# Assessment of Groundwater Quality for Drinking Purpose in Guya Village Its Surrounding Area, Tigray, Northern Ethiopia

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**Abstract**
This paper assesses the groundwater chemistry and evaluates its quality for drinking use in the area using groundwater chemistry analysis method and compare with International water quality standards in Guya area (157.015 $km^2$) in Tigray, northern Ethiopia. Chemical composition of the water varies widely depending up on climate and hydrology in a specific drainage area, which contributes a seasonal influence .Among drainage area, composition is mostly depend on geology. Depth integrated groundwater sampling was applied to collect the water samples from two Bore hole, four springs as well as Three shallow wells.The dominant cations concentration in the area are mainly are $Mg^{2+}$, $Ca^{2+}$, $Na^+$, $K^+$ where the dominant anions are $HCO_3^-$, $CO_3^{2-}$, $SO_4^{2-}$ and $Cl^-$. The groundwater type in the area is generally classified in to Mg-K-HCo3-Cl, K-Ca-HCo3-Cl , K-Na-Mg-HCo3-Cl ,K-Mg-Cl-HCo3, Na-K-Mg-HCo3-Cl, Na-K-Mg-HCo3 and K-Na-Mg-HCo3-Cl. Physically and chemically, the groundwater in the area is suitable for drinking purpose but, from hardness point of view ther groundwater need to be soften as far as the drinking purpose is concerned
**Keywords:** Groundwater, Drinking, Suitability, Quality, Guya, Ethiopia

## 1. INTRODUCTION

In is known that the distribution of chemical elements over the earth's surface is not random but is controlled by physiochemical parameters that increasingly well understand as a result of progress in geochemistry. Geochemistry in its broadest sense which concerns with understanding the distribution of elements and their isotopes in the atmosphere, hydrosphere, crust, mantle and core of the earth (Alene, etal 1998).

Hydro geochemistry is the study of the chemical composition of natural waters. The chemical composition of natural result from both geogenic (natural) and anthropogenic sources (Alene, M etal 1998. According to Hem I. D 1989, once precipitation reaches the ground, it reacts with soils, rocks and organic debris (matter) and gets enriched in different elements by dissolution and dissolving still more chemicals naturally aside from any pollution generated by human activities That is why Rain and snow are the most pure forms of water. The type and concentration of salts in water depend on the processes that have affected the water since it fells as rain .Among the factors determining the several of trace and major elements are the content of solute in initial rain , the extent of reaction with rock and soil , loss of constituents by precipitation or absorption, and loss of water because of evaporation, transpiration or reaction with minerals(Todd,1980). In Remote areas, the composition of groundwater can be affected by human intervention including municipal and agricultural input as well as by withdrawal groudwater for different uses, which changes water temperature. There are many processes that contribute to the change of the composition of natural water (Appelo, C.A.J, etal, 1996). The total compositional natural water include Ions &molecules in solution, Ions adsorbed on colloidal particles and on sediments carried by flow in suspension, Organic molecules adsorbed on particle surfaces or complexes with functional groups on particle surfaces, Bacterial and algae and Dissolved gases.

Chemical groundwater data obtained from depth integrated sample can be useful in identifying regional patterns .in groundwater compositions and its relation to the rock types, however in many cases groundwater compositions show most or variation with data even on a small scale. Integrated sample over screened interval of several meters may accordingly represent mixture of water with different compositions and mixing process may also reduce chemical reactions during sampling process.

## 1. 1 LOCATION

The study area is located in the west zone of Tigray region, about 18 km from Abiy Addi town to the west direction. Geographically it lies between (0476000-0484000) E and (1450000-1505500), having an aerial extent about 157.015 $km^2$. The elevation of the area ranges from 1630m to 1995m above sea level.

