Journal of Energy Engineering and Thermodynamics
ISSN 2815-0945
Vol : 02, No. 04 June-July, 2022
http://journal.hmjournals.com/index.php/JEET

Hydrogeophysical Investigation of Aquifer Layers in Nkporo, Ohafia Local Government Area

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Abstract: Drilling a borehole in Nkporo area of Ohafia in Abia state without proper investigation may lead to wasting resources if water bearing formation is not achieved. This is because borehole drilling is very expensive. It is therefore necessary to carry out proper hydro-geophysical investigation in order to identify a good aquifer before borehole drilling. Electrical resistivity method has been chosen for the investigation of the water bearing formation. The use of Schlumberger array (Vertical Electrical Sounding (VES)) method of electrical resistivity was chosen based on the geology of the study area. This method was chosen because not only will it delineate the layers of the near surface aquifer but will also determine the thickness and depth to the aquifer. Five (5) vertical electrical soundings data were obtained from five (5) locations in the community using the Schlumberger array method. The investigations reveal that the area is mostly underlain shale. The formations are poor in aquifer materials. Borehole therefore, in the area should be drilled deep to depths ranging between 700 – 900m into sandstone as revealed in VES 3 and VES 4.

Keywords: Anambra basin, Geophysical, Nkporo-Ohafia, Resistivity

1. INTRODUCTION:

Life without water is incomplete. Water is one of the factors for the existence of life. Almost every creature on earth needs for survivor. Water itself comprises seventy five percent of the earth while the rest twenty five percent is made of land. Water finds multiple uses in every sector of development like agriculture, industry, transportation, aquaculture, and even drinking. Water is always conserved in one way or the other. Water is always recycled through the usage and disposal. Any water disposed goes into the ground through natural filtering by the soil. The filtering method depends on the nature of the soil and the depth aquifer. Man is always in the need of quality water for drinking because it is an integral part of life on the planet Earth. Unadulterated water, is water of sufficient quality for use as drinking water. It is an essential ingredient for good health [1].

However, many communities in Ohafia, Abia State do not easily have access to natural portable water. This could be due to some natural factors while some factors are man-made.

Many communities rely under-ground water, stream or river waters. Even these sources of water in some communities are polluted due to the anthropogenic activities largely caused by the poor and uncultured living habit of people in such areas.

In the search for quality drinking water, the sinking of borehole has become necessary since most surface water have been polluted. However, even many of the boreholes water are also polluted due to the leachates from dumpsites near such boreholes. Therefore, in other to get a good quality drinking water, such boreholes must be drilled to reach a good aquifer that will be free of contaminants. The sinking of borehole can only be possible through proper investigation of the subsurface for quality water. Such investigation will also reveal the presence of other natural resources such as minerals deposit if any. Different geophysical techniques are used to investigate the subsurface for such water and mineral. They include electrical resistivity, gravity, and seismic, magnetic, seismic, remote sensing and electromagnetic. The results from such investigation can be used to delineate the water table in the underlying rocks. Such investigation can provide information on the vertical variation in the physical properties of the ground with depth. Electrical resistivity method employs the conductivity of ground water to locate its occurrence. Records show that the depths of aquifers differ from place to place because of vibrational geo-thermal and geo-structural occurrence [2][3]. Electrical resistivity method for conducting a vertical electrical sounding (VES) has proved very popular with groundwater studies due to the simplicity of the technique, the ruggedness of the instrumentation and because the resistivity of rock is very sensitive to its water availability. The main source of water supply is the surface water, which has grossly become inadequate because of rapidly increasing demand for water due to urbanization [4].

The area under investigation is located within Nkporo, Ohafia, Abia State. The coordinates of the Vertical Electrical Sounding (VES) points are: VES 1: N05^{o}37.119', with an elevation of 85m above sea level. VES 2: N05^{o}46.409', E007^{o}46.188' with an elevation of 92m above sea level. VES 3: N05^{o}46.129', E007^{o}45.719' with elevation of 118m above sea level. VES 4: N05^{o}80.248', E007^{o}76.776' with elevation of 71m above sea level, VES 5: N05^{o}81.204', E007^{o}76.726' with an elevation of 71m above sea level. Relief within the area is usually undulating.

