

(iii) Residual sodium carbonate (RSC)

RSC has been calculated to determine the hazardous effect of carbonate and bicarbonate on the quality of water for agricultural purpose and is expressed by the equation .RSC = (CO3 +HCO3) - (Ca+ Mg).. The classification of irrigation water according to the RSC values shown in (Table 6).

Table 6: Results and rating of waters based on residual sodium carbonate (WHO, 1989)

RSC meq/l	Irrigation Class	Number of samples
< 1.25	Safe	All
1.25 – 2.50	Marginal	-
> 2.50	Unsuitable	-

(iv) Permeability index

The soil permeability is affected by consistent use of irrigation water which increases the presence of sodium, calcium, magnesium and bicarbonate in the soil (Chandu et al.,1995). The permeability index (PI) is used to measure the suitability of water for irrigation purpose when compared with the total ions in meq/l (WHO, 1989). The classification of ground water (doneen,1964) shown in table 7. The PI is expressed as follows.

$$PI = \frac{Na+ +(HCO-3)0.5}{Na+ +Ca++ +Mg+} * 100$$

Table 7 : Classification of ground water on the basis of Permeability Index (Doneen, 1964).

Range (%)	Class	Quality of water	Sample No	% age
<25	I	Excellent	10	100
25-75	II	Good	-	-
>75	III	unsuitable	-	-

(v) Magnesium ratio

The large amount presence of magnesium in water adversely affects soil-quality. It converts the soil into alkaline in nature thus reducing its crop yield. It is expressed as Mg ratio = [Mg / (Ca + Mg)] x 100. Magnesium ratio of more than 50% in a water body will make the water poisonous to plants (Taqveem andAdil, 2013). The magnesium ratio in the groundwater samples of the area ranges from 1.73 to 7.12 percent Table 15. So all the samples not fall in the dangerous category.

Table 3: Water Quality parameters for irrigation use

S. No	Ca^{2+}	Mg^{2+}	Na^{+}	$HCO^{-}3$	CO^{2-}_3	SAR	RSC	PI	MR
S_1	6.32	0.12	0.07	0.08	0	0.04	-6.41	5.42	1.86
S_2	6.94	0.52	0.16	0.19	0	0.08	-7.27	7.82	6.97
S_3	6.63	0.3	0.11	0.12	0	0.06	-6.81	6.80	4.33
S_4	5	0.34	0.2	0.29	0	0.12	-5.05	13.33	6.37
S_5	4.05	0.23	0.16	0.12	0	0.11	-4.16	11.41	5.37
S_6	13.5	0.45	0.2	0.18	0	0.08	-13.8	4.41	3.22
S_7	7.44	0.37	0.11	0.62	0	0.05	-7.19	11.33	4.74
S_8	8.8	0.19	0.09	0.11	0	0.04	-8.88	4.64	2.11
S_9	2.48	0.19	0.08	0.10	0	0.07	-2.57	14.41	7.12
S_{10}	15.35	0.27	0.06	0.28	0	0.02	-15.3	3.76	1.73

IV. CONCLUSION AND RECOMENDATION

Conclusion.

From the current investigation, it can be concluded that the quality of selected groundwater (Hand dug boreholes, hand dug wells and protected spring) and pipe borne water samples in the study area for physical, chemical and bacteriological tests for a period of three months were analyzed and Compared with World Health Organization limits and Ethiopian Standard for drinking and domestic Water Quality.

The results showed that most of the physical and chemical parameters of the samples were not within acceptable limits for domestic purposes. These constituents should facing possible contamination which could change the quality of the groundwater in the near future. The sequence of the abundance of the major ions is in the following order of $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$ for cations and $Cl^{-} > HCO_3^{-} > SO_4^{2-} > CO_3^{2-}$ in anions. Piper diagram shows that the contents of alkaline earths (Ca^{2+} and Mg^{2+}) are higher than those of the alkalis (Na^{+} and K^{+}). strong acids (Cl^{-} and SO_4^{2-}) are found higher than the weak acids (CO_3^{2-} and HCO_3^{-}). However, they have shown a high degree of faecal and total coliform contamination as depicted in the result of bacteriological analysis which are poor and unsuitable for human consumption . The people living in these areas are therefore at higher potential risk of contracting water-borne and/or sanitation related diseases. Thus, it would be wise that all water sources should be treated with low cost technology methods (bio-adsorbent, Natural fitration, Membrane filtration, Chlorine, Alum coagulant, boiling and etc) before being used. However, to meet the millennium development goal of potable water supply, efforts are required to improve water supply, sanitation coverage and it is important to regularly assess the pollution risks to water sources posed by improper on-site sanitation systems. Based on the classification of irrigation water according to Water Salinity, Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC), Permeability index and Magnesium ratio values, all the sample locations are suitable for irrigation purposes.