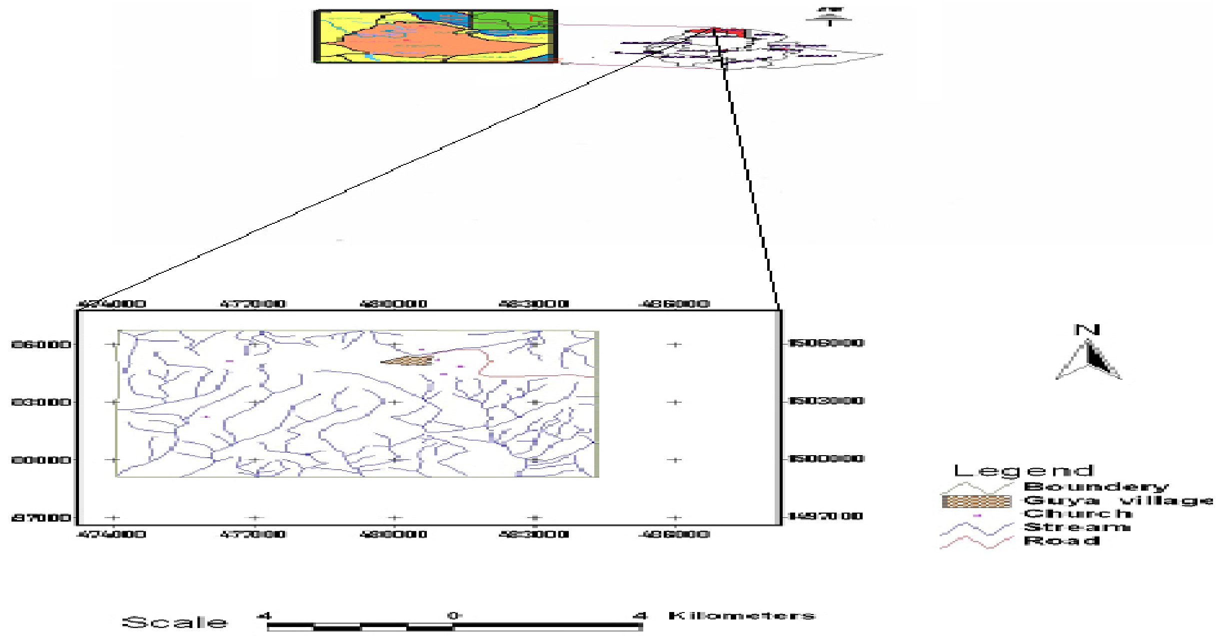


Figure 2.1 Location map of the area

## 1. 2 LOCAL GEOLOGY

According to Grmay K 2008, the area is covered by varieties of low grade metamorphic rocks and sedimentary rocks. These rock from older to younger includes; metavolcanic clastic and metavolcanic (nonclast), metasediment, metalimestone and sandstone. The area is affected by different types of structures, such as shear zone, fractured, joint, fault, fold, aperture, anastomasing, quartz veins and vein lets (Grmay K 2008).

## 1.3 ACCESSIBILITY

There are two main gravel roads that run from Guya to Abiy Addi and to Shlum-Emny. But these roads are not satisfactory enough to access the whole area by vehicles because the study area extends so far from the roads and topographically rugged. The southern part is more rugged and difficult when compared to the northern part. This area is very rugged and even difficult to travel on foot.

## 2. METHODS

## 2.1 GROUNDWATER SAMPLE COLLECTION

The method of sampling that we had used was a random depth integrated sampling and a total of 13 representative groundwater samples had been collected aiming to know general chemical nature of the water. We applied this method and collect five groundwater samples from Bore hole and from shallow and spring of four samples. As a result the nature chemical composition of the groundwater reflects the integrated sample over the whole depth. Most the sample obtained is integrated over the depth as well as over the permeability of the formation.

In collection the groundwater samples, the following basic steps had been involved:

1. Determining the purpose of sampling, which define the basic water chemistry and quality for drinking purpose?
2. Decide how many representative sampling points will be tested which nine (9) samples.

Table 2.1 Water sample and their field measurements.

| No | Water Source | Sample code | Location | Elevation | Lithology |
|---|---|---|---|---|---|
| 1 | Borehole | $BH_2$ | 0476859E&1503535N | 1736m | M.V |
| 2 | Borehole | $BH_3$ | 0482854E&1503698N | 1847m | M.V |
| 3 | Handug well | $HW_1$ | 0482826E&1503758N | 1833m | M.V |
| 4 | Handugwell | $HW_2$ | 0480221E&150426N | 1873m | M.V |
| 5 | Handugwell | $HW_3$ | 0484465E&1502423N | 1716m | M.LST |
| 6 | Spring | $SP_1$ | 0478014E&1502198N | 1734m | M.V |
| 7 | Spring | $SP_2$ | 047952E&1502729N | 1790m | M.V |
| 8 | Spring | $SP_3$ | 0479946E&1504507N | 1887m | M.V |
| 9 | Spring | $SP_4$ | 0485021&1503402n | 1631m | M.SED. |

Note: M.V=Meta volcanic, M.LST=Meta limestone, M.SED= Meta sediment

Water samples representing different unit characteristics were collected from springs, handug wells and boreholes in different parts of the study area. All the samples were collected in one liter pre-cleaned, numbered plastic bottles and with their marked location in the field note book. The plastic bottles were properly tightened to avoid oxidation from atmosphere. Mostly the spring well that were sampled are mainly from meta-volcanic and meta-sediments. At each water sample location, all the details regarding lithology units and structure were recorded.

**2.2 SAMPLE ANALYSIS**

To analyze $Na^+$, $Ca^{2+}$, $Mg^{2+}$ and $K^+$ of all the samples, atomic absorption spectrometer was used and titrimeric method was used to analyze $HCO_3^-$ and $CO_3^{2-}$ and $Cl^-$ in order to determine the alkalinity where as $SO4^{2-}$ and $NO_3^-$ of all the samples were measured by using by Ultra Spectrophotometer. The pH and the electrical conductivity of the sample were measured using pH meter insitu and in the laboratory.

From the chemical analysis results Alkalinity and total hardness as well as TDS were calculated using empirical formulas.

To check how the chemical analysis results accurate, the duplicated method was applied in such a way that the samples were analyzed two times per sample at different times of analysis by which I can see the variation in concentration between the results. In this one can look how the samples affected by external influence such as external reactions. Accordingly, the chemical analysis of these sample show a good repetition and very small and acceptable variations.

**2.3 RESULT INTERPRETATION**

The chemical analysis result data were analyzed and interpreted further using Aquachem 4.0 software and determination of groundwater types and the groundwater quality were evaluated for drinking with reference to the water quality standards

**3. RESULTS AND DISCUSSION**

**3.1 PHYSICAL ANALYSES**

The Property of groundwater evaluated in a physical analysis include, temperature, color, turbidity, odor and taste

**3.1.1 TASTE AND COLOR**

Most of the groundwater samples are tasteless. Regarding to the color all water samples is colorless. But the color for most of the surface water and open handdug wells in the area is greenish which can be caused due to natural processes in surface water sources.

**3.1.2 ODOR AND TURBIDITY**

Most of the water samples are odor less. But, two water samples, which were taken from spring water, are felling smell which may cause due to natural processes in surface water sources.

. Except two water sample which were taken from spring water body, most of the water samples are not turbid. The reason for the two water samples to be turbid is related to the human activities like washing their clothes and pumping continuously for their animals.

**3.1.3 TEMPERATURE**

Water has a considerable capacity to hold heat, much more than Air. Consequently a water body will be slower to heat and slower to cool than the surrounding air.