The area is located in the south eastern part of the Anambra basin, a late Cretaceous – palaeocene proto Niger – Benue complex located in the southern part of the regionally extensive northeast- southwest trending Benue Through. It falls within the south-eastern part of the Anambra basin, composed of deltaic marine sediments of cretaceous to recent. The Ajali formation, Bende-Ameki formation and Asata Nkporo shale formation are three essential geologic formations in the area. The Ajali formation which is cretaceous in age consists of arenite, loose angular to sub-rounded grained quartz. According to [5]. The main water-bearing geological strata of the region are the Late Maastricht Azali Formations. The formation consists mainly of quartz anite, from loose angles to semi-agglomerated grains. There are multiple models of particle size in a region [6] [3]. The Ajali Formation is below the shale formation belonging to the Mamu Formation. Covered by the Nsukka shale formation. The Ajali Formation is a limited aquifer at most locations in the region. The Ajali layer is very permeable. Groundwater flows from the east and northeast to the southwest recharge area under the young strata where groundwater conditions develop [7]. In places where groundwater conditions occur, springs usually appear. Among them, the Muri and Obaya rivers stand out. The formation narrows from the north of Isuochi in the Isuikwuato provincial government area to the south of Nguzu before leaving through Eluama, Ovim and Alai to the south. Eocene to Oligocene Bende Ameki Bende Ameki Coarse-grained white sandstone formation comprising gravel, grayish sandstone, variegated clay and bluish limestone mud with fine limestone. Indeed, there are significant lateral changes in the petrology of this region. The Asata-Nkporo shale in northern Uturu flows across the Agwu sandstone. In the east of Uturu, the shale increases in thickness and develops most along the eastern side of the anticlinorium, where the village of Nkporo is located. The formation consists mainly of blue or dark gray shale mudstone. The main aquifer in the region is the Ajali Reservoir, which is reported to be permeable. The climate of the study area generally alternates between dry and wet seasons. Located in southeastern Nigeria, this region receives more than 1400 mm of annual precipitation from March to October. The greatest amount of precipitation is observed in June. The period in which little rain falls is from November to February. It also has very high year-round temperatures, with an annual range of 23°C to 32°C, with the hottest period of the year being the dry season [8].

Research Elaborations

Electrical resistivity surveys are commonly used in hydrogeology to delineate subsurface structures. The success of electrical resistivity depends mainly on the presence of suitable resistivity contrast between earth materials. In the area under investigation, significant resistivity contrast is expected between the following pairs of rock units

1 Lateritic layer and the underlying sands and shale rock
2 Dry sandy materials above the water table and wet sand below the water table.

The Schlumberger method measurements were therefore performed at the survey sites to determine the subsurface formations based on resistivity contrast. It involves the measurement of ground resistivity due to an impressed current input to the earth by means of an array of electrodes at the surface. It delineates resistivity boundaries within the earth by investigating the vertical variations of the resistivity of conducting zones [9]. This enables one to estimate the thickness and resistivity of these zones. The resistivity data obtained using different spacing at a fixed location are then evaluated to yield a sounding curve and its corresponding geo-electrical model section showing the variation of layer resistivity with depth [10][11].

The resistivity measurement was carried out using IGS Resistivity meter and stainless steel electrodes. The Schlumberger array was employed with maximum electrode spacing of 900m between the current electrodes giving a depth of penetration of about 100m. The instrument directly displayed the ground resistance and apparently resistivity.

2. RESULTS

Table 1 shows the apparent resistivity, thickness and depth of layered formations encountered in the VES point investigated. The modeled curves are presented in fig. 1.

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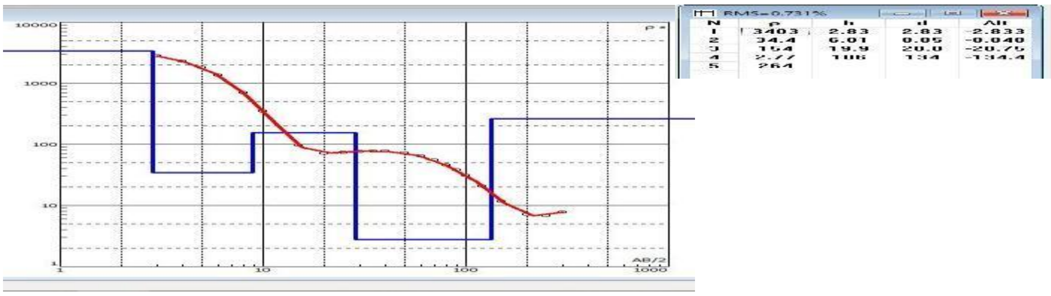
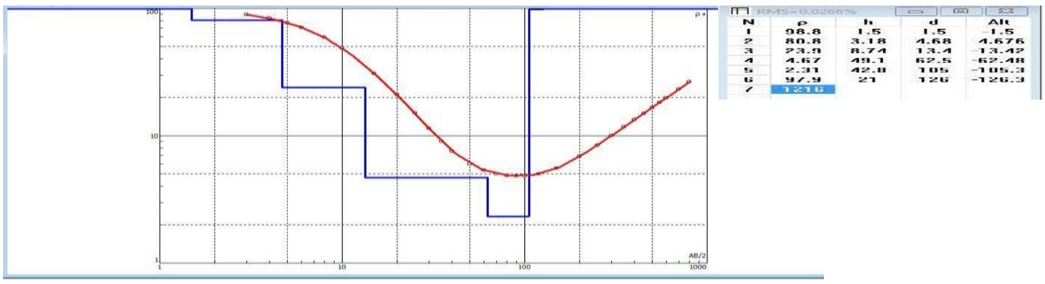


