# Investigation of Groundwater Potential in Some Selected Towns in Delta North District of Nigeria

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## Abstract

*This study was carried out to investigate the groundwater potential in some selected towns in Delta North District of Nigeria. A total of twenty vertical electrical soundings were conducted using the ABEM SAS 1000 Terrameter. The data obtained were subjected to interpretation by partial curve matching and then by computer iteration and the results correlated with records from existing wells. A total of six geoelectric layers namely; laterite, clay, sandy clay, fine sand, medium grain sand and coarse sand was delineated in this study. Results showed that the aquifer is located within the third and the sixth layers comprising mainly of medium grain sand and coarse sand. The depth to the top of the aquifer was obtained to be between 10.2 and 54.5 m while the resistivity of the aquifer ranged between 1834.5 and 4445.8 Ωm. Appropriate depths to which potable water can be obtained from the various locations are recommended in this study.*

**Keyword:** Groundwater, geoelectric, formation, Terrameter, vertical electrical sounding.

## *Introduction*

Groundwater is described as the water found beneath the surface of the earth in underground streams and aquifers (Anomohanran, 2011). The reason why groundwater has become more popular as a source of potable water in Nigeria is due to its quality when compared to other water sources. It is known to be free most times from pollutants and hence requires little or no decontamination before use. Lawrence and Ojo (2012) noted that groundwater is most generally free from odour, colour and has very low dissolved solid. It is also not usually affected by natural factors such as drought.

Various researchers have employed different methods in exploring this very essential life sustaining resource. Geophysical surveys have been most widely used because of the basic advantage of providing more accurate results than other methods. For instance, Gabr et al. (2012) successfully used the seismic refraction method to investigate the groundwater level in the Wadi Al-ain area of United Arab Emirates. The objective was to confirm or not the assumption that groundwater level can primarily be revealed by seismic refraction technique. Ayolabi et al. (2009) used the seismic refraction shooting to determine the structural setting of subsurface materials and groundwater potential in Igbogbo Township. This method was able to delineate the formation layers and the aquifer characteristics of the location under study. Lawrence and Ojo (2012) applied the low frequency electromagnetic and the electrical resistivity methods to evaluate the aquifer potential of a typical basement complex terrain of Ado-Ekiti in Nigeria. Other researchers such as Oseji et al., 2006; Nejad, 2009; Egbai, 2011; Anudu et al., 2011; Sirhen et al., 2011; Ibrahim et al. 2012; Utom et al., 2012; and Anomohanran, 2013 have all used the electrical resistivity method to explore for groundwater in different locations.

The electrical resistivity method has been the most commonly used geophysical tool for groundwater investigation because of its advantage which include simplicity in field technique and data handling procedure (Anomohanran, 2013). Electrical resistivity methods are effectively used for groundwater exploration in areas where good electrical resistivity contrast exists between the water bearing formation and the underlying rocks (Nejad, 2009). The method enables the determination of subsurface resistivity by sending an electric current into the ground and measuring the electrical potential produced by the current.

The resistivity distribution of the ground is sometimes related to some physical conditions such as lithology, porosity, degree of water saturation and presence of voids in the rocks. The vertical electrical sounding method of electrical resistivity gives detailed information about the vertical sequence of the different conducting zones.

In each case, the vertical electrical sounding is used to delineate the subsurface stratigraphy based on resistivity differences. Using the data obtained from the field survey and subjecting it to computer based interpretation, the resistivity, thickness and other parameters are determined.

When carrying out resistivity sounding studies, electrodes are connected along a line centred about a mid point that is considered the position of the sounding (Anomohanran, 2013). The types of electrode arrays that are most commonly used are the Schlumberger, Wenner and Dipole-dipole. There are other electrode configurations that are used experimentally or for non-geotechnical problems or are not in wide popularity today. Some of these include the Lee, Half-Schlumberger, Polar dipole, Bipole dipole and Gradient arrays. In the standard Wenner or Schlumberger array, the depth of investigation increases with the current electrode spacing. This gives rise to an electrical resistivity/depth sections which can be related to the geological structure beneath the survey line (Ayolabi et al., 2009).