With respect to water quality, one important aspect of water temperature is the influence it has on dissolved oxygen, the weigh or volume of oxygen dissolved in water. The solubility of a gas in water decreases as the water temperature increases, so warmer water simply hold less oxygen

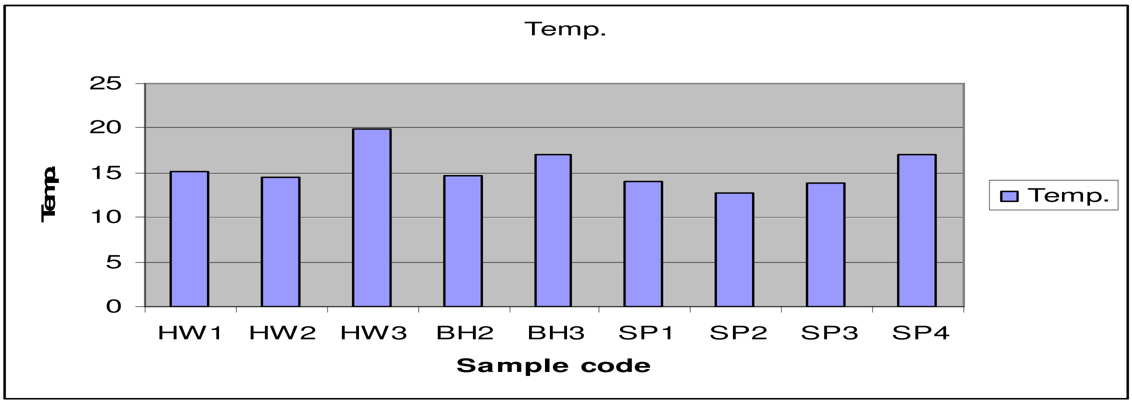
Temperature can also affect the various parameters such as alkalinity, salinity, electrical conductivity and temperature can has importance in other chemical reaction. Such as those involving water pH. In the physical analysis of groundwater temperature is reported in degree Celsius. The water temperature in our case ranges from $12.7T^0_c$ to $17T^0_c$.Generally the temperature is low and this may the cause to the low TDS concentration. .

Table 3.1 Chemical and Physical values of Groundwater samples

| No | Sample code | Temperature($T^0_c$) | TDS | Conductivity(EC) | pH | UNIT |
|---|---|---|---|---|---|---|
| 1 | $HW_1$ | 15.1 | 447.12 | 627 | 6.49 | M.V |
| 2 | $HW_2$ | 14.5 | 656.8 | 921 | 6.41 | M.V |
| 3 | $HW_3$ | 19.9 | 609.71 | 855 | 6.4 | M.LST |
| 4 | $BH_2$ | 14.7 | 576.2 | 808 | 6.59 | M.V |
| 5 | $BH_3$ | 17 | 497.75 | 698 | 6.22 | M.V |
| 6 | $SP_1$ | 14 | 658.91 | 924 | 6.98 | M.V |
| 7 | $SP_2$ | 12.7 | 625.4 | 877 | 6.98 | M.V |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | $SP_3$ | 13.8 | 634.67 | 890 | 6.91 | M.V |
| 9 | $SP_4$ | 17 | 703.13 | 986 | 6.15 | M.SED. |

Graph 3.1 temperatures of Groundwater samples




From the above data and Table 3.1, temperature of water from handug well (metalimestone unit) is relatively high and from spring water is comparatively low (metavolcanic). This indicates the temperature is variable between handug well and spring water body which is related with the elevation difference at surface of the water. In turn, this shows the capacity of the water in handug well to react with the in contact aquifer materials is more comparatively than that of the shallow spring. As a result water in handug well contains more dissolved materials.

### 3.2 CHEMICAL ANALYSIS RESULTS

### 3.2.1 TOTAL DISSOLVED SODS (TDS)

TDS is the total amount of solids in mg/l.TDS concentration in groundwater varies over many orders of magnitude. The total concentration of dissolved minerals in water is generally indications of its suitability for particular use.TDS may be determine from the weight of dry residue remaining in the water due to evaporated. It may be calculated by adding the concentration of all ions in the water.

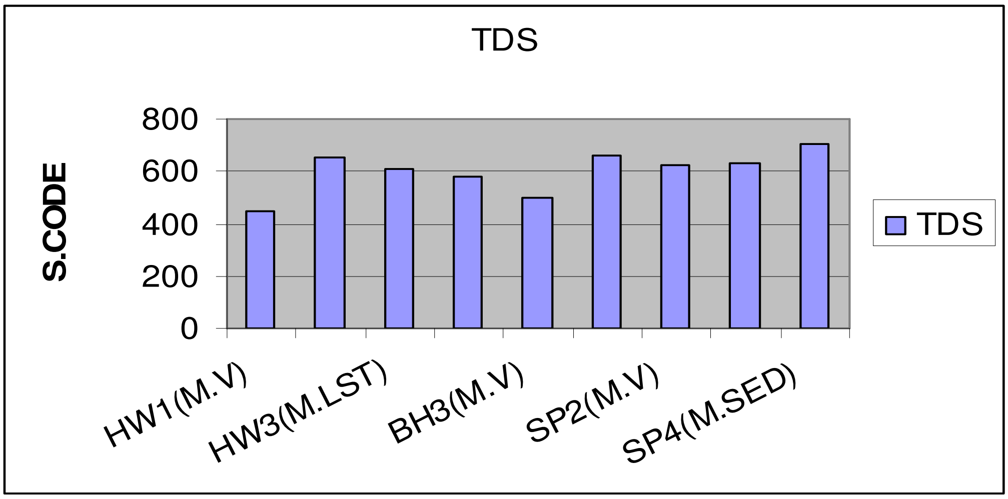
Empirically, TDS is given by the formula;

TDS= conductivity*$(1.027)^4/1.5$

Where conductivity is the ability of water to conduct an electrical current which is obtained from the analytical lab

The values of TDS of water sample in area under investigation show that all of them are fresh water because the value of TDS less than 1000 in the below table. (After Daris and Dewicol, 1966).This is the result because of low temperature, low tendency of the rock to be dissolved etc.