Figure 1: Resistivity sounding curve for Nkporo 1



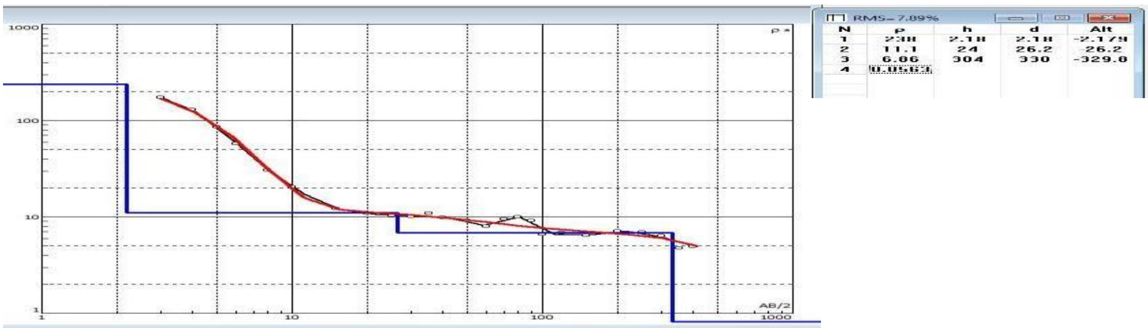


Figure 3: Resistivity sounding curve for Etitiama

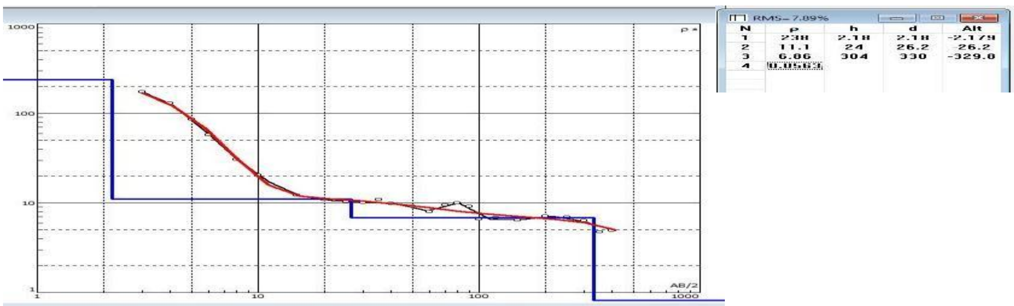


Figure 4: Resistivity sounding curve for Ndi Agbo Community School,

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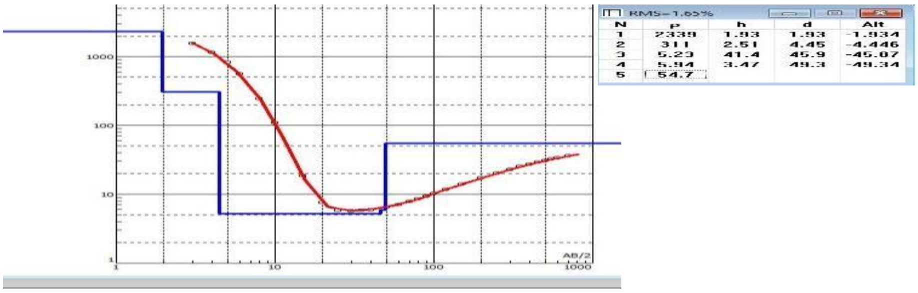

Figure 5: Resistivity sounding curve for Ukwa Comm

Table 1: Apparent resistivity, thickness and depth of layered formations within the VES site.

