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Research Article

Assessment of Groundwater Potential in Adudu and It's Environ Part of Akiri Sheet 232 Middle Benue Trough, Central Nigeria

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ABSTRACT

Electrical resistivity investigation was carried out around Adudu and its environ, part of Akiri sheet 232, Middle Benue Trough, Central Nigeria, in order to study the subsurface geologic layer with a view of determining the depth to the aquifer and thickness of the geoelectric layers. Vertical Electrical Sounding (VES) using Schlumberger array was carried out at seventeen (17) VES stations with the aid of ABEM tetrameter (SAS 300) for data acquisition. The field data obtained have been analysed using computer software (WinResist) which gives an automatic interpretation of the apparent resistivity. The VES results revealed heterogeneous nature of the subsurface geological sequence. The geologic sequence beneath the study area is composed of hard pan top soil (clayey and sandy-lateritic), weathered layer, partly weathered or fractured basement and fresh basement. The resistivity value for the topsoil which have resistivity values varying from 17 Ωm-828 Ωm up to 2 m lateritic with a resistivity value ranging from 80 Ωm-1700 Ωm and 1.4 m to 2.9 m, shaly sand, with resistivity and thickness value varying between 46 Ωm-132 Ωm and 6 m to 19 m, fractured basement with resistivity and thickness values ranging from 161 Ωm-457 Ωm and 4.8 m to 30 m, and finally, fresh basement whose resistivity vary from 600 Ωm-1691 Ωm with an infinite depth. The aquifer resistivity in the study area ranges from 80 Ωm to 457 Ωm with an average value of 120 Ωm.

Keywords: Aquiferious; Shaly sand; Structural trend; Formation

INTRODUCTION

Water is a vital need for life, nature, agriculture activities and civilization. Nature, ecosystems and biodiversity are essential to decrease vulnerability to extreme hydrological events. Groundwater is the largest source of fresh water in the world and accounts for about one third of one percent of the earth water. It is of major importance to civilization being the largest reserve of drinkable water that can be used by humans. Before 1980, there was only minor development of groundwater resources in Nasarawa State. The population depended on surface water and a few number of hand-dug wells as sources of water. Hand dug wells are less than 15 m deep and only sustain their users adequately during the rainy season. As a result of this the water needs of the population have not been adequately met especially during the dry season. Efforts have been made over the years to meet the water needs of the population and this included establishment of government agencies as well as private companies and individual involved in the exploration and exploitation of sustainable water supply for the increasing population. Increasing industrialization and growth of large rural area have been accompanied by increase in the population stress on the aquatic environment. Water in rivers and lakes as well as abandoned wells has been considered as convenient receiver of waste. This abuse conflicts with almost all other uses of water and most seriously with the use of freshwater for drinking, personal hygiene and food processing [1-5].

There are number of geophysical exploration techniques available which gives insight on the nature of water bearing layers, they include; seismic, electromagnetic, geophysical borehole logging and geo-electric. These methods measure properties of formation materials, which determine whether such formation may be sufficiently porous and permeable to

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serve as an aquifer. Electrical resistivity method of geophysical method is the best in groundwater studies. It is due to easy in the field operation, the portable equipment, greater depth of penetration and it is accessible to modern communication system.

Location, extent and accessibility

The study area is located in Adudu, North Central Nigeria, between latitudes 08° 10'00"N and 08° 19'00"N and longitudes 08° 55'00"E and 09° 6'30" E (Figure 1). It is bounded to the west by Keana, north by Lafia and to the east by Awe. The area is accessible by the Lafia-Obi roads, minor roads and footpaths. It is a town under Obi Local Government Area.

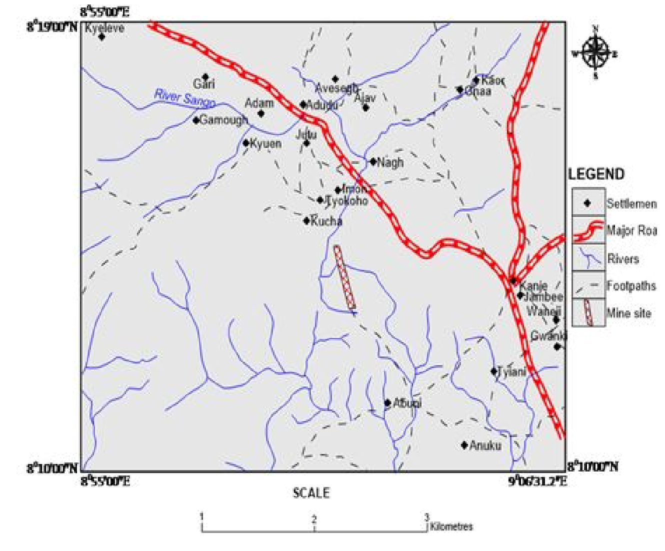

Figure 1: Location map of the study area.