Graph 3.2 TDS values of Groundwater samples




From Table 3.1 and the above graph one can understand the value of TDS in all water sampled have almost same. But comparatively the TDS from spring in metasediment is high which is related with soft nature of the rock unit and water from handug well in metavolcanic is low which is indicated to hard nature of the rock unit. Generally, they are considered as fresh water because they have the TDS value less than 1000mg/l Therefore, the groundwater is suitable for drinking.

Table 3.2 classification of water quality depending on TDS (after *Daris* and Dewicol, 1966).

| Water type | TDS in mg/l |
|---|---|
| Fresh | 0-1000 |
| Brackish | 1000-10,000 |
| Saline | 10,000-100,000 |
| Brines | >100,000 |

Table 3.3. Upper limits of various constituents (mg/l) in drinking water

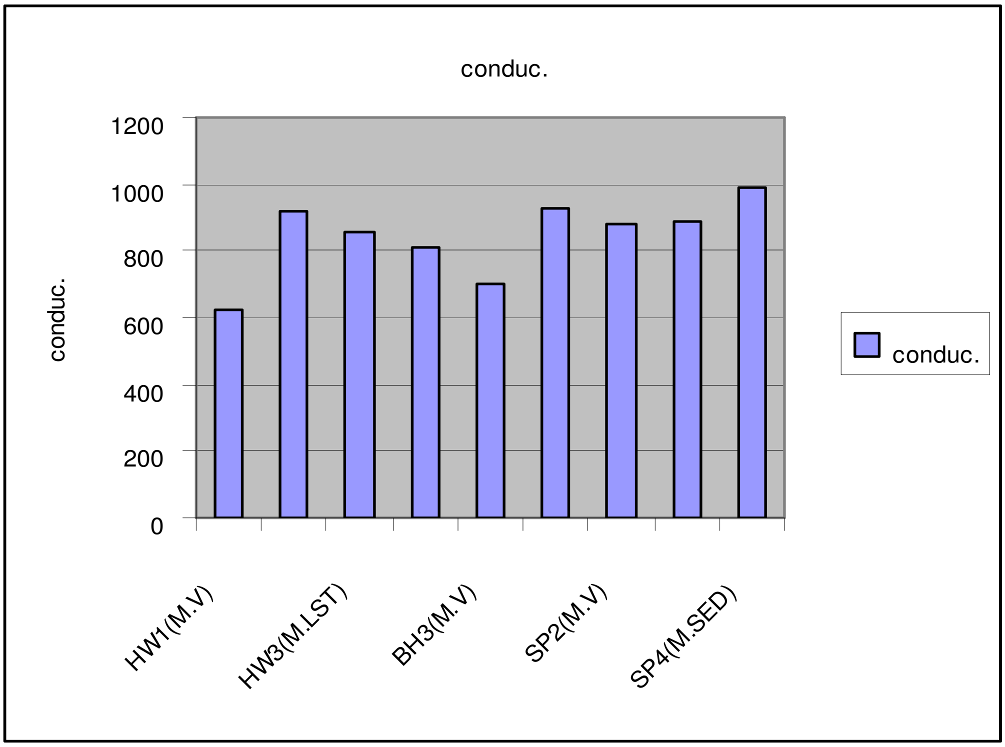
| Parameter | WHO (1984) |
|---|---|
| TDS | 1000 |
| pH | 6.5 – 8.5 |
| Total Hardness $CaCO_3$ | 500 |
| Ca | 75 – 200 |
| Mg | - |
| Na | 200 |
| Cl | 250 |
| $SO_4$ | 400 |
| $NO_3$ | 45 |

Source: Singhal and Gupta, 1999.

### 3.2.2 ELECTRICAL CONDUCTANCE

The source of Conductivity includes variable which are non-specific measure of the amount of natural dissolved inorganic substances in source waters It measures the ability of water conduct an electrical current. Current flows in ionized or mineralized water because the ions are electrically charged and move toward a current that will neutralize them. Conductance increase with salt content. As a result the concentration of dissolved salts can be estimated on the basis of electrical conductivity measurements.

Graph 3.3 conductivity values of Groundwater samples

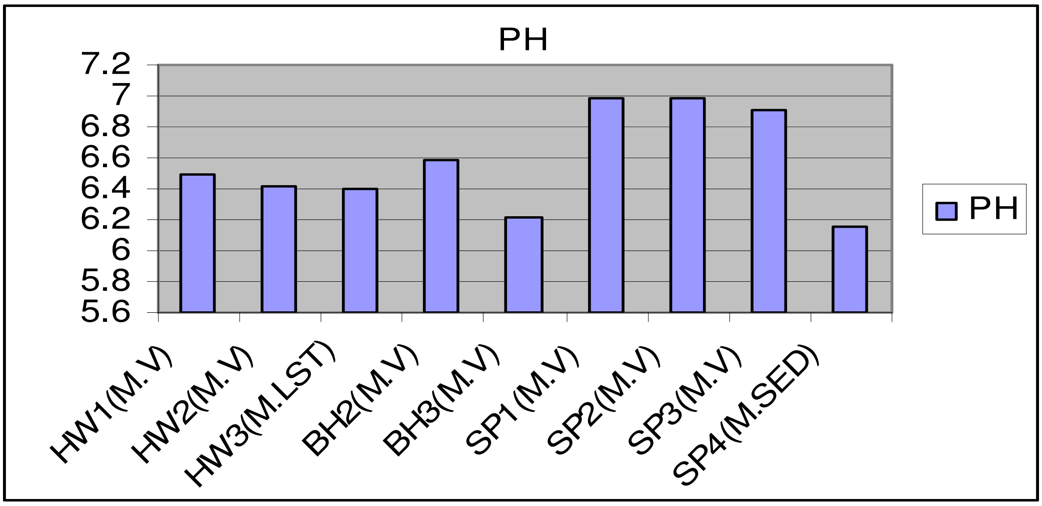



From the above data, the conductivity of water from metasediment is relatively high as compared to that of metavolcanic. This indicates the water from metasediment is highly mineralized and contains more salt concentration and dissolved materials. Based on the European and National Drinking Water Quality Standards, 2014, the groundwater quality is below the maximum limit and therefore, the water is suitable for drinking purpose.