Sounding Location	Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Probable Lithology
	1	2339	1.93	1.93	Lateritic soil
	2	311	2.51	4.45	Clays
	3	5.23	41.4	45.9	Wet Coarse Sand
	4	5.94	3.47	49.3	Sandstones
	5	54.7	∞	∞	Shale

Table 2: Apparent resistivity, thickness and depth of layered formations within the VES site.

Sounding Location	Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Probable Lithology
	1	3403	2.83	2.83	Compacted sand
	2	34.4	6.01	8.85	Wet Clay
	3	154	19	28	Clay
	4.	2.77	106	134	Sandstones
	5	264	∞	∞	Shale

Table 3: Apparent resistivity, thickness and depth of layered formations within the VES site.

Sounding Location	Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Probable Lithology
	1	92.1	4.01	4.01	Clayey sand
	2	27.2	8.51	12.5	Wet Clay
	3	4.89	38.6	51.1	Sandstones
	4	3.00	64.8	116	Sandstones
	5	3841	∞	∞	Shale

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Table 4: Apparent resistivity, thickness and depth of layered formations within the VES site.

Sounding Location	Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Probable Lithology
	1	111	1.5	1.5	Clayey sand
	2	0.925	2.42	3.92	Wet Sandstones
	3	4.24	6.31	10.2	Sanstones
	4	1977	176	186	Shales
	5	3400	∞	∞	Shale

Table 5: Apparent resistivity, thickness and depth of layered formations within the VES site

Sounding Location	Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Probable Lithology
	1	238	2.18	2.18	Clayey sand
	2	11.1	24	26	Wet Sand
	3	6.86	304	330	Sandstones
	4	0.0563	∞	∞	Wet Silt Sand

Table 1 presents the primary geo-electric parameters from each of the five VES points in the study area. It shows the total number of layers, Apparent resistivity, thickness, depth and inferred lithology delineated in each of the locations. 4-5 geo-electric layers were delineated across the area. Resistivity values ranged from 0.0563(Ωm) to 3841(Ωm) across the stations, thickness ranged from 1.5m to 304m while a maximum depth of 330m was delineated. The lithology of the area consists of lateritic top soil Clayey sand, Sandstones and Shale materials
VES 1 (Nkporo 1): Table 1 shows the site underlain by five geo-electric layered formations. The first layer has an apparent resistivity value of 2339Ωm and a thickness of about 1.93m. It represents the top layer which is composed mainly of Lateritic soil. Underlying the top layer is the second geo-electric layer with an apparent resistivity value of 311Ωm and a thickness of about 2.51m, interpreted to be a layer of clays. The third layer which is approximately 41.4m thick has an apparent resistivity value of 5.23Ωm, interpreted to be a layer of Wet coarse sand. This layer is directly underlain by the fourth geo-electric layer with an apparent resistivity value of 5.94Ωm and 3.47 thickness, interpreted to be layer of sandstones. At the base of the geo-electric section is the fifth layer which is infinitely thick with an apparent resistivity value of 54.7Ωm, interpreted to represent shale rock.
VES 2 (Nkporo 2): Table 2 shows that the site is underlain by five geo-electric layered formations. The first layer has an apparent resistivity value of 3403Ωm and a thickness of about 2.28m. It represents the top layer which is composed mainly Compacted sand. Underlying the top layer is the second geo-electric layer with an apparent resistivity value of 34.4Ωm and a thickness of about 6.01m, interpreted to be a layer of wet clay sand. The third layer which is infinitely thick has an apparent resistivity value of 154Ωm, with a thickness of 19m interpreted to be a layer of Clay. The fourth geo-electric layer is interpreted to consist mainly of sandstones with a resistivity of 2.77Ωm and a thickness of 106m
VES 3 (Etitiama): Table 3 shows that the site is underlain by five geo-electric layered formations. The first layer has an apparent resistivity value of 98.8Ωm and a thickness of 1.5m. It represent the top layer which is composed clayey sand. Underlying the top layer is the second geo-electric layer with an apparent resistivity value of 80Ωm and a thickness of about 3.18m., interpreted to be a layer of Clays. The third layer which is approximately

