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# Hydrogeochemical and Microbial Investigation of Groundwater Quality, A Case Study of Aviele, Edo State

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**Abstract**

Water quality of both surface water and groundwater indicates its usage and consumption, they are usually prone to pollution, which alter the physico-chemical and biological properties. This study investigates the hydrogeochemical and microbial properties of groundwater, the study area falls into the Anambra Basin of Nigeria, within latitude N 7°00' to N 7°05' and longitude E 6°10' to E 6°15', and can be access by the Benin - Auchi expressway. This was done by collection of seven water samples from wells for insitu and laboratory analysis. The study indicates that the groundwater is slightly acidic in nature with an average value of 6.27, indicating slightly acidity and lies below permissible limit of the World Health Organization (WHO) and the Nigeria Standard for Drinking Water Quality (NSDWQ). The total dissolved solid (TDS) of 93.84mg/l average value indicates fresh water in the area. The anions and cations of the groundwater in the study area, falls within the permissible limit of the WHO and NSDWQ, with high iron and cadmium and chromium present in some location. This is probably due to the water bearing formation and the slightly acidic nature of the groundwater in the area, and the water type is Calcium – Chloride (Ca-Cl), with no presence of micro-organisms. Hence, there is need for water treatment plant to be installed in the area and proper waste disposal.

***Keywords****: Groundwater, Physico-Chemical, Microbial, Anions and Cations.*

## I. INTRODUCTION

Water is essential domestic, agriculture, power and industry purposes. The lack of access to safe drinking water and basic sanitation are some of the problems affecting health of billions of people around the world, to estimate the quality of this resources, there is the need for an assessment of the physical, chemical and biological characteristics, especially how they relate to the suitability of the water for a particular use (Kevin, 2005). Both surface and groundwater are usually prone to pollution, which alter the quality of the water and it suitability for consumption and usage (Patil *et. al.*, 2012). The high dissolved or suspended constituents in water than the permissible limit are undesirable (Amadi *et. al.*, 2010). Poor water supply impacts on public health in developing and developed countries have been recognized. These manifest in the outbreak of water borne diseases (Payment and Hunter, 2001). The effects of the possible harmful contaminants in both surface and groundwater can be limited by various measures developed to protect water bodies and their users (Olasunmbo, 2001).

Waterborne diseases contributes to the total diseases associated with diarrhea and other gastro-intestinal diseases, this lead to about 2.2 million deaths and over 72 million disability (WHO, 2002). In developing countries children are most affected by water-related and diarrheal disease (Pruss *et al.,* 2002). Globally, majority of people utilizes poor water quality supplies at a costly rate at great distant from their home (WHO & UNICEF, 2000). Groundwater found in the zone of saturation is not easily prone to pollution as compared to surface water found on the earth surface (Umoru *et al.,* 2021). To effectively monitor and manage the ground water quality in the study area, there is need to take into consideration the hydrochemical and biological properties of the groundwater in the study. The study of hydrogeochemical and microbial properties of groundwater will significantly revealed the conditions of the quality of water. Thus, there is the need to investigate the hydrogeochemical and

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microbial constituents/concentrations of the groundwater quality of the study area.

## II. STUDY AREA

The study area lies within N 7°00' to N 7°05' latitude and E 6°10' to E 6°15' longitude, in South-south geopolitical region of Nigeria. The study area can be access by the Benin - Auchi expressway. The study area is within the Etsako – west Local Gvernment Area of Edo State, Nigeria. The climate condition of the study area and its environs falls within the warm-horrid tropical climate region where the summer and winter season are prominently in the area, with wet (May to October) and dry seasons (November to April). The area vegetation (of guinea savannah) is characterized by few grasses, shrubs and scattered moderately trees of about 6m tall, it is dense at the rain season and less dense and altered at dry season, due to fire, animal grazing and farming activities, enhancing erosion in the area (Matthew, 2002).

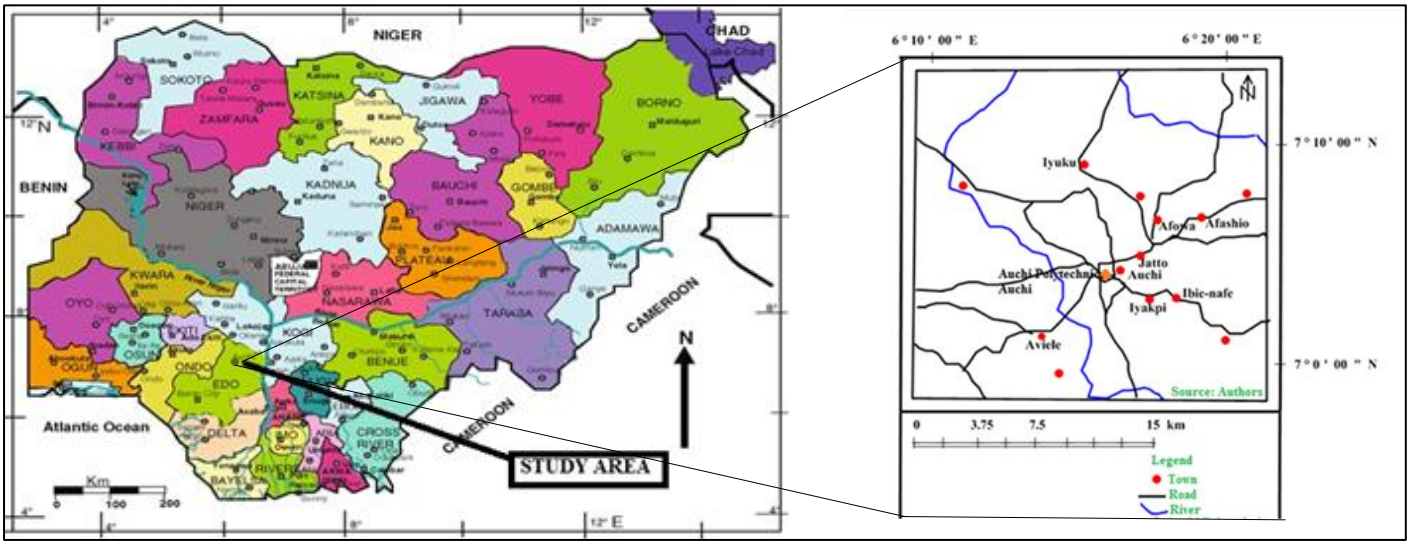


Fig 1 Map of Nigeria Showing the Study Area

The Study area falls into the Anambra Basin of Nigeria which is one of the sedimentary basins, exclusively belongs to Nigeria (Okogbue, 2005) and a structural depression located at the south-western of the Benue Trough. Anambra Basin is bounded on the north by Benue Basin, the east by Cross River basin, the south by the Niger Delta Basin and on the west by River Niger. The geologic age of the basin is Upper Senonian – Maastrichtian and Paleocene at the end of Benue Trough with accumulation of Nkporo Shales and younger sediments, and extends towards the southwest to the Niger Delta Basin. Figure 2 is the Geology map of Nigeria and table 1 shows the lithology of Anambra Basin.

