# Hydrochemical Analysis of Water Quality in Gosa and Dei-Dei Area of Abuja, NorthCentral, Nigeria

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## Abstract

*The geology of Gosa and Dei-Dei, in Abuja, therefore, makes the groundwater conditions in the area very unpredictable, and so jeopardizes the fulfilment of the water supply needs of one of the fastest growing cities in Nigeria. Vertical Electrical Sounding (VES) was carried out at two locations within and around Gosa and Dei-Dei area to detect the depth to the aquifer and water quality investigation. The study involves the hydrochemical characterisation of waters to ascertain their physico chemical, quality and suitability for domestic purposes. The borehole depths measuring 62m at Gosa with low yield and 70m at Dei-Dei with good yield of static water level of 4-6m thick were analysed for their cations and anions contamination. In Gosa, the chemical analysis was within the limit of WHO standard. Consequently, at Dei-Dei, some results of the chemical; $Mg^{2+}$ (74mg/l) $Ca^{2+}$ (86mg/l), Total hardness (160mg/l), Phosphate (1.3mg/l), Fe (0.78mg/l), Mn (0.731) were above the limit for drinking water. The contaminant could be some precipitation, transported through a typical aquifereous medium. Petrophysically, the caves or fractured openings through different rock types maybe in solution as ion, molecules and colloids or may have acquired their chemistry from the basement rocks, dissolution of Silicate, Nitrate and cation exchange reactions. The contamination detection above WHO standard, therefore consider the water not suitable for drinking. Recommends further work for radionuclide in groundwater.*

**Key words**: Abuja, basement complex, VES, Water Analysis



## 1. Introduction

In any hydrogeological setting, surface water and groundwater are main sources of water. Surface water includes water from rivers, streams and lakes whereas groundwater constitutes water from boreholes, hand-dug wells and springs. Both sources of water are prone to pollution and contamination hence the need for quality assessment. Okagbue (1988) stated that a complete appraisal of available sources of water in any area is commonly accomplished when aspects of water quality are included. The chemistry of water is determined by some constituents which occur in solution. These makes up the major and minor constituents of water. The major constituents include elements of calcium, magnesium, sodium, and potassium, as cations, and carbonates, bicarbonates, sulphates, chlorides and nitrates as anions. Other minor chemical constituents, occurring in concentrations are boron, Fluoride, Silica, Phosphate, Sulphide, Lithium, and Alluminium. The minor elements are generally not critical in determination of the quality of ground water. The chemical composition of groundwater varies greatly, because of the lateral and vertical heterogeneity of the aquifers. Areas with fairly homogeneous aquifer lithology present uniform groundwater chemical composition, as illustrated Schneider (1971) and Barber et al, 1965, in the water table aquifers. The introduction of a contaminant or pollutant into an aquifer system starts with the infiltration of the contaminant through a water medium, sometimes induced by rainfall or some precipitation. Then it is transported through a typical aquifereous medium, caves or fracture openings through different rock types in solution as ion, molecules and colloids. The mobility of elements depends on the solubility of the various compounds, the tendency of its ions to take part in ionic exchange, and the extent to which organism can extract the elements from the hydrosphere (Ofodile, 1988). The solubility is controlled by several factors like temperature, pressure, pH and Eh. Under low temperature, more gases are taken into solution. Of these gases, carbon dioxide is most important. The geochemical process, though complicated, result in dissolution or deposition of materials extracted from the host rock (Ofodile, 1975). Most of the Nigerian groundwater fall into the category of predominantly calcium Bicarbonate water. The aquifers include carbonate rocks and sandstone in various stages of consolidation. The high carbonate in water from lime stone area is explicable and can be attributed to the rock type (Du Peeze, and Barber, 1965). Groundwater treatment and protection can be achieved in a well coordinated land use plan designed to incorporate groundwater protection zone for the very important aquifer system. This requires the hydrogeological mapping of the town or proposed urban area, to identify possible recharge areas, or project areas, as the case maybe, in the case of confined and unconfined aquifer areas. Such identified recharge zones should be protected against contamination by inorganic or organic contaminants. In this regard, the physico-chemical and biological characteristics of the possible pollution must be considered in the planning and citing of pollution causing industries or in the use of certain type of insecticides, fertilizer and herbicides. The situation in which pollutants industries are piped or channelled away into aquiferous area or outcropped aquiferous formations, should be prevented, except adequate treatment process of the waste can be guaranteed. This paper is aimed at identifying the fractured trend and its effect in groundwater contamination as the pathway through which the borehole is infiltrated or the source.