Review of the hydrogeology of the middle benue trough

The Middle Benue and most areas of the Benue Valley, have difficult hydrogeological situations; these conditions arise from the fact that most of the potential aquifers are either limited in extent, thinly developed with consistent clay and shale interblending's or even so highly indurated that only the development of secondary voids created by fractures, joints and solution channels can attract hydrogeological interest [6-10].

The occurrence of groundwater in the sedimentary rocks of Nasarawa State was studied by Offodile He found out that groundwater occurs in the rocks within the following formations:

- The aquifer of Awe formation
- The aquifer of Makurdi/Keana and Ezeaku formations.
- The aquifer of Awgu formation and
- The aquifer of Lafia formation.

Awe formation aquifer is the lowest aquifer as it is below the Keana formation aquifer. It is composed of series of shale and porous sandstone beds and is highly productive. However, the presence of salt in it renders it unfavorable for groundwater exploration as the water from wells tapping the aquifer around Old Awe Town (TsohonGari) show high saline.

Geology and hydrogeology of the study area

Adudu and environ lies within the Awe and Agwu formations (Figure 2) which falls under the Middle Benue Trough of Nigeria and also igneous origin, The study area is underlain by shales (baked and compacted) Basalt and Sandstone, Bluish-grey to dark black carbonaceous shales of Late Albian–Early Cenomanism age predominate the study area. Basalts intruded the black shale forming a hill of about 250 m high, and the common structural features observed are mud cracks, veins, joints.

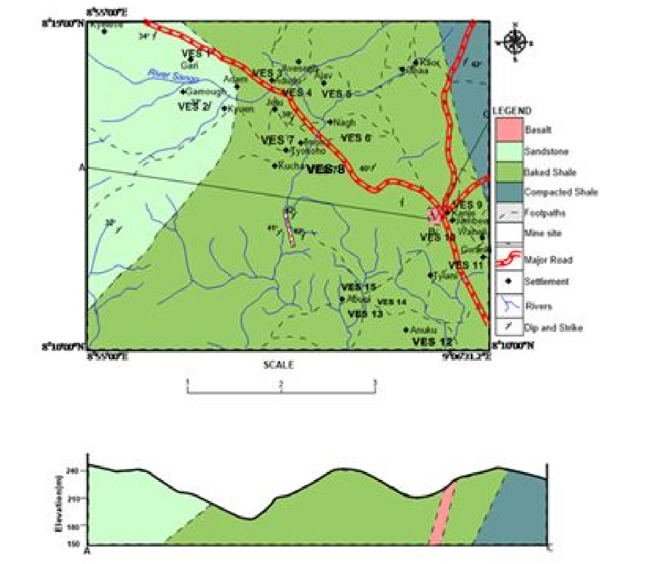

Figure 2: Geology and VES map of adudu and its environment.

Furthermore, the formations consist top soil/laterite, Sandy shale, Shaly sand (aquiferous) and Shale (aquiferus) and highly indurated sandstones, which are impermeable in places, where well fractured or less indurated, and however, the formation is usually less compact, more permeable and better prospect as an aquifer. The usefulness of the formations as a potential groundwater reservoir depends on its secondary permeability derived from weathering and fracturing. When the rocks are fractured or faulted the aquifers are interconnected and recharge into them increases considerably.