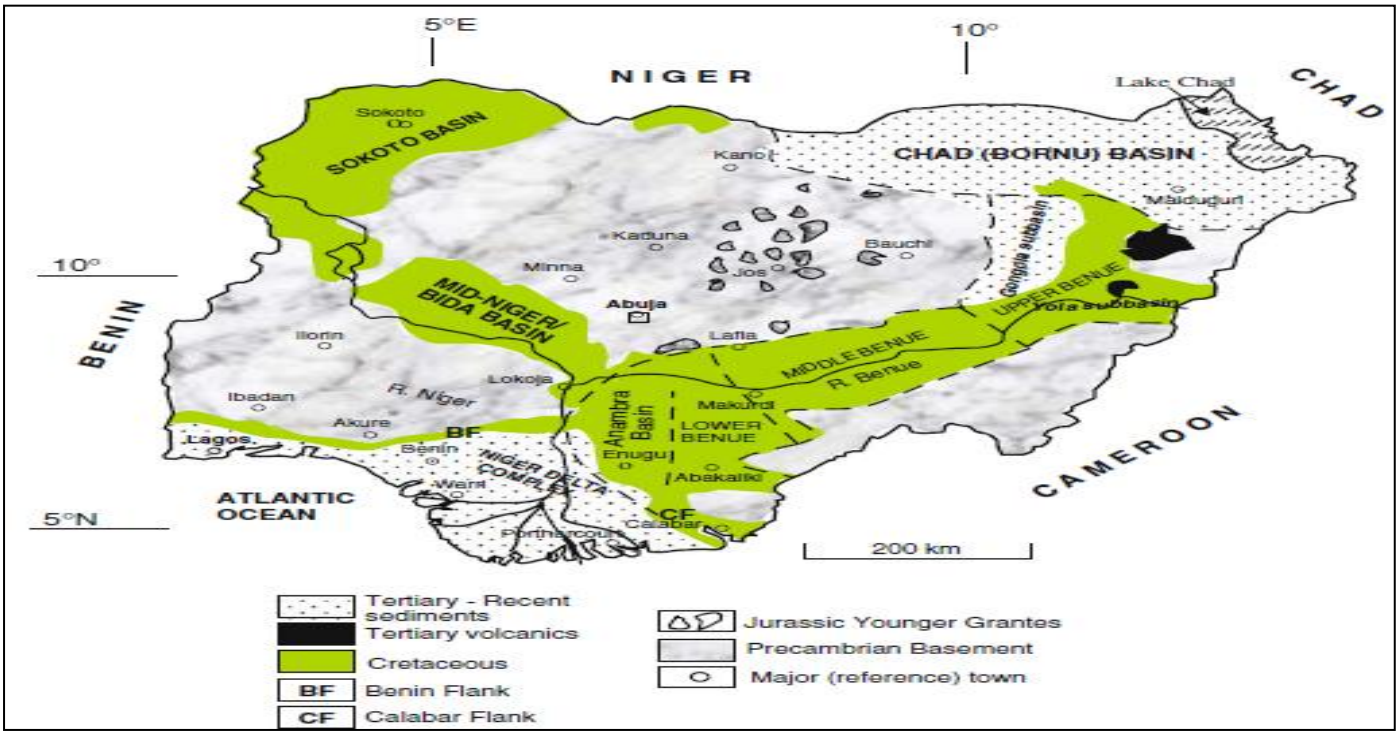


Fig 2 Geology of Nigeria map (Obaje, 2009)

Table 1 Anambra Basin Sequence of Lithological (Okogbue, 2005)

| Stratigraphic Units | Lithology |
|---|---|
| Nsukka Formation | Ferruginized reddish clay, sandy shale, shale and sandstone, silts and clay stones, Upper Coal Measure |
| Ajali Formation | Sandstone |
| Mamu Formation | Carbonaceous shale, sandy shale, shale, Lower Coal Measure |
| Nkporo Formation | Inter-bedded sand, shale and mud |

Martins, (2001) further pointed out that

Two main aquifer types exists across the 11 groundwater provinces in Nigeria, the crystalline aquifer covering about 50% and the sedimentary aquifer covering the remaining 50% of the country. The aquifer in the area is a false-bedded sandstone formation (Ajali formation) with an average 457m thickness (Macaulay, 2008). Akujieze *et al*. (2002), study the groundwater in Nigeria, and established that the lack of hydrogeological map of Nigeria, is one of the major challenges to groundwater exploitation. The range to water table in the Anambra-Benin section of the basin is about 183 to 244 m, the water in Auchi section of the basin is slightly acidic with high iron content, and drained by Orle river, into the River Niger.

## III. METHODOLOGY

The assessment of ground water quality in the area was conducted in three stages, by collection of samples of groundwater in seven hand dug well (figure 3) and with the coordinates of each well using Global Positioning System. The water samples were subjected to insitu testing using PHS-3D pH meter Uniscope for temperature, pH, turbidity and conductivity in the field, the samples was analyzed suing the American Public Health Association standards (APHA, 2008) for physico-chemical and biological analysis. The characteristic of water was compared to World Health Organization (WHO) and the Nigeria Standard for Drinking Water Quality (NSDWQ).