In a Schlumberger array of electrodes, the two current electrodes and the two potential electrodes are placed in line with one another and centred on a common point. The potential and current electrodes are not placed equidistance from one another. The field data are obtained by introducing current into the ground by means of the current electrodes and the potential electrodes then used to measure the voltage pattern of the surface resulting from the current flow pattern of the current electrodes (Anomohanran, 2013).

In analysing the field data, the potential difference obtained is divided by the induced current and multiplied by a geometric factor specific to the array being used and the electrode spacing to give the apparent resistivity. The apparent resistivity is the bulk average resistivity of all soils and rock influencing the current. The observed apparent resistivity data are plotted against half current electrode separation and are useful in the first stage of interpretation to estimate the anomalous zones. The variation of resistivity with depth is then modelled using modelling computer software which gives the true formation resistivity, thickness and depth from the surface. The importance of this is that it allows the estimation of the true position and depth of the groundwater aquifer. The area under study has been a problematic zone for water scheme in Delta State hence this work was carried out to evaluate the groundwater condition of the area. This study will integrate the field data from the various sites and give an overview of the groundwater potential of the area.

### *Materials and Methods*

The study locations namely Agbor, Ozanogogo, Issele-Uku, Otulu and Anwai are situated between latitude $6.24^0$ and $6.34^0$ North and longitude $6.10^0$ and $6.80^0$ East (Fig. 1). The stratigraphy is made up of lateritic sand, clay and sandstone with occasional lignite seam which is the characteristic of the Asaba-Ogwashi formation.

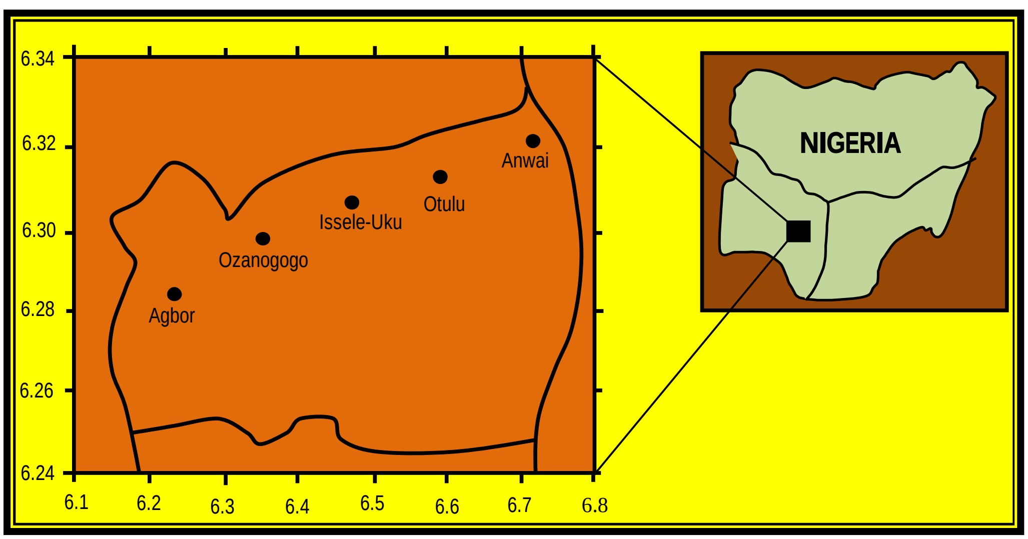


**Fig. 1: Location Map of the Study Area**

A total of 20 vertical electrical soundings were carried out in the area using the ABEM SAS 1000 Terrameter. The Schlumberger electrode array was employed for the vertical electrical sounding profile with maximum current electrode spacing of 350 m. Measurements were done by expanding the current electrode distance and the potential electrode was kept constant but changed only when the reading became too small to be accommodated by the instrument's sensitivity. The values of the apparent resistivity obtained were plotted against current electrode spacing using a log-log graph paper. The field data were first curved matched and the result subjected to computer iteration software to obtain the layers true resistivity and thickness.