MATERIALS AND METHODS

Vertical Electrical Soundings (VES) using Schlumberger array were carried out at seventeen (17) stations. A regular direction of N-S azimuth was maintained in the orientation of the profiles. Overburden in the sedimentary formation area is thick as to warrant large current electrode spacing for deeper penetration, therefore the largest current electrode spacing covered 120 m of AB and 7.5 m of AB/2. In the Schlumberger array method, the current electrodes (C_1 and C_2) are outer electrodes and potential electrodes (P_1 and P_2) are inner electrodes, the inner potential electrodes were fixed at a point while current electrodes were expanded symmetrically about the spread. Measurement were taking while introducing an artificial electric current into the ground through two electrodes (AB) and the resulting potential drop across the other two potential electrodes (MN) were taken.

The principal instrument used for this survey is the ABEM Tetrameter Signal Averaging System, (SAS 300). The resistance readings at every probe point were automatically displayed on the digital readout screen and then written down on the field data. The field data was interpreted using a computer simulated program, Win Resist version 1.0. The VES point were determine in the field using GARMIN channel personal navigation Global Position System (GPS) receiver to locate the points and the maps were produced using Golden Surfer 12 program.

RESULTS AND DISCUSSION

The apparent resistivity, ρ_a, values were plotted against the electrode spacing (AB/2) on a log-log scale to obtain the VES sounding curves using an appropriate computer software Wine Rsisit in the present study. The modeling of the VES measurements carried out at seventeen (17) stations has been used to derive the geoelectric sections for the various profiles. Geoelectric sections are shown in Figures 3-17. These have revealed that there are mostly five geologic layers beneath each VES station. The field results obtained of the seventeen (17) stations carried out within the study area is presented in (Table 1).

Table 1: Quantitative interpretation showing geo electric parameters.

S/N	VES Station	Curve	Location type	No of layer (s)	Resistivity (ohm-m)	Thickness (m)	Depth (m)	Lithological Units
1	V_1	QHA	Gari	5	326 69 15 117 2452	0.6 4.4 14 25.9 -	0.6 5 19 44.9 -	Topsoil/ laterite Sandy shale Shaly sand Sandstone
2	V_2	QH	Gamough	5	118 28 21 231 106	0.8 4.9 22.3 98 -	0.8 5.7 28 126	Topsoil/ laterite Sandy shale Shaly sand Sandstone
3	V_3	AAK	Adudu	5	17 63 144 163	0.8 2.1 5.6 65 -	0.8 2.9 8.2 74 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
4	V_4	AAK	Adudu	5	87.5 137 234 1988 632	2.0 4.0 9.2 95 -	2.0 6.0 15.2 110 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
5	V_5	AAK	Adudu	5	75 100 218 1741 558	1.7 5.2 9.5 101 -	1.7 7 16.5 117 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
6	V_6	KHA	Nagh	5	60	1.9	1.9	Topsoil/ laterite

					84 31.7 135 665	5.2 11.4 12.6 -	7.2 18.5 31 -	Sandy shale Shaly sand Shale sand
7	V_7	QHK	Imon	5	98 57 43.8 660 556	0.4 6.4 18.8 52.8 -	0.4 6.8 25.6 78.4 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
8	V_8	QHK	Kucha	5	144 58 40.9 93.6 6.7	0.4 6.9 12.2 12.5 -	0.4 7.2 19.4 31.9 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
9	V_9	QHA	Kanje	5	1912 63.3 11.1 60.2	0.7 2.4 4.7 5.3	0.7 3.1 7.7 13	Topsoil/ laterite Sandy shale Shaly sand Shale sand
10	V_{10}	QHK	Kanje	5	264 79 14.8 289 181.9	0.7 2.5 6.3 34 -	0.7 3.1 9.4 44 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
11	V_{11}	QHA	Kanje	5	133 62.3 14.8 239 266	1 1.9 4.8 12 -	1 2.9 7.7 19.8 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
12	V_{12}	HKH	Anuku	5	104 34 1054 558 35	0.3 0.6 10.6 14.4 -	0.3 0.9 11.5 26 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
13	V_{13}	HAA	Abuni	5	139 13.6 111 365 1055	1.3 2 5.5 19.3 -	1.3 3.3 8.8 28 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand