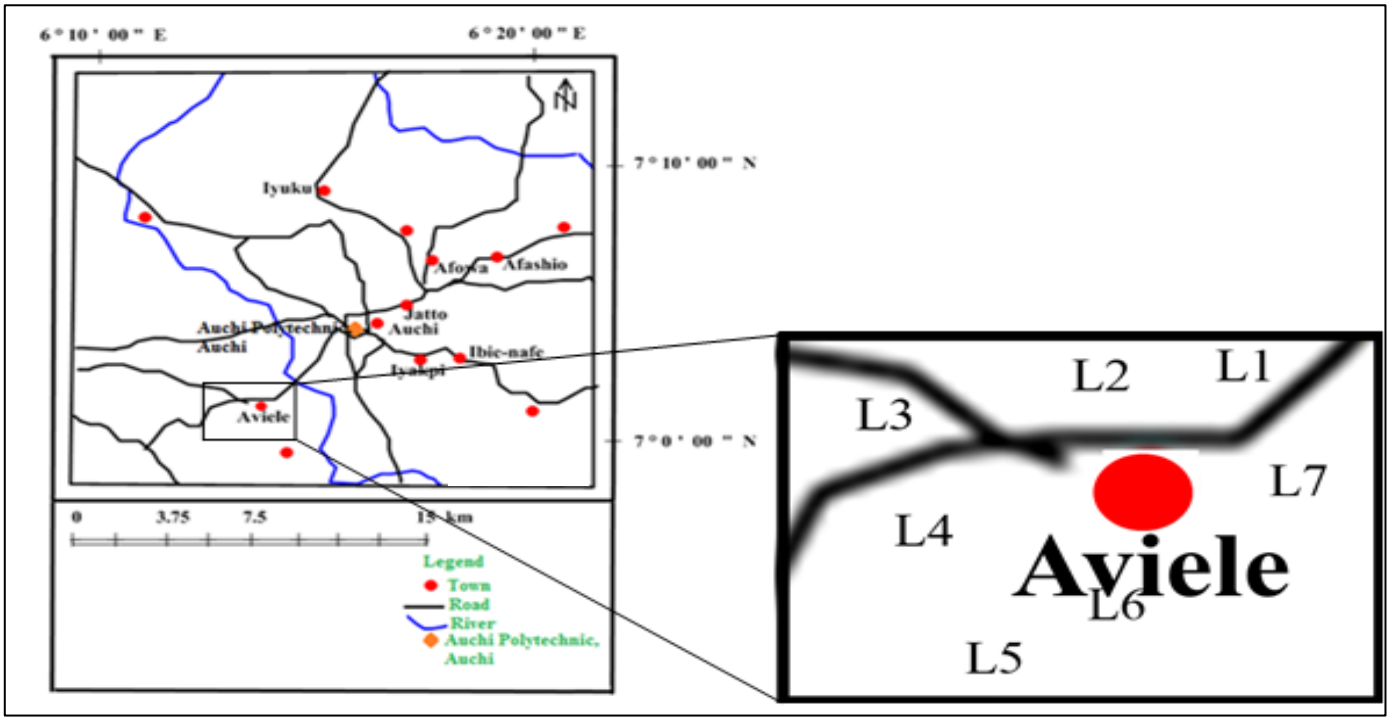


Fig 3 Sample Locations Map

Titration method was used in the laboratory for quantitative.

The chemical analysis for the anions (Sodium, Potassium, Calcium, Magnesium) and heavy metals (Fe, Zn, Cu, Mn, Pb, V, Ni, Cr, Cd, and CN.) was done using Atomic Absorption Spectrometer (AAS) and APHA, 1985, was used to determine the total Coliform in the water samples.

## IV. RESULTS AND DISCUSSION

➢ *Results*

The figure 4 to 12 shows physico-chemical parameters of the groundwater and figure 13 the heavy metals concentration of water in the area.