Basement complex rocks do not inherently make good aquifers. The hydrogeologic characteristics of basement rocks are only enhanced when the rocks are fractured and/or when they are weathered. The conditions are better enhanced when the rocks are overlain by thick overburden. Groundwater potentials of a basement complex area are often determined by geophysical means, which determines the thickness of the overburden and the network of fractures that may exist in the area. Geophysical surveys are also important for groundwater investigation in basement areas in view of the discontinuous (localized) nature of basement aquifers (Satpatty and Kanugo, 1976). The use of the vertical electrical sounding (VES) method is popular for groundwater investigation in both soft rock (sedimentary) and hard rock (igneous and metamorphic) terrains (Barongo and Palacky, 1989; Benson and Jones, 1988; Omosuyi, 2000; De Beer and Blume, 1985; Mbonu et al., 1991; Shemang, 1993). In the Basement Complex of Nigeria, extensive application of geoelectrical method for groundwater investigation has been reported (e.g. Zohdy *et al*., 1974; Pulawski and Kurth, 1977; Acworth, 1987; Olorunfemi and Okankune 1992; Olorunfemi and Fasuyi, 1993; Edet and Okereke 1997; Nur and Ayuni, 2004).

The area of study is Dei-Dei and Gosa. It is bounded by the coordinates Lat: 9$^o$ 6’52”N and Log: 7$^o$ 15’39”E (Dei-Dei) and Lat: 8$^o$ 56’ 45.6”N and Long: 7$^o$ 13’ 26.2”E (Gosa). The two areas have become important because of the increasing population of the suburbs of Abuja. Many residents of the areas embark on the development of private boreholes to augment public water supplies which are inadequate. But most boreholes here are abortive, contaminated and so counter the intentions of the owners, in addition to loss of capital. This study is to evaluate the possible groundwater contaminant that is being consumed without treatment and the possible source.

## 2. Geology and Hydrogeology of the area

The area of study forms part of the Basement Complex of northcentral Nigeria; with lithologic units falling under three main categories, which include (1) Undifferentiated migmatite complex of Proterozoic to Archean origin, (2) Metavolcano-Sedimentary rocks of Late Proterozoic age and (3) Older Granite Complex of Late Precambrian - Lower Paleozoic age, also known as Pan-African Granites. All these rocks have been affected and deformed by the Pan-African thermotectonic event. Detailed reports of the lithological description, age, history, structure and geochemistry of the Basement Complex of Nigeria are given in Oyawoye, 1972, Black et al., 1979, Ajibade et al., 1987, Rahaman, 1988, Caby, 1989, and Dada,

2008. The geologic map of the area is discussed elsewhere, Omeje et al, 2013.

### 3. 0 Materials and Methods

The search for groundwater in some parts of Abuja and it's environ was carried out through the use of integrated structural interpretation from remotely sensed data and electrical methods of geophysical survey. The Schlumberger configuration in Vertical Electrical Sounding (VES) was used to obtain field data. Vertical electrical sounding probes, the vertical variation in resistivity of the subsurface, thereby indicating the presence of fluid and ionic concentration in the subsurface materials. It is also applied to determine the depth to bedrock, delineate the various units that constitute the overburden (regolith), determine the degree of fracturing of the bedrock; all of which would help in making the choice for a feasible site for constructing a successful borehole. VES data for this work were obtained using the Allied Omega C2 Terrameter. The field data obtained was presented as curve of apparent resistivity values against half of the current electrode separation (AB/2) in metres on a log-log scale. A 3-mode filter was employed to jettison associated noise due mostly to electrical signals and interference from adjacent power transmission lines. The VES data obtained were analyzed using the WINRESIST 2004 Version computer software to improve the quality of the interpretation by iteration and modelling to goodness of fit.

Four samples were collected which comprise 2 samples each from Borehole of depth 62m at Gosa and 59m at Dei-Dei after drilling down through soft and hard formation with the help of 30 Ton capacity Rig machine. These constitute the main sources of water supply for the inhabitants.