## *Results and Discussion*

The plot of the apparent resistivity against current electrode separation is presented as shown in Fig 2. Figure 2 depicts the fact that the curve types for Agbor, Ozanogogo, Issele-Uku, Otulu and Anwai are mainly HAAA, QHKH, QHAA, QHAA and HAKH respectively. These are good curve types for the existence of a viable groundwater aquifer.

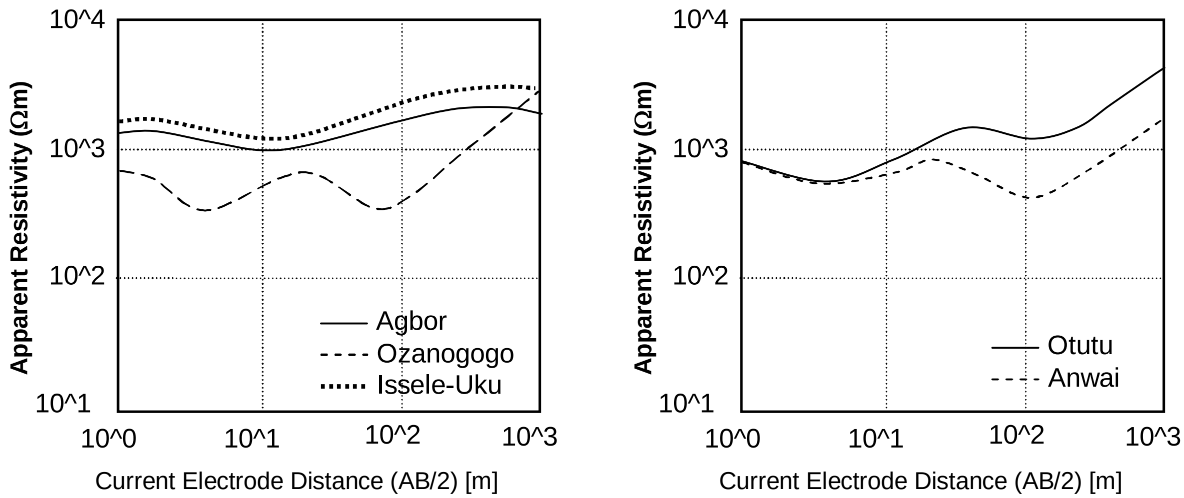


**Fig. 2: Typical vertical electrical sounding curves obtained from the study area.**

The summarized results of the interpretation of the field report is presented as shown in table 1. Table 1 has revealed the existence of six geoelectric layers. The first geoelectric layer has a resistivity range of 39416 and 62204 Ωm and comprise of laterite in all the locations. The depth ranged between 0.8 and 1.2 m. The resistivity of the second geoelectric layer ranged between 19.75 and 89.96 Ωm while the depth ranged between 1.9 and 3.4 m. The formation is composed of clay to sandy clay. This layer in all the locations can be referred to as a confining bed to the aquifer. The third geoelectric layer has a resistivity range of 16.0 and 915 Ωm and depth range between 3.9 and 20.5 m. The formation is composed of clay, sandy clay and fine sand. This layer also acts as a confining bed to the aquifer layer in some locations such as Ozanogogo and Issele-Uku.

The geoelectric interpretation also shows that the fourth layer resistivity lies between 453.6 and 1834.5 Ωm while the depth layer ranged between 13.2 and 36.3 m. This layer in Agbor, Ozanogogo and Anwai constitute an aquifer layer hence groundwater can be sourced from this layer. It is comprised of fine sand, medium grain sand and coarse sand. The fifth layer resistivity lies between 177.7 and 2453.0 Ωm while the depth ranged between 38.4 and 84.1 m. This layer in both Anwai and Ozanogogo constitute an aquitard.