14	V_{14}	KHAK	Abuni	6	82 83 44.5 1323 4207 320	1.5 2.7 2.2 10.2 132 -	1.5 4.1 6.4 16.5 148 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand
15	V_{15}	QHA	Abuni	5	385 271 54 95 1239	1.3 0.5 2.7 12.7 -	1.3 1.8 4.4 17.2	Topsoil/ laterite Sandy shale Shaly sand Shale sand
16	V_{16}	HAAK	Abuni	6	828 83 445 1323 4707 3206	1.5 2.7 2.2 10.2 132 -	1.5 4.1 6.4 16.5 148 -	Topsoil/ laterite Sandy shale Shaly sand Shale sand Shale sand
17	V_{17}	QHA	Abuni	5	385 271 5.4 946 1739	1.3 0.5 2.7 12.7 -	1.3 1.7 4.4 17.2	Topsoil/ Laterite Sandy shale Shaly sand Shale sand

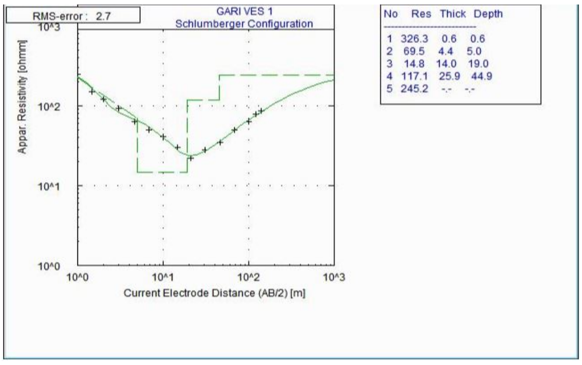

Figure 3: QHA-curve type.

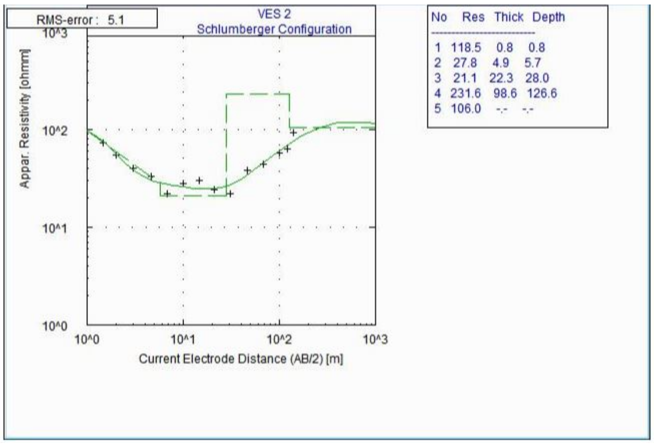

Figure 4: QH-curve type.

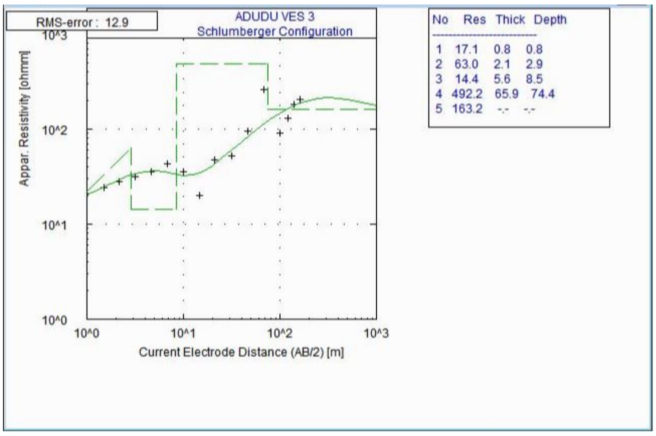

Figure 5: HQHA-curve type.

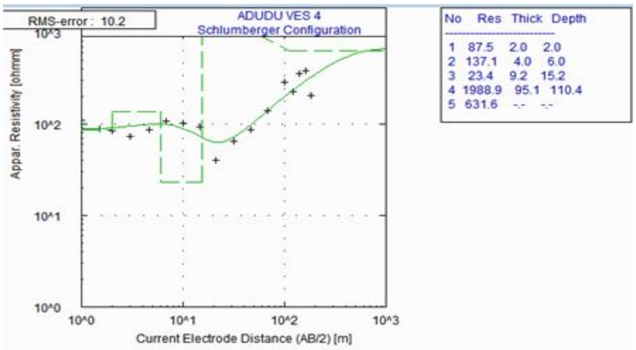

Figure 6: HQHK-curve type.