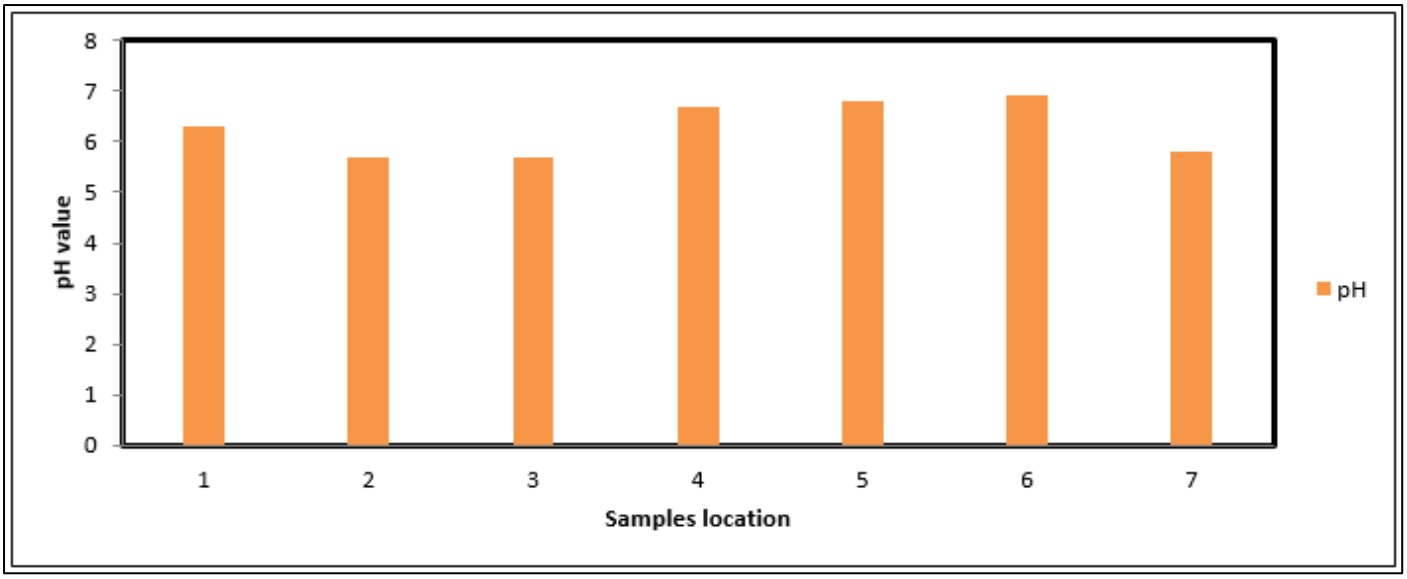


Fig 4 Ph Plot for the Groundwater

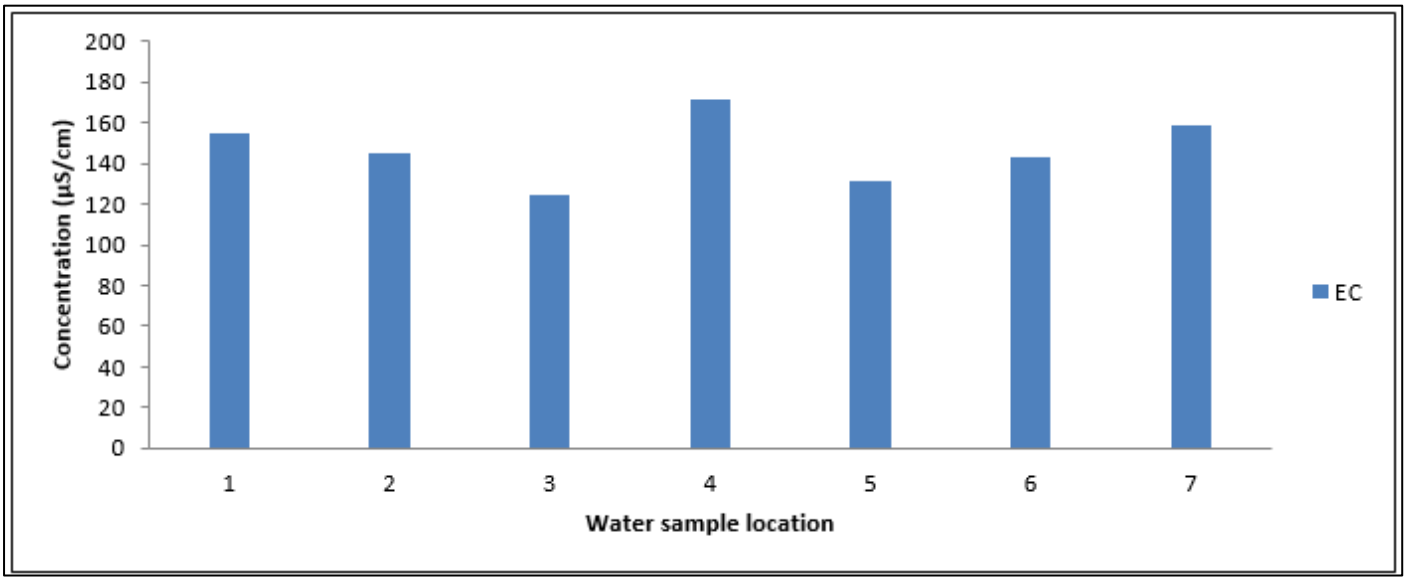


Fig 5 EC plot for the groundwater

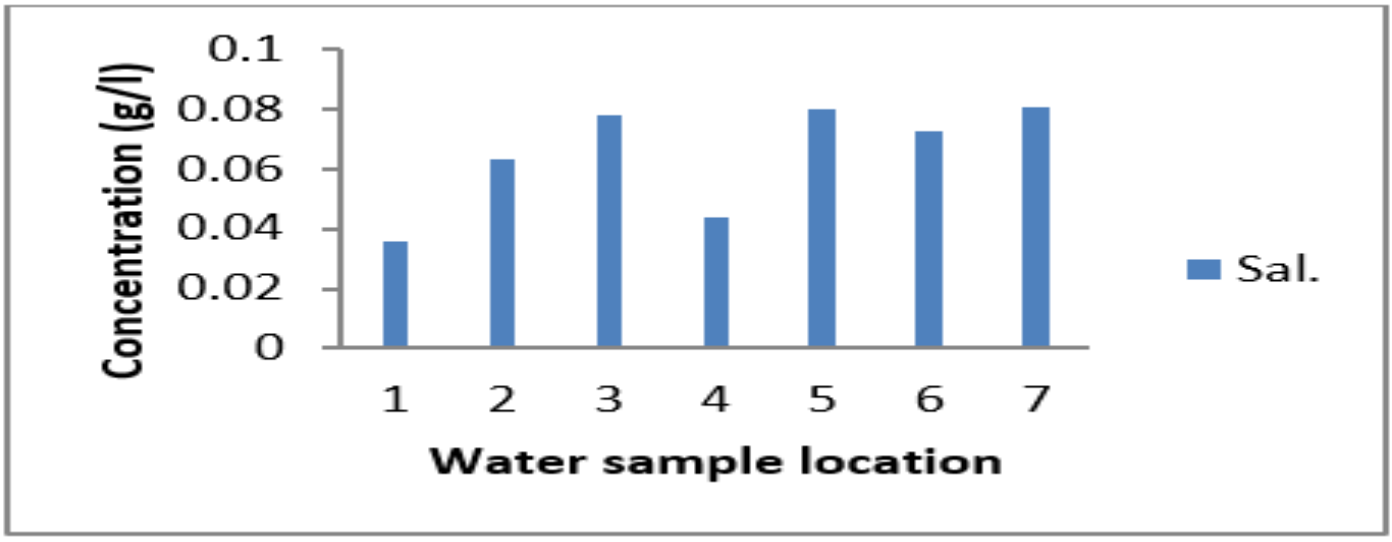


Fig 6 Salinity plot for the groundwater

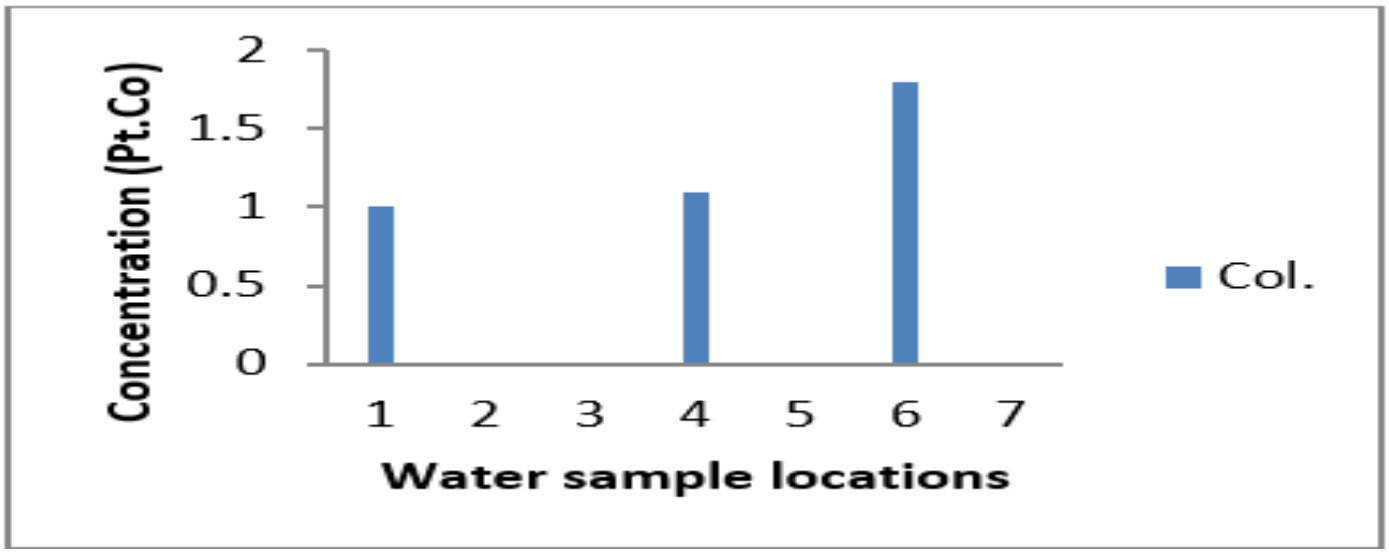