Sampling was conducted at the end of October at the peak of dry season to avoid the effect of dilution that may result from precipitation during rainy season. Parameters such as temperature, pH,Total Dissolved Solids (TDS) were measured in the field. Water samples were collected in new screw-cap; high-density polyethene bottles one litre which was first rinsed 3 times with the water to be sampled to avoid contamination. A set of water samples was collected from each sample location for cationic, anionic and microbial analysis. Samples for cationic analysis were acidified with dilute nitric acid at the point of collection. The samples were adequately labelled and were immediately sent to the laboratory for analyses. The analyses were conducted at the National Geosciences Research Laboratories Centre, Kaduna, Kaduna state North central Nigeria. Atomic absorption spectrometry (Model Young LIN AAS 5010) method was employed for determining the concentration of the Cation and anion parameters in the preserved water samples. The APHA and AWWA (1998) standards were maintained in accordance with the sample analysis.

## 4. Results and Interpretation

### *4.1 VES Data Analysis and Interpretation*

Two VES points were studied in this work; one from areas around Gosa and one from Dei-Dei parts of Abuja, figures 1 and 2.



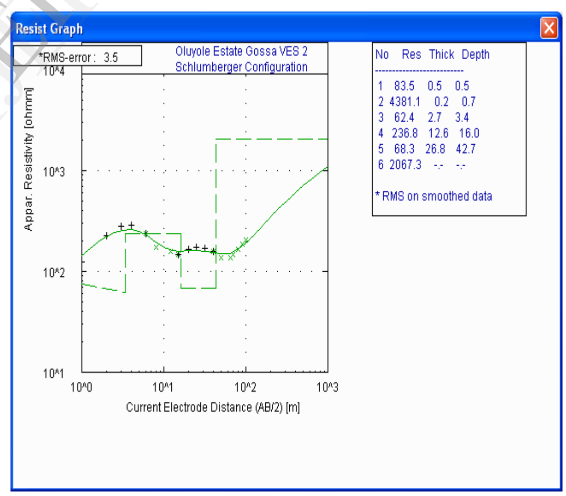


**Fig.1. Gosa VES, Plot of the Apparent Resistivity against Electrode Spacing.**

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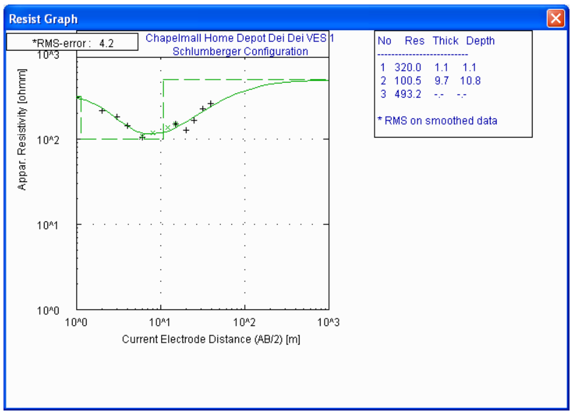


**Fig.2. Dei-Dei VES, Plot of the Apparent Resistivity against Electrode Spacing.**

The one point at Gosa area was close to abortive borehole sites. Table 1 shows a summary of the results of the VES interpretations. The Table shows that at the location of VES 1, there is a thick lateritic topsoil of up to 3.4 m, underlain by a thick micaceous sandy clay layer of weathered basement rock that cannot sustain boreholes. This is directly underlain by unweathered, unfractured basement. The unweathered and fractures not connected in the area would have prevented the contaminants but could have caused low yield. The lithology around the other VES points, Dei-Dei area, is similar to that of Gosa area described above. The absence of micaceous sand stone might not have affected the pore spaces in the weathered zones and joints. However the well is productive but more of heavy metal contaminations, which is close to above permissible limit. It could be observed that the fractured basement in this Dei-Dei may have been the source of contaminants, transporting them through the joints and permeable rocks to the aquiferous zone.

### *4.2 Petrographyic Characteristics*

Macroscopically, the studied subsurface samples are of different colours of grayish, pink, ashy, milky, blackish, redish and brown-black, ranging from medium-to-coarse grain size, and characterized by equigranular and porphyritic texture

- The study Dei-Dei (70m) samples are homogenous with different modal compositions, but generally ranging from laterite, granodiorite. Rocks are composed of orthoclase, biotite, minor hornblende and muscovite. The granodiorite rocks are composed of potash-feldspar, biotite, minor hornblende and muscovite.
- Gosa Area (50m), composed of reddish laterite top soil, the deeper area composed mainly of potash-feldspars, plagioclases and quatze. The accessory minerals are zincron, apatite and biotite, altetered to chlorite.