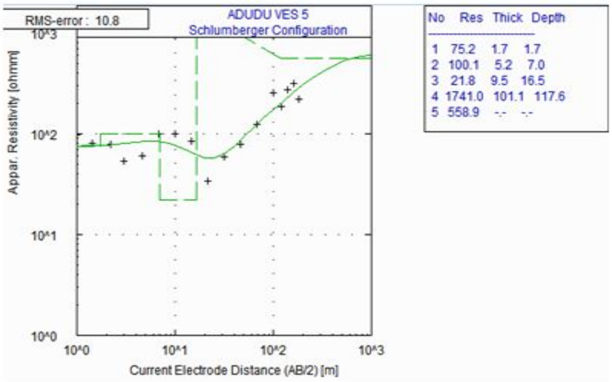

Figure 7: AHKHK-curve type.

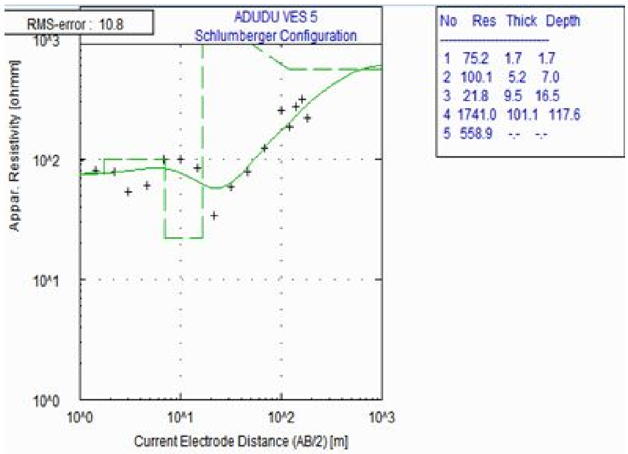

Figure 8: AHKHK-curve type.

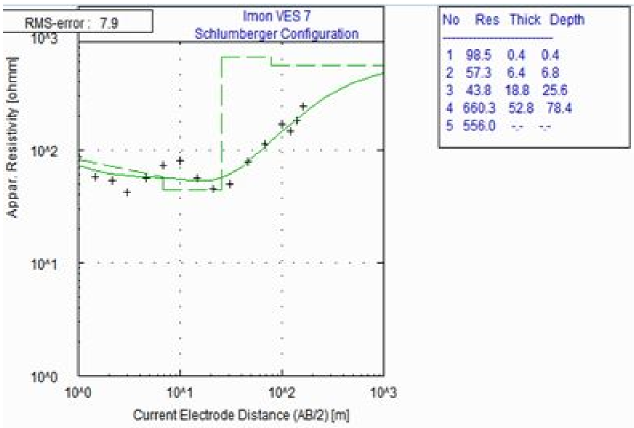

Figure 9: AHKHK-curve type.

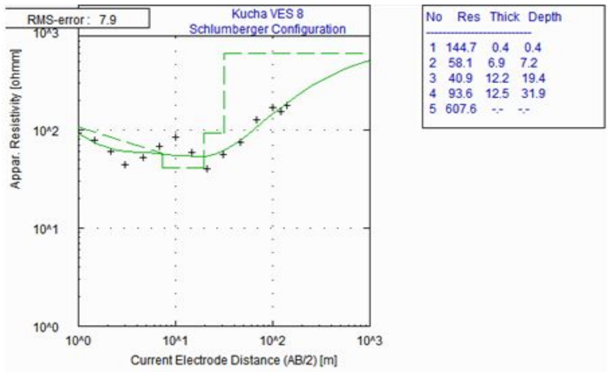

Figure 10: AHKHA-curve type.

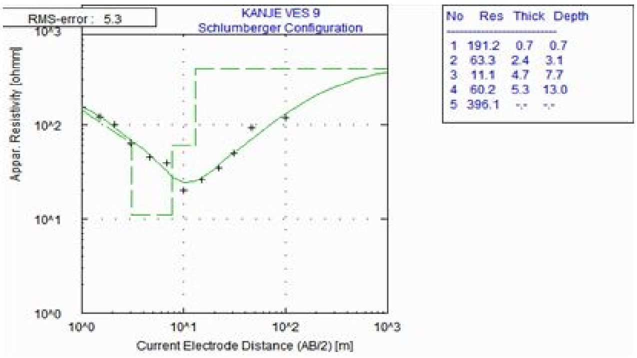

Figure 11: HQHK-curve type.