**Table 1: Summarized results of data interpretation**

| VES Location | Layer | Resistivity (Ωm) | Thickness(m) | Depth (m) | Layer Characteristic |
|---|---|---|---|---|---|
| Agbor | 1 | 47110.0 | 1.2 | 1.2 | Topsoil/Laterite |
| | 2 | 19.8 | 1.3 | 2.5 | Clay |
| | 3 | 915.0 | 18.0 | 20.5 | Fine sand |
| | 4 | 1781.2 | 15.8 | 36.3 | Medium grain Sand |
| | 5 | 1893.9 | 17.5 | 53.8 | Medium grain Sand |
| | 6 | 2488.5 | - | - | Coarse sand |
| Issele-Uku | 1 | 43576.3 | 0.9 | 0.9 | Topsoil/Laterite |
| | 2 | 44.3 | 1.1 | 2.0 | Sandy clay |
| | 3 | 16.0 | 2.2 | 4.2 | Clay |
| | 4 | 829.7 | 17.6 | 21.8 | Fine sand |
| | 5 | 2453.0 | 17.3 | 39.1 | Medium coarse sand |
| | 6 | 2857.2 | - | - | Coarse sand |
| Ozanogogo | 1 | 62204.1 | 0.8 | 0.8 | Topsoil/Laterite |
| | 2 | 90.0 | 1.1 | 1.9 | Sandy clay |
| | 3 | 19.2 | 2.0 | 3.9 | Clay |
| | 4 | 1490.8 | 9.3 | 13.2 | Fine grain sand |
| | 5 | 177.7 | 25.2 | 38.4 | Clayey sand |
| | 6 | 4179.0 | - | - | Coarse sand |
| Otulu | 1 | 49310.0 | 0.9 | 0.9 | Topsoil/Laterite |
| | 2 | 44.3 | 1.0 | 1.9 | Sandy clay |
| | 3 | 453.6 | 17.2 | 19.1 | Wet sand |
| | 4 | 16.0 | 4.0 | 23.1 | Clay |
| | 5 | 2317.4 | 31.4 | 54.5 | Medium grain sand |
| | 6 | 4445.8 | - | - | Coarse sand |
| Anwai | 1 | 39416.3 | 1.0 | 1.0 | Topsoil/Laterite |
| | 2 | 10.0 | 2.4 | 3.4 | Clay |
| | 3 | 674.6 | 6.8 | 10.2 | Wet sand |
| | 4 | 1834.5 | 21.2 | 31.4 | Medium grain sand |
| | 5 | 339.6 | 52.7 | 84.1 | Wet sand |
| | 6 | 1861.2 | - | - | Medium grain sand |

The sixth geoelectric layer has a resistivity which ranged between 1861.2 Ωm in Anwai to 4445.8 Ωm in Otulu. It is an aquifer layer in all the locations. The distance to the top of this layer are 53.8 m in Agbor, 38.4 m in Ozanogogo, 39.1 m in Issele-Uku, 54.5 m in Otulu and 84.1 m in Anwai. The result of the geoelectric interpretation compares favourably with record of existing wells in the area and the lithologic section obtained for the five locations is presented as shown in Fig. 3.