Recommendation.

Based on the outcome of the study the following is recommended to minimize groundwater deterioration:It is recommended that water quality analysis be carried out on all the water sources in the area at least once every two years. This will ensure that incidences of contamination are noticed for remedial action to be taken.Environmental awareness campaign should be organized to educate members of the community on the proper disposal of waste, management and protection of their water resources to reduce acute problem of water related diseases, which are endemic to the health of man. Groundwater sources should be properly lined and covered. Relocate refuse dump away from sources water and build wall around the sources of water for protection.

REFERENCES

[1]. American Public Health Association (APHA), (2005). Standard Methods for the Examination of Water and Waste, 21th edition Washington DC.
[2]. American Public Health Association (APHA), (1985). Standard Methods for the Examination of the Water and Waste, 14 Edition Washington D. C. P p. 76-265.
[3]. American Public Health Association (APHA), (1992). Standard Methods for the Examination of Waste th and Wastewater, 18 Edition Washington D. C. Pp72-265.
[4]. Weiner, E. R. (2000). Application of Environmental Chemistry: A Practical Guide for Environmental Professionals.Lewis Publishers Washington
[5]. World Health Organisation (WHO), (2004). Guidelines for drinking-water quality 3 Ed. Vol. 1 Geneva Pp. 145-196.
[6]. World Health Organization, (2008), "Guidelines for drinking-water quality". third edition. WorldHealth Organization, (2011), "Guidelines for drinking-water quality". Fourth edition.
[7]. Bear J (1979) Hydraulics of groundwater. McGraw-Hill International Book, New York
[8]. D.K. Todd, Groundwater Hydrology, 2nd ed., John Wiley & Sons, Singapore, 1995.
[9]. EPA (2001) Parameters of water quality: Interpretations and Standards. A publication of Ireland Environmental Protection Agency.
[10]. EPA, 2002. US Environment Protection Agency, Safe Drinking Water Act Ammendment http:// www. epa. gov/safe water /mcl.Html
[11]. Kebede T, Selomon W, Shiferaw L, Abebe G (2004). Groundwater management using groundwater modeling; case study Akaki well field, Addis Ababa.
[12]. Obi, C.L., A.O. Coker, J. Epoke and Ndip, R.N. 1998. Distributional pattern of bacterialdiarrhoeagenic agents and antibiograms of isolates from diarrhoeic and non-diarrhoeic patients in urban and rural areas of Nigeria. Cent. Afr. J. Med. 44 (9): 223-229.
[13]. Cordoba E., Martinez A., Ferrer E.,(2010) " Water quality indicators: comparison of a probabilistic index and a general quality index. The case of the confederacion hidrografica del jucar (spain) ". Ecological Indicators 10,1049–1054.
[14]. Godfrey, S., Timo, F. & Smith, M. 2005. Relationship between rainfall and microbiological contamination of shallow groundwater in Northern Mozambique. Water SA, 31(4): 609-614.
[15]. Akindutire and E. O. Alebiosu (2013). "Waste management strategies in Ado-Ekiti Metropolis of Ekiti State, Nigeria. ." European Scientific Journal 9 (29): 269 - 276.
[16]. Jameel A (1998).Physico-chemical studies in Vyyakondan Channel water of Cauvery.PollutionResearch., 17 2,111-114.
[17]. Karikari , A. Y., and Ansa-Asare ,O. D. (2004). Physico-Chemical and Microbial Water Quality Assessment of Densu River of Ghana, CSIR-Water Research Institute, Accra, Ghana
[18]. Mpenyana-Monyatsi, L. & Momba, M.N.B. 2012. Assessment of groundwater quality in the rural areas of the North West province, South Africa. Scientific Research and Essays, 7(8): 903-914.

Vighneswara Rao.K" Evaluation of Ground water Quality and its Suitability for Drinking and Irrigation at Nekemte, East wollega zone, Oromia regional state, Ethiopia" International Journal Of Engineering Research And Development , vol. 15, no. 3, 2019, pp 47-58