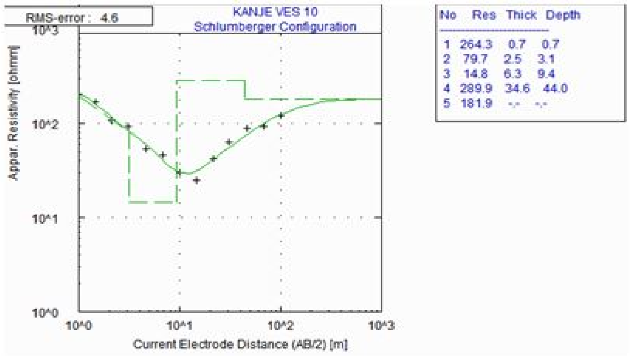

Figure 12: HQHA-curve type.

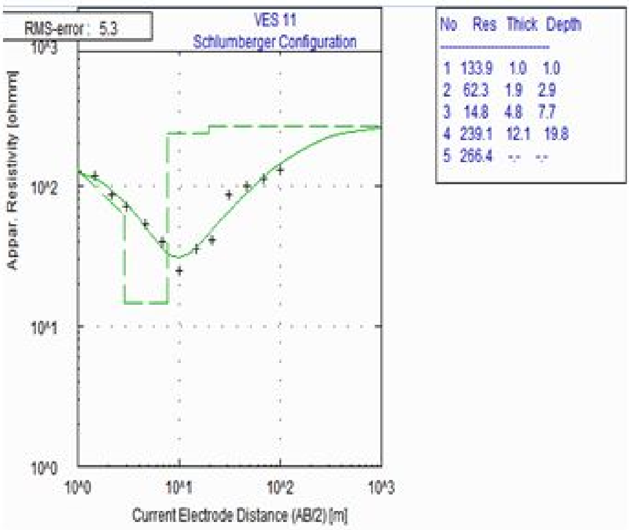

Figure 13: HQHA-curve type.

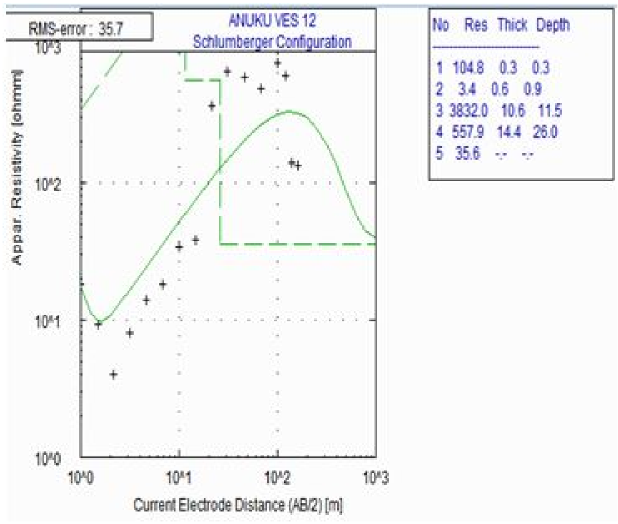

Figure 14: HQHK-curve type.

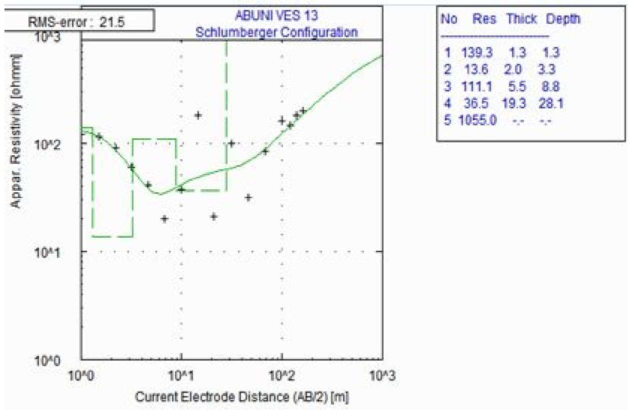

Figure 15: HQHA-curve type.