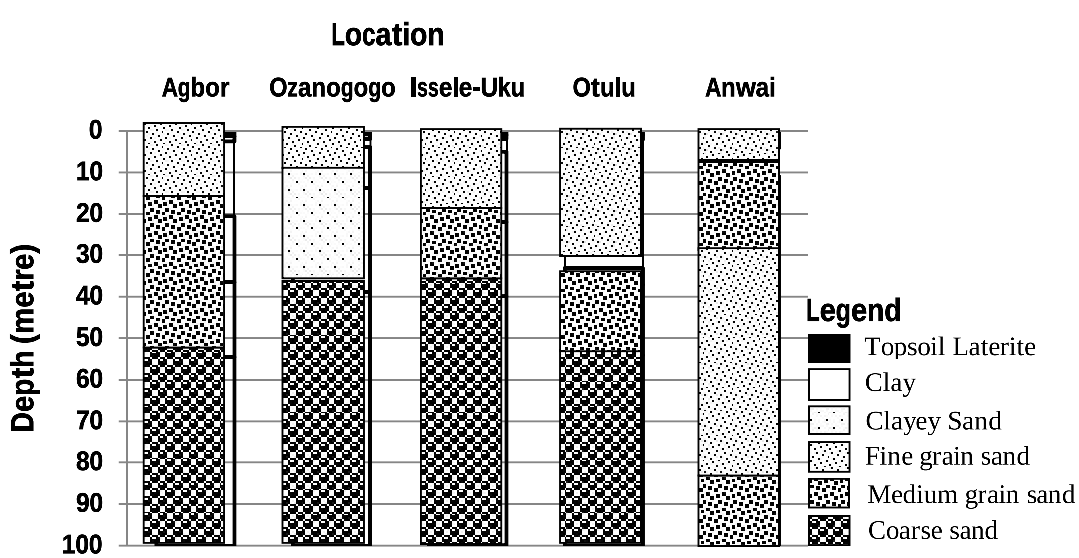


**Fig. 3: Lithologic section of the study area.**

Figure 4 shows the depth chart of the aquifer level in the various locations. It shows the depth to which potable water can be sourced and the groundwater level pattern in the study area. The aquifer resistivity chart for the five locations is presented as shown in Fig. 5. Figure 4 and 5 are useful in selecting a suitable site for the establishment of a water scheme for the district under study. Drillers of water boreholes will also find these results useful in drilling reliable and productive wells for the people.

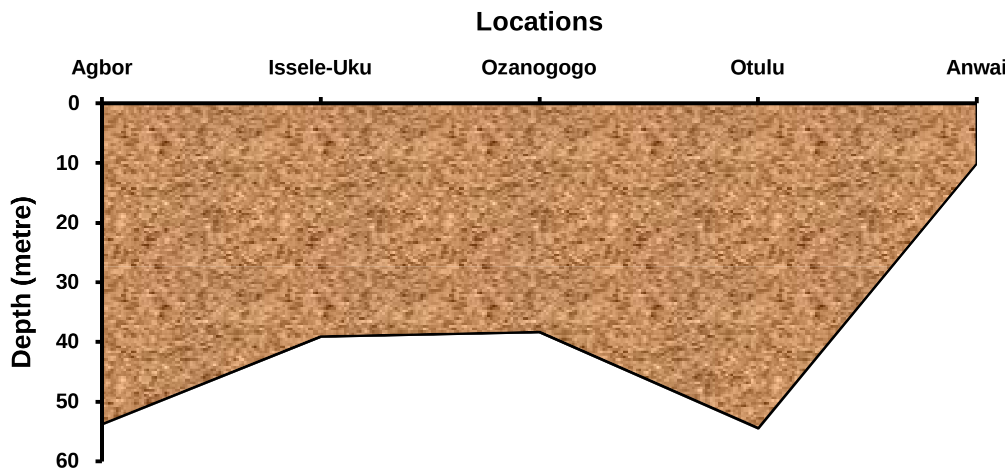


**Fig. 4: Depth chart of the aquifer level in the various locations**

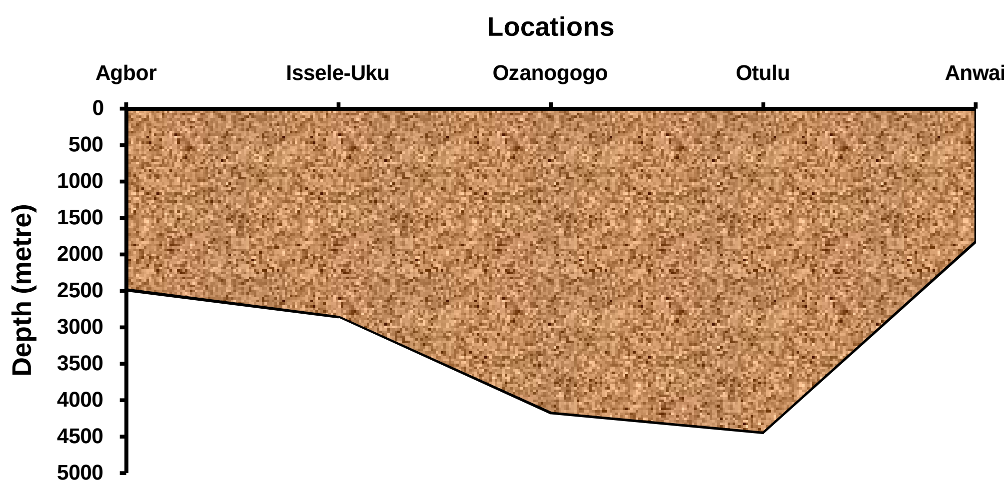


**Fig. 5: Resistivity chart of the aquifer layer in the various locations**

This study has shown that the sixth layer is the location of interest where good quality potable water can be accessed. This study therefore recommends that borehole for potable water with adequate quality should be sourced from the sixth layer in all the locations. In the case of Anwai, potable water of good quality can also be sourced from the fourth layer.