Fig 7 Colour plot of the groundwater

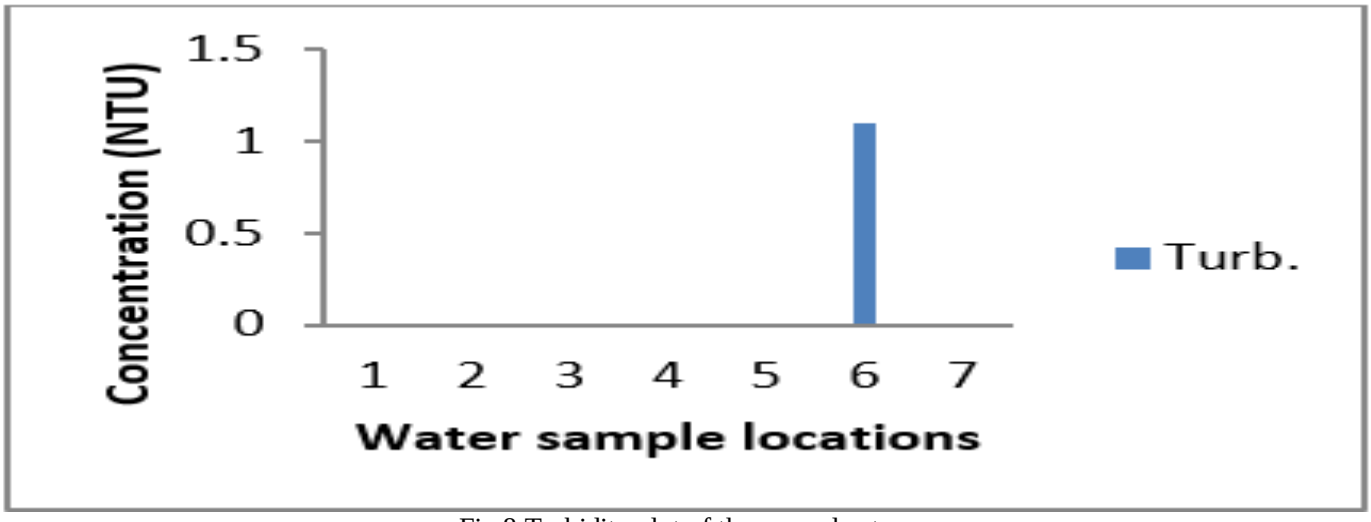


Fig 8 Turbidity plot of the groundwater

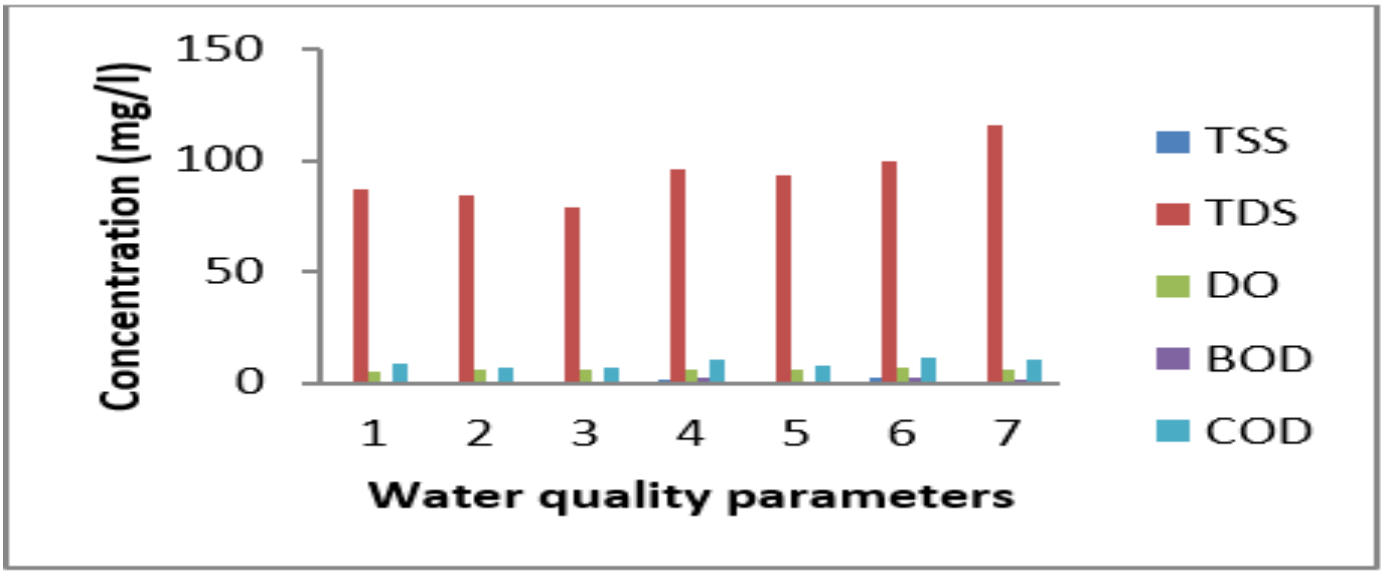


Fig 9 Plot of TSS, TDS, DO, BOD and COD of the groundwater

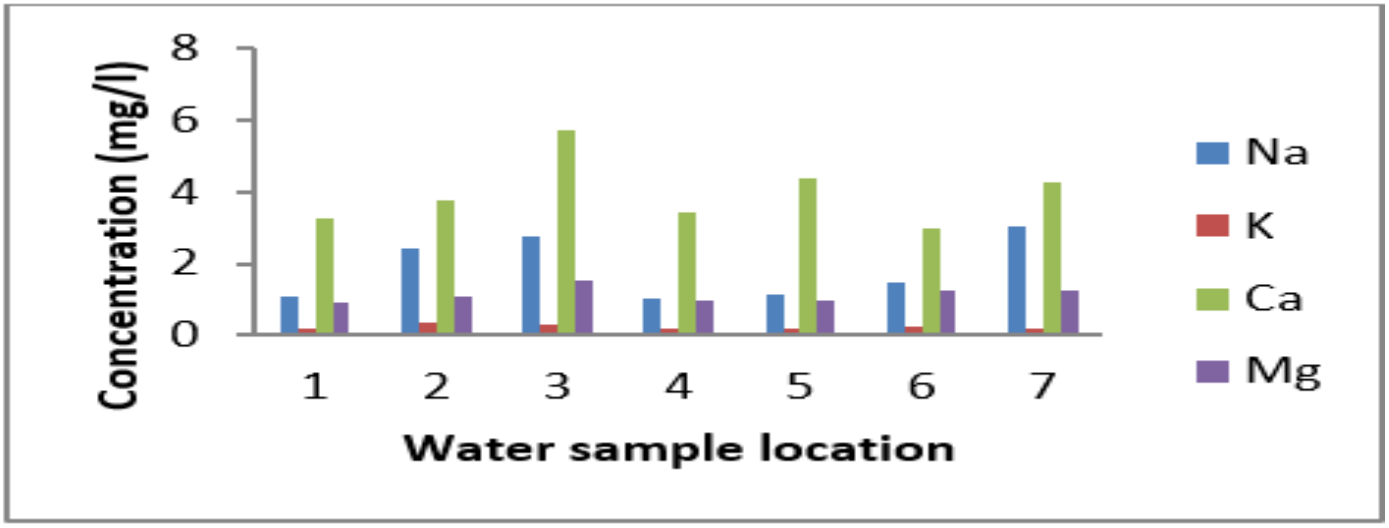


Fig 10 Anions Plot of the Groundwater