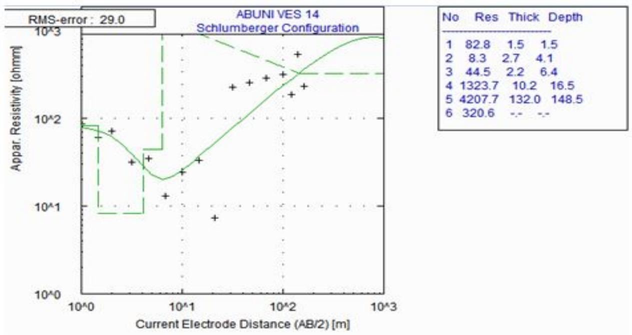

Figure 16: KHHKA-curve type.

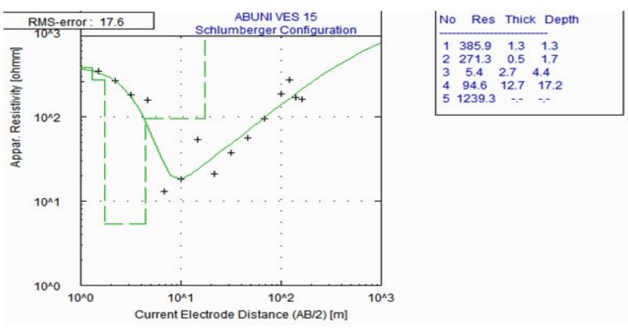

Figure 17: HHKH-curve type.

The interpretation of the data identified aquifer layers at various VES points showing the variation of aquifer resistivity and thickness due to lithology composition, which revealed that four to six geologic layers, composed of topsoil which have resistivity values varying from 17 Ωm -828 Ωm up to 2 m lateritic with a resistivity value ranging from 80 Ωm-1700 Ωm and 1.4 m to 2.9 m, shaly sand, with resistivity and thickness value varying between 46 Ωm 132 Ωm and 6 m to 19 m, fractured basement with resistivity and thickness values ranging from 161-600 Ωm and 4.8 m to 30 m, and finally, fresh basement whose resistivity vary from 600 Ωm-5000 Ωm with an infinite depth.

The aquifer resistivity in the study area ranges from 80 Ωm to 757 Ωm with an average value of 120 Ωm. From the results obtained, aquifer thickness ranges from 5 m to 35 m having an average value of 15 m. The VES with the greatest thickness of 30 m was observed at VES 17 layouts while VES 15, 16 and 18 have the thinnest of 10 m. The main aquifers of the study area are located in Gamough, Adudu, Nagh, Kanje and Abuni showing good water potential in the area. Areas with low water potential are Part of Kanje. Below are the geo electric curve of the seventeen VES points with their respectively depth, thickness and curve type.

CONCLUSION

Geologically, the study area is underlain by baked and compacted shale, basalt and sandstone, Bluish-grey to dark-black carbonaceous shales of Late Albian–early cenomanism age. The structural trending of the area is NE-SW direction. Geoelectrical investigation using the D.C. electrical resistivity method was employed to establish seventeen (17) VES points in Adudu and its Environ, part of Akiri sheet (232) Nasarawa State, Nigeria. The study area is mostly characterized by five geoelectric layers comprising of Top soil composed with resistivity values varying from 17 Ωm-828 Ωm and thickness of 2 m, Lateritic ranging from 80 Ωm-1700 Ωm with thickness of 1.4 m to 2.9 m, Sandy shale has resistivity of 46 Ωm-132 Ωm with thickness from 6 m to 19 m, Shaly sand (aquiferious) ranging from 161 Ωm-600 Ωm with thickness of 4.8 m to 30 m and Shale (aquiferious) and fresh basement whose resistivity vary from 600 Ωm-5000 Ωm. Which implies that some areas (Gari VES 1 and 2,Adudu VES 3 and 5,Ngah VES 6, Kucha VES 8, Kanje VES 9 and 10, VES 11, Abuni VES 13 and 15) have good prospect for groundwater development, especially places with distinctive. Shaly sand (aquiferious) and Shale (aquiferious) thicknesses. Boreholes drilled through these probe area yield will be productive. Also the investigation was carried out to deduce the nature of subsurface and for proper description of relationship between yield and other parameters and to improve our knowledge of the variable of interest.

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