8.74m in thickness with an apparent resistivity value of 23.9Ωm, interpreted to be a layer of Sandstones. This layer is directly underlain by the fourth geo-electric layer with an apparent resistivity value of 4.67Ωm and a thickness of about 49.1m, interpreted to be a layer of Sandstones. Beneath is the fifth layer interpreted to consist of shale, with an apparent resistivity value of 1216Ωm and a thickness of about 47.4m.
VES 4 (Ndi Agbo Community School, Okwoko): Table 4 shows that the site is underlain by five geo-electric layered formations. The first layer has an apparent resistivity value of 111Ωm and a thickness of 1.5m. It represents the top layer which is composed mainly of Clayey sand. Underlying the top layer is the second geo-electric layer with an apparent resistivity of 0.925Ωm and a thickness of about 2.42m, interpreted to be a layer of Sandstones. The third layer which is approximately 6.31m thick has an apparent resistivity value of 4.24Ωm, interpreted to be a layer of Sanstones. The Fourth and Fifth layer is interpreted to consist of Shale with apparent resistivity of 1977 Ωm and 3400 Ωm and 176m and infinite Thickness respectively.
VES 5 (Ukwa Community): Table 5 shows that the site is underlain by four geo-electric layered formations. The first layer has an apparent resistivity value of 238Ωm and a thickness of about 2.18m. It represents the top layer which is composed mainly of clayey sand. Underlying the top layer is the second geo electric layer with apparent resistivity value of 11.1Ωm and a thickness of about 24m, interpreted to be a layer of Sandstones. The third layer which is approximately 304m thick has an apparent resistivity of 6.86Ωm, interpreted to be a layer of Sandstones. This layer is directly underlain by the fourth geo-electric layer which is infinitely thick with an apparent resistivity value of 0.0563Ωm, interpreted to represent wet Sand.

3. CONCLUSION

This study has demonstrated the usefulness of the VES method in the exploration of groundwater.[10], proposed values of overburden thickness ranging between 20m and 30m for productive wells. Similarly, they also prescribed a minimum overburden thickness of 25m for viable groundwater abstraction. In the surveyed area, the depth to the fresh basement (total overburden) varies from 45m to 300m. Overburden thickness of between 26m and 50m occurred in 95% which thus suggests that the water-bearing horizon across the area is generally significantly thick and can support productive groundwater abstraction.

4. REFERENCES

[1] E. O. Nwaichi and I. O. James, Groundwater quality assessment in selected Niger Delta
[2] communities in Nigeria. Journal of Environmental & Analytical Toxicology, 02(03), 2012.DOI: 10.4172/2161-0525.1000133
[3] S. Ekine and S. Osobonye, Surface geo-electric sounding for the determination of
[4] aquifer characteristics in parts of Bonny Local Government Area of Rivers State. Nig. Journal of Physics., 85, 93-97,1996.
[5] K. K. Ibe, A. O. Adlegbemobo, and J. O. Mafemi, Natural fluoride levels in some
[6] springs and streams from the Late Maastrichtian Ajali Formation in Ohafia-Arochukwu area of South Eastern Nigeria. Odonto-Stromatologie Tropicale, 87, 1998.
[7] E. E. Okwueze, Preliminary findings of the groundwater resource potentials from a

[8] regional geo-electric survey of the Obudu basement area. Nigeria Global Journal of Pure Applied Science, 2(2), 201-211. 1996.
[9] Eke and M. U. Igboekwe, Geoelectric investigation of groundwater in some villages in
[10] Ohafia locality, Abia State, Nigeria. British Journal of Applied Science & Technology1(4):190-203, SCIENCEDOMAIN international www.sciencedomain.org. 2011.
[11] M. U. Igboekwe, E. E. Okwueze, and C. S. Okereke, Delineation of patential aquifer
[12] zones from geoelectric soundings in KWA-IBOE river watershed, southeastern, Nigeria. Journal of Engineering and Applied Sciences, 1(1), 410-421, 2006.
[13] M. E. Offodile, An approach to groundwater study & development in Nigeria.
[14] Mecon Services Ltd Jos, Nigeria , 1992.
[15] S. Ekine, Fundamentals of Applied Geophysics. Pearl Publishers. ISBN 978-978-
[16] 48309-3-6, 2010.
[17] C. Morka and O. C. Molua, Volume resistivity and permitivity of solid dielectrics;
[18] Case study how to determine the effective area of measurement electrode. Chukwuemeke Odumegwu Ojukwu, University Journal of Physical Sciences 5(1) Pg 433-439, 2022.
[19] A.I. Olayinka M.O. Olorunfemi. Determination of geoelectric characteristics in Okene
[20] area and implications for borehole siting. Journal of Min Geology. 28:403–411, 1992.
[21] D .A. Ogwu, O.C. Molua, and Edobor, Investigating rock electrical properties of Anambra River Basin, using geophysical technique. International Journal of Technical & Scientific Research Engineering www.ijtsre.org ISSN: 2581-9259, Volume 5 Issue 3, 2022