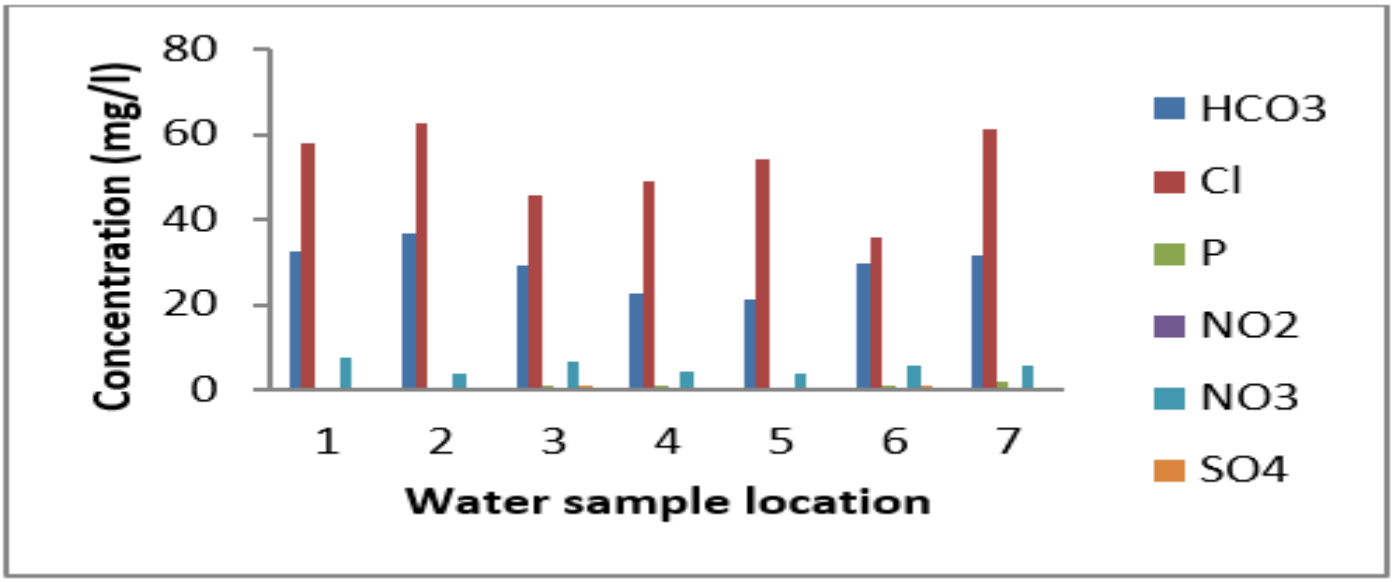


Fig 11 Anions Plot of the Groundwater in the Study Area

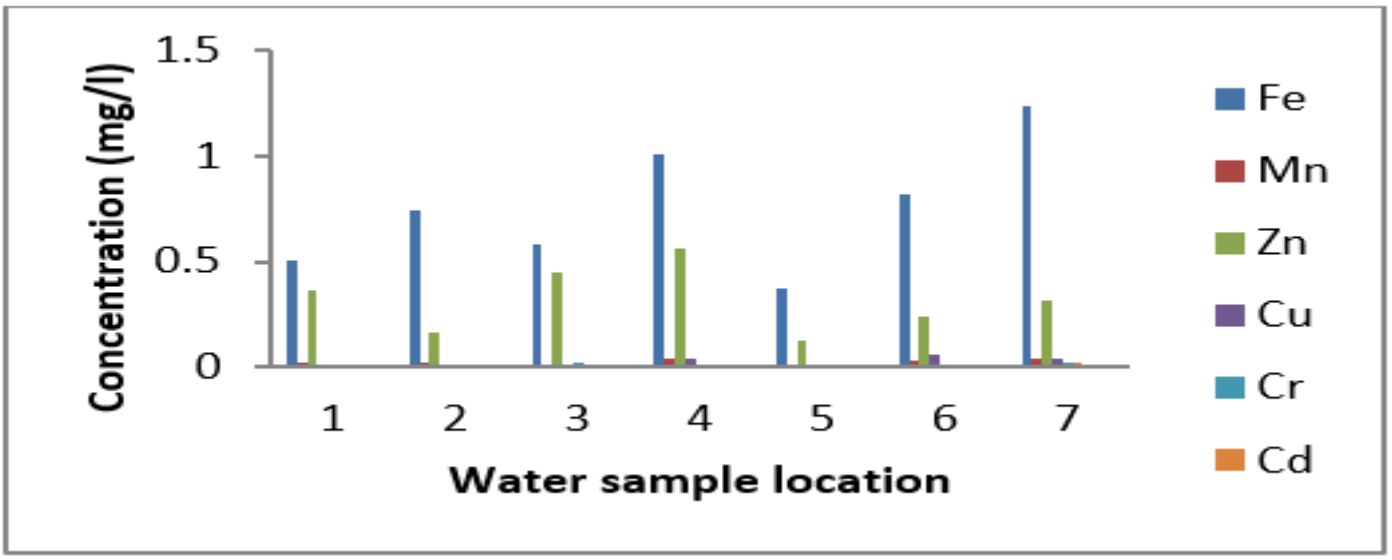


Fig 12 Heavy Metals Plot of the Groundwater

The microbial concentration of the groundwater in the area is shows in table 2.