## *Conclusion*

This study meant to investigate the groundwater condition of Agbor, Ozanogogo, Issele-Uku, Otulu and Anwai have been carried out using the electrical resistivity technique. The result has shown that groundwater in the form of confined aquifer is obtainable between a depth of 10.2 and 54.5 m. The resistivity of the aquifer layer ranged between 1834.5 and 4445.8 Ωm. The study has also shown that groundwater can be sourced from the fourth layer in Anwai at a depth of 10.2 m while the sixth layer is recommended as the aquifer where good quality groundwater can be sourced for the remaining locations.

### References


Anomohanran, O. (2011): Determination of groundwater potential in Asaba Nigeria using surface geoelectric sounding, International Journal of the Physical Sciences, 6(33): 7651-7656.

Anomohanran, O. (2013): Geophysical Investigation of Groundwater Potential in Ukelegbe, Nigeria, Journal of Applied Sciences, 13(1): 119-125.

Anudu, G. K., Onuba, L. N. and Ufondu, L. S. (2011): Geoelectric Sounding for Groundwater Exploration in the Crystalline Basement Terrain Around Onipe and Adjoining Areas, Southwestern Nigeria, Journal of Applied Technology in Environmental Sanitation, 1(4): 343-354.

Ayolabi, E. A., Adeoti, L., Oshinlaja, N. A., Adeosun, I. O. and Idowu, O. I. (2009): Seismic Refraction and Resisitivity Studies of part of Igbogbo Township, South-West Nigeria, Journal Science Research and Development, 11: 42-61.

Egbai, J. C. (2011): Vertical Electrical Sounding for the Determination of Aquifer Transmissivity, Australian Journal of Basic and Applied Sciences, 5 (6): 1209-1214.

Gabr, A., Murad, A., Baker, H., Bloushi, K., Arman, H. and Mahmoud, S. (2012): The use of Seismic Refraction and Electrical Techniques to Investigate Groundwater Aquifer, Wadi Al-ain, United Arab Emirates (UAE), Conference Proceedings of the Water Resources and Wetlands, 14-16 September 2012.

Ibrahim, K. O., Olasehinde, P. I., Akinrinmade, A. O. and Isa, A. (2012): Geoelectrical Soundings to Invesgigate Groundwater Potential of Orisunmibare Village in Ilorin South Area of Kwara State, Nigeria, Journal of Environment, 1(1): 21-25.

Lawrence, A. O. and Ojo T. A. (2012): The use of Combined Geophysical Survey Methods for Groundwater Prospecting in a Typical Basement Complex Terrain: Case Study of Ado-Ekiti Southwest Nigeria, Research Journal in Engineering and Applied Sciences 1(6): 362-376.

Nejad, H. T. (2009): Geoelectric Investigation of the Aquifer Characteristics and Groundwater Potential in Behbahan Azad University Farm, Khuzestan Province, Iran, Journal of Applied Sciences 9(20): 3691-3698.

Oseji, J. O., Asokhia, M. B. and Okolie, E. C. (2006): Determination of groundwater potential in Obiaruku and Environs using Surface Geoelectric Sounding, Environmentalist, 26: 301-308.

Sirhan, A., Hamidi, M. and Andrieux, P. (2011): Electrical Resistivity Tomography, an Assessment Tool for Water Resource: Case Study of Al-Aroub Basin, West Bank, Palestine, Asian Journal of Earth Sciences 4(1): 38-45.

Utom, A. U., Odoh, B. I. and Okoro A. U. (2012): Estimation of Aquifer Transmissivity Using Dar Zarrouk Parameters Derived from Surface Resistivity Measurements: A Case History from Parts of Enugu Town (Nigeria), Journal of Water Resource and Protection, 4: 993-1000.