### 3.2.3 PH

The pH value of the water is affected by its age and chemicals discharged by community and industries. All the groundwater samples, in the area have a pH value below 7 (Table 3.1 and Graph 3.4). However, pH almost 7 is seen metavolcanic ($SP_2$) and the minimum pH values are observed in met sediment units. Generally, since the pH values are below the maximum limit, the groundwater is suitable for drinking.

Graph 3.4 pH values of Groundwater sample




### 3.3.4 HARDNESS

It is predominantly caused by divalent actions such as, calcium, magnesium, alkaline earth metals (iron, manganese, strontium etc).

Hardness is the indication of water quality which is concentration of alkaline salts in water and is normally expressed as the total concentration of calcium and magnesium as mg/l equivalent calcium carbonate. It is know that the total hardness is defined as the sum of calcium and magnesium concentrations, both expressed as calcium carbonate in mg/l

Analytical hardness is given by the formula;

Hardness (H) = $[2[Ca^{2+}]/40 + 2[Mg^{2+}]/24] *100/2$

Based on this formula, the hardness value of all water samples were measured and organized the table below.

Table 3.3 Hardness of Groundwater samples

| No | Sample code | Hardness | Alkalinity($CaCO_3$) | UNIT |
|---|---|---|---|---|
| 1 | $HW_1$ | 170 | 280 ml | M.V |
| 2 | $HW_2$ | 215 | 270 ml | M.V |
| 3 | $HW_3$ | 327.5 | 150 mlk | M.LST |
| 4 | $BH_2$ | 211.67 | 370 ml | M.V |
| 5 | $BH_3$ | 110 | 120 ml | M.V |
| 6 | $SP_1$ | 120 | 270 ml | M.V |
| 7 | $SP_2$ | 153.33 | 330 ml | M.V |
| 8 | $SP_3$ | 140.83 | 250 ml | M.V |
| 9 | $SP_4$ | 259.17 | 90 ml | M.SED. |

Graph 3.5 hardness of Groundwater samples

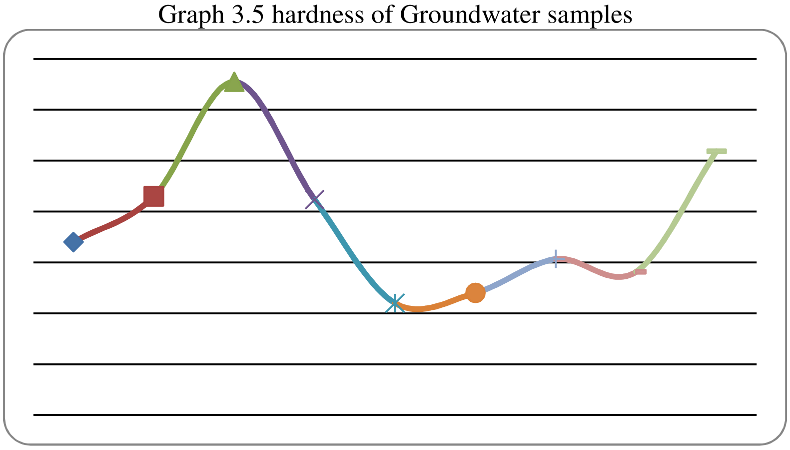


Table 3.4. Hardness classification of water (after Sawyer and McCarty, 1967)

| Hardness rating | Concentration of Calcium Carbonate (mg/l) |
|---|---|
| Soft | 0 to < 75 |
| Medium hard | 75 to < 150 |
| Hard | 150 to < 300 |
| Very hard | 300 and greater |

From the Table 3.3 and Graph 3.5, the Hardness from meta volcanic ($SP_1$) is moderate, hardness from both metasediment and metalimestone (SP4 and $HW_3$) are very hard which indicates that high concentration of calcium and magnesium in sedimentary soft materials. But most of the groundwater samples from metavolcanics have hardness between moderate and very hard with respect to hardness which need softening the groundwater as far as drinking purpose is concerned.

**3.3.5 ALKALINITY**

It the alkalinity that indicates a solutions power to react with acid k8and buffer its Ph. The main sources of natural alkalinity are rocks, which contains carbonates, bicarbonates and hydroxide compounds. Empirically, alkalinity of water sample is given by the formula;

Alkalinity ($CaCO_3$) = $[V_{titrate\ (HCl)} - V_{blank(0.2)}]/V_{of\ sample}$ *N *50,000

Where - N is normality of HCl (0.1), 50,000 is given and 50 ml is Volume of samples

From the above table, the alkalinity of water sample taken from metasediment water is comparatively higher than the water sample taken from metavolcanic. This indicates the water in the met sediment has more tendency or capacity to neutralize acid than the water in the metavolcanic

**3.3. 6 MAJOR CAT IONS**

Based on their concentration, calcium, sodium, potassium and magnesium are thedominate among the cations.