Table 2 Microbial concentration of the groundwater in the study area

| Location | Total Heterotrophic Bacterial Counts (Cfu/ml) | Total Coliform Counts (Cfu/ml) | Total E. Coli counts (Cfu/ml) |
|---|---|---|---|
| 1 | $1\times10^3$ | $0\times10^3$ | $0\times10^2$ |
| 2 | $1\times10^2$ | $0\times10^3$ | $0\times10^3$ |
| 3 | $1\times10^3$ | $0\times10^2$ | $0\times10^3$ |
| 4 | $1\times10^3$ | $0\times10^3$ | $0\times10^3$ |
| 5 | $1\times10^3$ | $0\times10^2$ | $0\times10^3$ |
| 6 | $1\times10^2$ | $0\times10^3$ | $0\times10^2$ |
| 7 | $1\times10^3$ | $0\times10^3$ | $0\times10^3$ |
| WHO | - | - | - |
| NSDWQ | 0cfu/100ml | 10 cfu/ml | 0cfu/100ml |

➢ *Discussion*

The pH of the groundwater ranges 5.70 to 6.90, with average value of 6.27 ± 0.54, indicating slightly acidic groundwater. The groundwater in locations 1, 2, 3 and 7 does not fall into the permissible limit of WHO and NSDWQ standards with the exception of groundwater from the well in location 4, 5 and 6. Figure 4.10 shows the pH plot for the groundwater in the area. The electrical conductivity of the groundwater ranges from 124.10 to 171.80 µS/cm, with average value of 146.93 ± 16.21 µS/cm. They fall into the permissible limit standards of NSDWQ and WHO. The salinity of the groundwater ranges from 0.04 to 0.08g/l, with average value of 0.07±0.02g/l.

The colour of the groundwater has an average value of 0.56±0.74Pt.Co and ranges from 0.00 to 1.80Pt.Co. The total suspended solids of the groundwater has an average value of 0.50±0.88mg/l, and ranges from 0.00 to 2.10mg/l. The total dissolved solids of the groundwater has an average value of 93.84±12.16mg/l and ranges from 79.40 to 116.10mg/l, it fall into the permissible limit standards of NSDWQ and WHO. The dissolved oxygen, biological oxygen demand and chemical oxygen demand of the groundwater has an average value of 6.03±0.49mg/l and 0.96±1.08mg/l and 8.91±1.72mg/l respectively, and ranges from 5.40 to 6.90mg/l, 0.00 to 2.60mg/l and 7.00 to 11.40mg/l respectively.

The sodium, potassium, calcium and magnesium concentration of the groundwater has an average values of 1.86±0.86mg/l, 0.24±0.07mg/l, 3.97±0.93mg/l and 1.13±0.22mg/l respectively, with a range of 1.03 to 3.05mg/l, 0.17 to 0.36mg/l, 2.96 to 5.73mg/l, and 0.91 to 1.52mg/l respectively. They all falls into the permissible limit standards of NSDWQ and WHO.

The bicarbonate, chloride, nitrite, nitrate, phosphorus and sulphide concentrations has an average values of 29.17±5.49mg/l, 52.30±9.56mg/l, 0.10±0.07mg/l, 5.36±1.54mg/l, 0.21 to 1.69mg/l and 0.34 to 0.91mg/l respectively, and ranges from 21.40 to 37.00mg/l, 35.60 to 62.50mg/l, 0.03 to 0.19mg/l, 3.72 to 7.65mg/l, 0.85±0.54mg/l and 0.34 to 0.91mg/l respectively. They lie within the standards of NSDWQ and WHO limits.

The iron contents in the groundwater ranges from 0.37 to 1.24mg/l, with average value of 0.75±0.30mg/l, and it exceeded the permissible limit of NSDWQ and WHO standards of 0.3mg/l. The ferruginous sandstone in the area and slightly acidic nature of groundwater in the area is probably the cause of high iron content. Manganese with an average value of 0.03±0.02mg/l in the groundwater and ranges of 0.00 to 0.05mg/l, falls within standard limit of WHO 0.05mg/l and exceeded the permissible limit NSDWQ standards of 0.2mg/l.

The zinc and copper contents in the groundwater has an average values of 0.32±0.15mg/l and 0.02±0.02mg/l respectively, and ranges from 0.13 to 0.56mg/l and 0.00 to 0.06mg/l respectively they both falls within permissible limit standards of NSDWQ and WHO.

Chromium and cadmium contents in the groundwater have average values of 0.01±0.01mg/l and 0.01±0.01mg/l respectively, and ranges from 0.00 to 0.02mg/l and 0.00 to 0.02mg/l respectively. It was observed that chromium was not detected in water from well at locations 1, 2 and 5, but in water from well in location 3, 4, 6 and 7 with high concentration exceeding both the NSDWQ and WHO standards of 0.1mg/l and 0.05mg/l respectively. Cadmium was not detected in well water at locations 1, 2, 3 and 5, but well water from location 4, 6 and 7 with higher contents than the WHO and NSDWQ standards of 0.03mg/l. The lead content in the groundwater with 0.01±0.01mg/l average values and ranges of 0.00 to 0.01mg/l, was not detected in well water at locations 1, 2 and 5, but in wells at location 3, 4, 6 and 7, with a lower concentration than WHO and NSDWQ standards of 0.02mg/l. The nickel and vanadium was not detected in groundwater from the area.

The stiff plot (figure 13) shows that the groundwater have the same hydrogeochemical signature indicating same aquifer source.