**Table 1**: Summary of results obtained from the computer output of the (12) VES in the area studied.

| Location VES | Resistivity (ohm-m) ρ1 ρ2 ρ3 ρ4 p5 p6 | Thickness (m) h1 h2 h3 h4 h5 h6 | Lithology |
|---|---|---|---|
| Gosa VES 1 | 83, 438, 62, 236, 68,2067 | 3.4, 39.3, ∞ | Lateritic topsoil,sandy clay, unweathered basement,fresh basement |
| Dei-Dei VES 2 | 320, 100, 493 | 1.1, 9.7, ∞ | Sandy clay topsoil, weathered basement |

**Table 2**: Summery of Borehole sample analysis of Gosa and Dei-Dei
Area of Abuja. Guidelines with some additions from EU (WHO, 2006 Guideline

| Quality Parameters | Location 1(Gosa) **Results** | Location 2 2(Dei-ei) **Results** | WHO Desirable Limit | WHO Permissible Limit |
|---|---|---|---|---|
| **A) PHYSICAL ANALYSIS** | | | | |
| Test | N.OBJ | OBJ. | N. OBJ | N. OBJ |
| Odor | N. OBJ | OBJ. | N. OBJ | N.OBJ |
| Turbidity | Nil | 9 | - | <5 |
| Temp. $^{o}$C | 22.1 | 29.9 | 31 | <31 |
| Appearance | Clear | Redish Brown | N. OBJ | N.OBJ |
| pH | 6.98 | 6.3 | 6.5-8.5 | 6.5-9.2 |
| **B) CHEMICAL ANALYSIS** (mg/l) | | | | |
| Total Alkalinity | 34 | 78 | 100 | 100 |
| Carbon Dioxide | 18 | 34 | NS | - |
| Chloride | 18 | 39.76 | 250 | 500 |
| Conductivity (µS/cm) | 230 | 398 | 100 | <1400 |
| Total Chlorine | 0.1 | 0.03 | 0.20 | <500 |
| Nitrate | 0.2 | 13.8 | 50 | |
| Nitrite | - | 0.01 | - | - |
| Cyanide | - | - | - | - |
| Total H. (as$CaCO_3$) | 29.3 | 160 | <150 | <500 |
| Manganese | 0.3 | 0.9 | 0.5 | 0.5 |
| TDS | 70 | 117 | 500 | 1000 |
| Phosphate | - | 1.3 | - | - |
| Chromium | 0.016 | ND | 0.05 | - |
| Magnesium | 12.7 | 74 | <50 | <150 |
| Calcium | 16.6 | 86 | <75 | <200 |
| Salinity | 0.01 | 0.1 | 100 | <250 |
| Iron | 0.01 | 0.7 | 0.3 | 1.0 |
| Sulphate | 2 | 10 | - | <400 |
| Sodium | 12.3 | 29.7 | <120 | <400 |
| **C) MICROBIOLOGICAL ANALYSIS (cfu/ml)** | | | | |
| Tot.Bacteria Plate Count | Nil | +ve | -Ve | |
| Coliforms | Nil | +Ve | -Ve | -Ve |
| E. coli | Nil | +Ve | Nil | -Ve |
| Salmonellasp/Shingella sp | Nil | +Ve | Nil | -Ve |
| Pseudomonas sp | Nil | Nil | Nil | -Ve |
| Yeasts/Moulds | Nil | Nil | Nil | -Ve |



## 5. CONCLUSION

Results from the two VES surveys carried out in the study area indicate the presence of lateritic or sandy topsoil, weathered basement and fractured basement. The similarity in the geoelectric sections suggests a homogenous aquiferous setting for the area. However this is not the case as borehole drilled in the Dei-Dei area with good water yield with the static water level ranging from 4 – 6m, while borehole around Gosa area was low yield, even when drilled to depths of over 60m. Based on the findings stated above, the following conclusions can be made.

1. Geoelectrical surveys indicate the existence of both weathered and fractured basement, which ideally could form good aquifers in the study area. The regolith over the unweathered basement is, however, clayey, and so does not constitute a good aquiferous material.
2. Petrophysically, subsurface rocks in Dei-Dei are composed of orthoclase, biotite, minor hornblende and muscovite. The granodiorite rocks are composed of potash-feldspar, biotite, minor hornblende and muscovite; the major aquiferous zones in the area is zone of brecciation developed by the intersection of regional fractures which could serve as pathway for groundwater contamination and oxidation of rock dissolve salts.
3. The water analysis has indicated contaminant in the in Dei-Dei, which could be caused by the large scale fractured zones in the area. The fault and fractures could have been caused by the unequivocally intrusive rocks into the migmatic gneiss during tectonic activity. Further research on groundwater radionuclide is recommended.

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