Table 3.5 concentration of potassium of the Groundwater samples

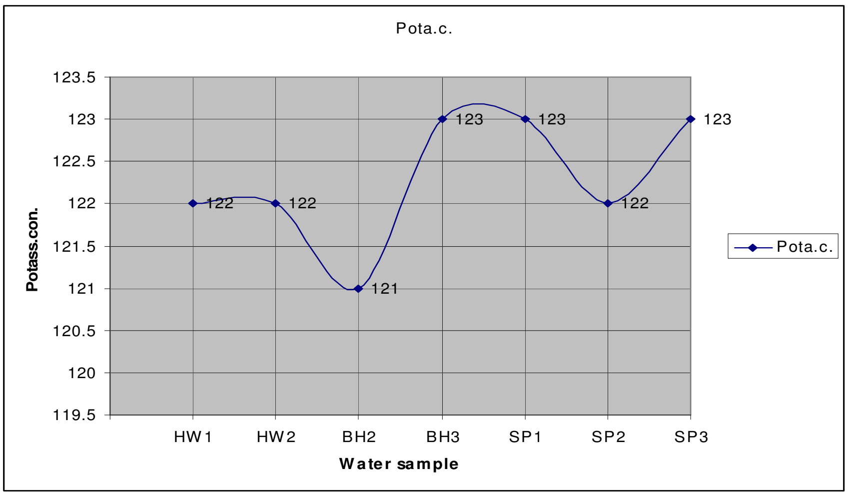
| Sample code | Groundwater type | Major ions composition in mg/l | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | Cl- | $SO_4^{2-}$ | $NO3^-$ | $HCO3^-$ | $CO_3^{2-}$ |
| HW2 | Mg-K-HCo3-Cl | 44 | 122 | 16 | 42 | 113 | 30.00 | 45.00 | 329.33 | 0.042 |
| HW1 | K-Ca-HCo3-Cl | 22 | 122 | 43 | 15 | 103 | 31.30 | 29.30 | 341.50 | 0.052 |
| HW3 | K-Ca-HCo3-Cl | 28 | 123 | 14 | 18 | 40 | 28 | 25 | 146.38 | 0.023 |
| BH2 | K-Na-Mg-HCo3Cl | 62 | 121 | 6 | 25 | 70 | 26.30 | 22.60 | 451.22 | 0.0865 |
| BH3 | K-Mg-Cl-HCo3 | 28 | 123 | 14 | 18 | 118 | 29.30 | 28.30 | 146.38 | 0.012 |
| SP1 | Na-K-Mg-HCo3-Cl | 94 | 123 | 3 | 27 | 86 | 29.30 | 20.60 | 329.41 | 0.154 |
| SP2 | Na-K-Mg-HCo3 | 72 | 122 | 3 | 35 | 60 | 33.60 | 32.40 | 402.20 | 0.1894 |
| SP3 | K-Na-Mg-HCo3-Cl | 68 | 123 | 8 | 29 | 78 | 28.60 | 38.30 | 304.80 | 0.122 |
| SP4 | K-Na-Mg-HCo3-Cl | 53 | 122 | 42 | 37 | 47 | 30.2 | 21.5 | 109.78 | 0.0076 |

**3.3.6.1 POTASSIUM CONCENTRATION [$K^+$]**

Potassium is the most dominant concentrated in study area (Table 3.5). Its concentration value ranges between 122mg/l to -122 mg/l. The concentration of potassium is almost uniform in all water sample taken from water body with in the area.

According to the data from analysis, both maximum and minimum concentration value of potassium is observed in the groundwater sample taken from springs which indicating that the dominant source of feldspars (orthoclase and microcline), feldspathoids, are high around the spring.

Graph 3.6 concentration of potassium ion in Groundwater samples



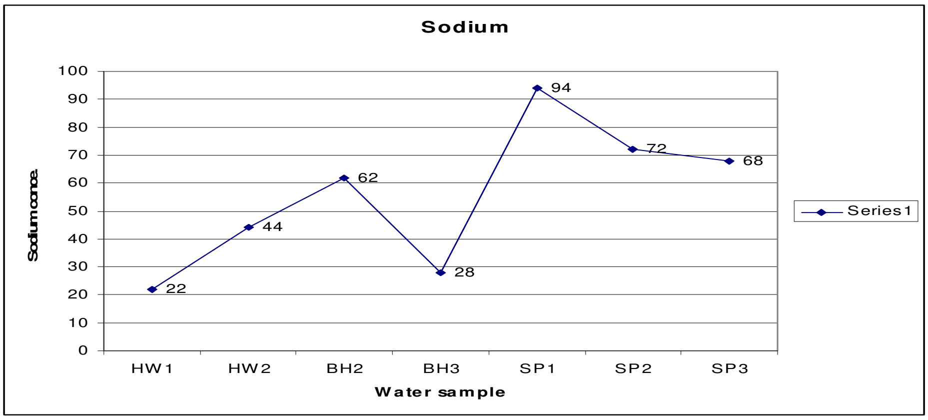
 

**3.3.6.2 SODIUM ($NA^+$)**

Sodium is the second most dominant cation in the area having the value ranging from 22mg/l to 94mg/l in the water sample taken from highly weathered metavolcanic unit (Table 3.5). Its concentration value is highly variable within the water sample in the area. This indicates that the water from spring is comparatively is rich in albite, Clay minerals and sodium chloride etc.

Based on the WHO guideline (Table3.3), the sodium concentration is below the permitable limit and therefore, the groundwater in the area is suitable for drinking purpose as far as sodium concentration is concerned.