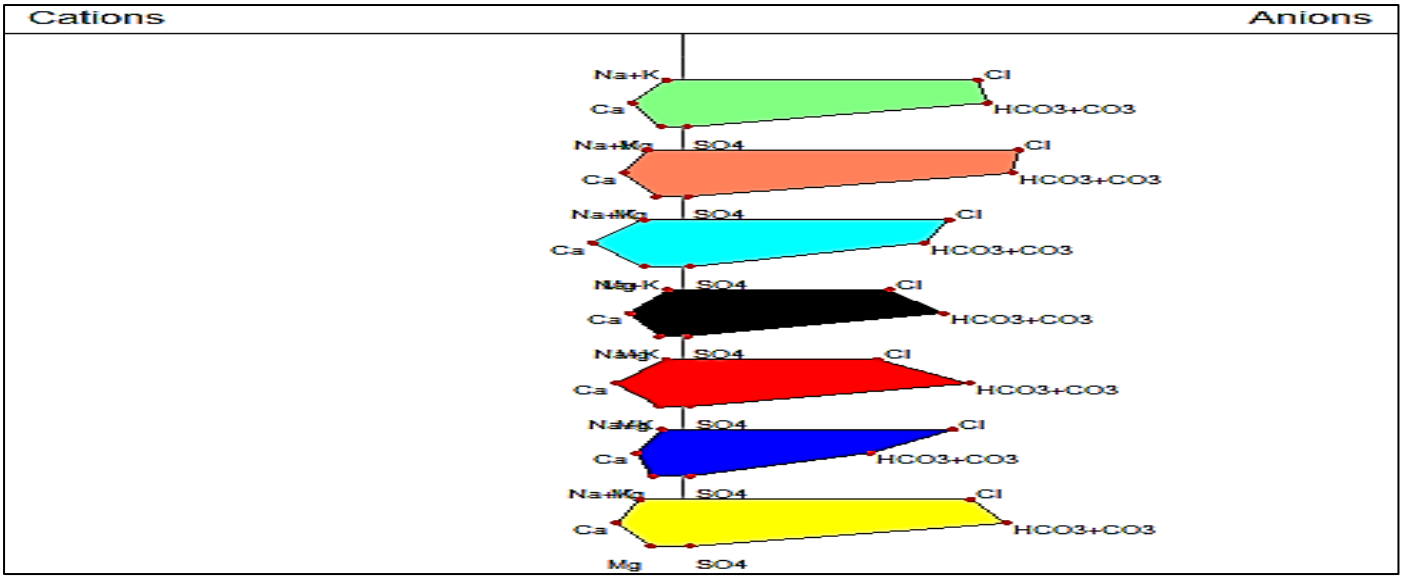


Fig 13 Stiff Plot of the Groundwater of the Study Area

The Piper diagram (figure 14) shows that the water type in the study area is Calcium – Chloride (Ca - Cl) water type.

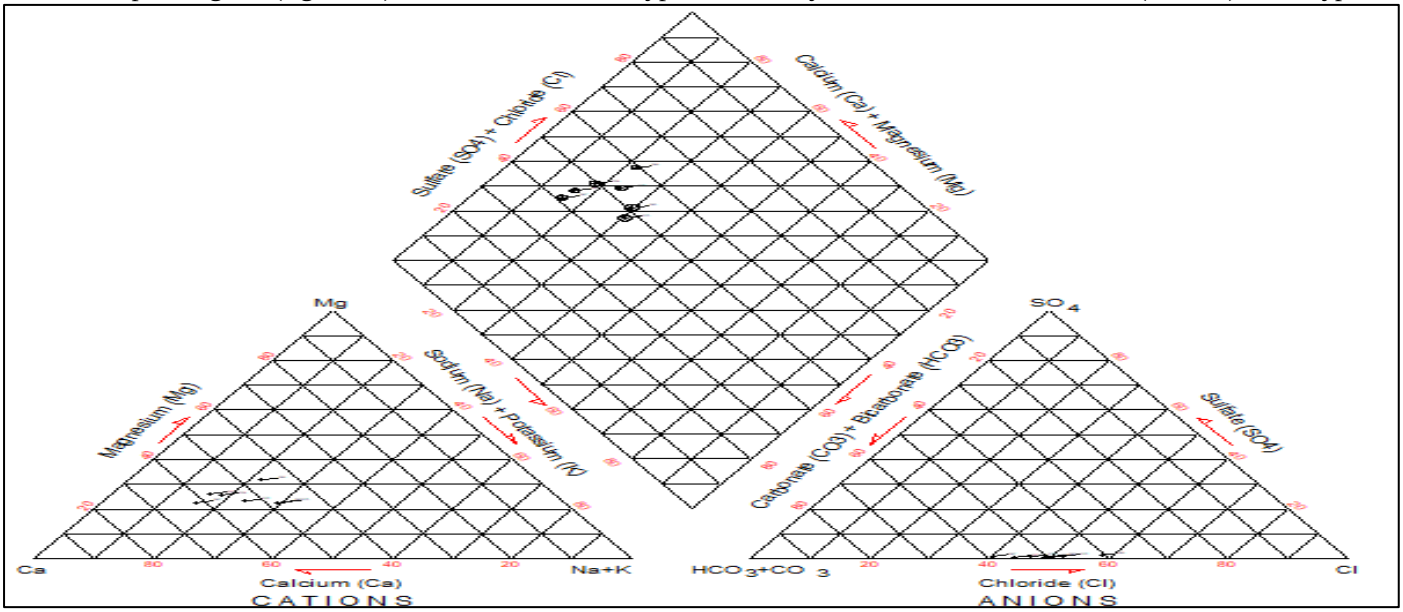


Fig 14 Piper Diagram of the Groundwater of the Area

The microbial analysis shows that the groundwater of the area has no presence of microbes.

## V. CONCLUSION AND RECOMMENDATIONS

Water is being an important resource for human consumption, usage and the ecosystem, which is being sourced mainly from groundwater, it quality determines its usability (Patil *et. al.*, 2012). This study conducted to determine groundwater quality in the area, shows that the water is slightly acidic with an average value of 6.27, and does not falls within the NSDWQ and WHO permissible limit. The TDS of 93.84mg/l in the water is with both permissible limits indicating a fresh water. The anions and cations of groundwater in area is within both permissible limit, their concentration shows that calcium is predominate cation while chloride is the predominate anion showing a Calcium – Chloride (Ca-Cl) water type. There is high iron, cadmium and chromium present in some wells and this indicates high concentration of heavy metals, which is probably due to the water bearing formation and the slightly acidic nature of the groundwater in the area. The groundwater has no presence of microbes.

The slightly acidic nature and high heavy metals contents of groundwater in the area has serious health implications, thus there is need for water treatment plant to be installed in the area and the host community should educate the on the need for proper waste disposal and sensitized on the environmental implication and potential health challenges associating with poor groundwater quality.

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