Graph 3.7 concentration of Sodium ion of the Groundwater samples




**3.3.6.3 MAGNESIUM ION ($MG^{2+}$)**

The concentration of magnesium depends on the amount of magnesium in the dolomite or calcite lithology and other sources. Magnesium is the third (3rd) dominant cation in the area. The concentration of magnesium is range from 15mg/l to 42mg/l in weathered and fractured metavolcanic (Table 3.5). The variation in magnesium concentration with in the area is low.

**3.3.6.4 CALCIUM CONCENTRATION ($Ca^{2+}$)**

Source of calcium for groundwater are dissolved of calcite and dolomite and other minerals which could exert some concentration of calcium. As a result concentration of calcium depends on the availabilities of these minerals in rocks. Calcium is the fourth dominant cation in the area with highly variation of concentration. Generally, the concentration of calcium ion ($Ca^{2+}$) is ranging from 3mg/l to 43 mg/l. From the Table 3.5, one can understand that the calcium concentration is higher in metalimestone which shows the country rock round the handug well is rich in minerals such as clay minerals, calcite, dolomite etc. According to the WHO 1984 (Table 3.3) water quality standards, the calcium concentration under the maximum limit which indicates that the groundwater is suitable for drinking purpose.

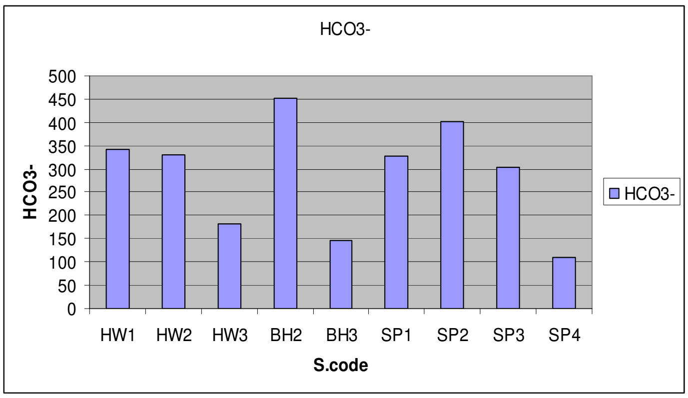
**3.3.7 ANIONS**

Among the major anions which were analyses are bicarbonates ($HCO_3^-$), carbonates ($CO_3^{2-}$), chlorine ($Cl^-$), sulphate ($SO4^{2-}$), nitrate ($NO3^-$) are the dominant.

**3.3.7.1 BICARBONATE ($HCO_3^-$) AND CARBONATE ($CO_3^{2-}$)**

The concentration of bicarbonate ranges from 146.38 to 402.2 mg/l in metavolcanic unit where as the concentration value of carbonate ranges from 0.012mg/l to 0.1894mg/l in metavolcanic unit (Table 3.5).

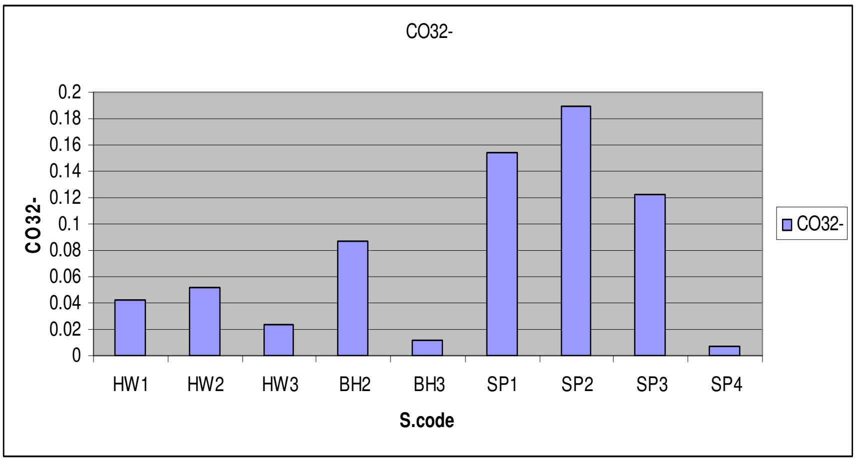
Graph 3.8 bicarbonate value of groundwater samples




From the above graph, one can understand the value is higher in boreholes (metavolcanic) which show the source of rocks is excess with depth. (Guidelines and Suitability)

Graph Fig 3.9 carbonate values of Groundwater samples

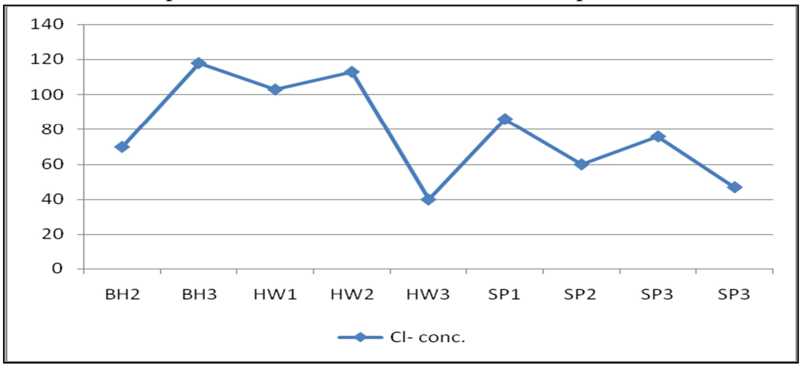



The graph indicates, the value of carbonate concentration is high in spring and generally, all groundwater samples show a value of the carbonate with the permitable limit and the groundwater in the area is suitable as far as drinking purpose (standared and suitability)

**3.3.7.2 CHLORIDE ($Cl^-$)**

The limits of chloride have been put more from taste point of view rather than its adverse effect on human health. The chloride concentration is range from 40 mg/l to118 mg/l (Table 3.3) and is highly variable. The highest concentration value is recorded in metavolcanic and the lower is belongs to metasediment.

Graph 3 .10 chlorine concentration of sample water

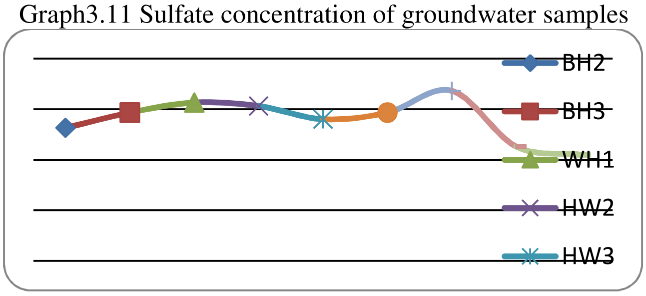



From the above graph, one can understand the value is highly variable which indicates as there are different source for the concentration of chloride. Based on the WHO 1984, the maximum limit of water quality standards for drinking use is 250mg/l. Since the all the groundwater samples indicate a value under this limit, the groundwater quality in the area is suitable for drinking.

**3.3.7.3 SULFATE ($SO_4^{2-}$)**

Major natural sources of sulfate are oxidation of sulfide ores, gypsum and anhydrite. Water containing about 500mg/l of sulfate tastes bitter and water containing about 1000mg/l may be cathartic (Todd, 1980). The concentration of sulphate is characterized by almost uniform variation with the highest value of 33.6 g/l in $SP_3$ and low concentration value of 26.3g/l in $BH_2$ (Table 3.3).

Graph3.11 Sulfate concentration of groundwater samples




From the above graph, indicate that the value is highly variable which indicates different sources that contributed for the concentration of sulfate. Based on the WHO 1984 water quality standards for drinking purpose, since the maximum concentration value of sulfate in the groundwater in the area is within the maximum limit, the groundwater quality in the area is suitable for drinking.

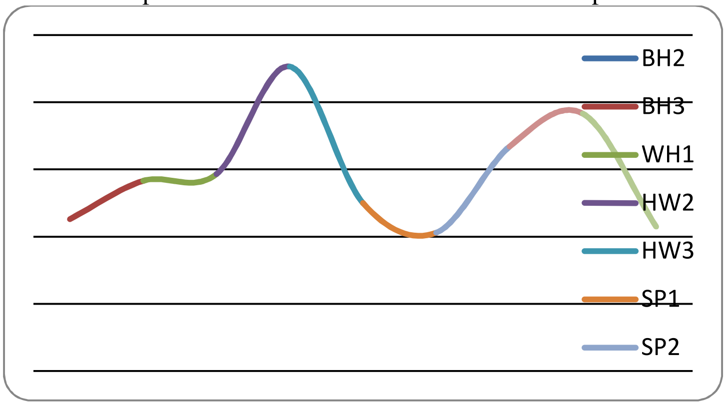
 

### 3.3.7.4 NITRATES ($NO_3^-$)

The concentration of nitrate depends on only oh the natural source but also on the agricultural fertilizers. The concentration of nitrate is range from 20.6 mg/l to 45.3 mg/l (Table 3.5) and is generally high in metavolcanic but low in meta sediment.

The maximum prescribed limit of $No3^-$ in municipal water supplies is 50mg/l. in many countries water supplies having high levels of nitrate have been responsible for baby disease in infants and death.

Graph3.12 Nitrate concentration of water sample




The above graph shows that the value is highly variable which indicates different sources that contributed for the concentration of nitrate. Based on the WHO 1984 water quality standards for drinking purpose, since the maximum concentration value of nitrate in the groundwater in the area in general is within the maximum limit, the groundwater quality in the area is suitable for drinking.

### 3.4 GRONDWATER TYPE

The groundwater type of the area is different in different water bodies (Table3.3). From this, one can understand that the dominant and major ionic compositions of the groundwater are $Mg^{2+}$, $Ca^{2+}$, $Na^+$, $K^+$, $HCO3^-$ and $Cl^-$ .

### 3.5 DRINKING WATER

Water used for drinking must have high standards of physical, chemical and biological purity.

Drinking water standards are based on two criteria; the presence of objectionable taste, odor or color and the presence of substances with adverse physical effects (Davis and Dewiest, 1966).

Drinking water quality can be determined on the basis of its specific electrical conductance or its amount of TDS.

The TDS value of the sample collected ranges from 447.12mg/l to 658.91mg\l in the meta-volcanic units. Since the TDS value of the water sample is range between 447.12 mg/l – 658.91mg\l, the water is categorized as freshwater which suitable for drinking purpose.

Table 3 .6 Standards for drinking water

| Constituent | Recommended level in mg/l |
|---|---|
| $Cl^-$ | 250 |
| $SO4^{2-}$ | 250 |
| TDS | 500 |
| pH | 6.5to 8.5 |
| Odor | 3 threshold odor number |
| Corrosity | Non corrosive |
| Color | 15 color unit |

Source U.S Environmental Protection Agency (1975)

## 4. CONCLUSION AND RECOMMANDATION

### 4.1 CONCLUSION

The area is located near by the Giba basin which is characterized by highly ragged topography. The handug wells, boreholes and springs are mainly the water sources for the local village.

The water type of the area is classified in to Mg-K-HCo3-Cl, K-Ca-HCo3-Cl , K-Na-Mg-HCo3-Cl ,K-Mg-Cl-HCo3, Na-K-Mg-HCo3-Cl, Na-K-Mg-HCo3 and K-Na-Mg-HCo3-Cl. This shows that the dominant cations are Mg, Ca, Na, K and the dominant anions are HCO3 and Cl. The temperature of the groundwater from borehole is relatively high and from spring water is comparatively low. This indicates the temperature is high in deep bore hole and is low in shallow well and handug well water body which indicate the capacity of the water