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INVESTIGATION OF GROUNDWATER POTENTIAL ZONES USING ELECTRICAL RESISTIVITY METHOD IN MUBI SOUTH LOCAL GOVERNMENT AREA OF ADAMAWA STATE, NORTH EASTERN NIGERIA

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ABSTRACT: *The groundwater potential zone investigation using electrical resistivity method in Mubi south Adamawa state ,North Eastern Nigeria was carried out to determine the depth, groundwater potential zones , geo-electric parameters and the possible areas to drilled bore hole. ABEM SAS 1000 Terrameter was used in the geo-electrical survey of the area with the maximum electrode spacing of 100m using the Schlumberger array. Five Vertical Electrical Sounding (VES) points were sounded. The qualitative and quantitative analysis of the data collected was interpreted using the Interpex 1x1D software. The result shows that VES 24 was found to have potential for ground water exploration due to low resistivity value and high conductivity in the area, while VES 21, 22, 23, and 25 has no potential for groundwater exploration due to high resistivity value and low conductivity.*

KEYWORDS; Groundwater, Investigation,, Schlumberger array, Vertical Electrical Sounding (VES) and Terrameter.

INTRODUCTION

Groundwater is a mysterious nature's hidden treasure. Its exploration and exploitation have continued to remain an important issue due to its unalloyed needs. Though there are other sources of water, like streams, rivers, ponds, etc., none is as hygienic as groundwater because groundwater has an excellent natural microbiological quality and generally adequate chemical quality for most uses (Okpoli, 2017). Ground water is one of the most essential natural resources to support human health, economic development and ecological diversity. Due to its several inherent qualities (e.g. widespread and continuous availability,

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excellent natural quality, limited vulnerability, low development cost and drought reliability), it has become an important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries (Todd & Mays, 2005).

In order to increase the rate of water supply in Mubi, Adamawa State Nigeria due to increase in population of people living in the community, there is need to focus more on identification of groundwater potential zones of the area under study. Resistivity method comes to play in this aspect.

The proper exploration of groundwater involves deep and comprehensive techniques to provide valuable information with respect to distribution, thickness, and depth of groundwater bearing formation. Various surface geophysical techniques are used in groundwater exploration which includes the electrical resistivity method, seismic refractive method, magnetic method, radioactivity method, gravity method, and electromagnetic method. These techniques are capable of mapping overburden thickness, aquiferous zones, as well as bedrock architecture and topography (Adagunodo & Sunmonu, 2013; Adagunodo *et a*l., 2014, 2017; Joel *et al.,* 2016; Oyeyemi *et al.,* 2017).

The resistivity method is used in the study of horizontal and vertical discontinuities in the electrical properties of the ground, and also in the detection of three-dimensional bodies of anomalous electrical conductivity. It is routinely used in engineering and hydrogeological investigations to investigate the shallow subsurface geology, in the resistivity method, artificially-generated electric currents are introduced into the ground and the resulting potential differences are measured at the surface. Deviations from the pattern of potential differences expected from homogeneous ground provide information on the form and electrical properties of subsurface in homogeneities (Philip *et al*., 2002).

LITERATURE REVIEW

A lot of research work has been done by so many authors about the possible best site to drill bore hole for water exploration. The occurrence, storage, and distribution of groundwater in Precambrian basement complex are influenced by different geological factors (Amadi & Olasehinde, 2010; Olurunfemi & Fasuyi, 1993). Most often, the occurrence of groundwater in basement complex terrains is localized and confined to weathered/fractured zones (Adiat *et al.,* 2009; Ariyo & Adeyemi, 2009; Mbiimbe *et al.*, 2010).

.Olorunfemi and Oloruniwo (1987) used the electrical resistivity method for groundwater investigation in parts of the Basement terrain in Southwest Nigeria and concluded also, that the weathered layer and the fractured Basement constitute the aquifer zones. Olorunfemi and Fasuyi (1993) used the electrical resistivity method in investigation of geo-electric and hydro-geologic characteristics of areas in Southwest Nigeria.

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This research is aimed at Investigation of Groundwater Potential Zones Using Electrical Resistivity Method in Mubi South Local Government Area of Adamawa State North Eastern Nigeria.

GEOLOGY OF THE AREA

Mubi town, Adamawa state, Northeastern Nigeria lies on the bank of the Yedseram River, a stream that flows north into Lake Chad and is situated on the western flanks of Mandara Mountains (https://www.britannica.com/place/Mubi). The area lies within Latitude 10 ^{0} 015'N and 10^{0} 025'N and Longitude 13^{0} 015'E and 13^{0} 025'E. The area is $16km^{2}$. The topography of the area is typically of steep hills, undulating slopes and gentle escarpment. The landform is the consequence of geological and geomorphological processes. The study area is underlain by the undifferentiated rocks of the Basement complex which have been subjected to weathering that produced a fairly deep regolith (Kogbe, 1989). The rocks are of Precambrian origin and consist of metamorphic and igneous rock types common among which are the granite descriptions; migmatite, gneisses and phillites. The granite dominates the structures, hence, is refer to as the Older Granites (Carter, 1963). In most areas underlain by the Basement complex is a thin, discontinuous mantle of weathered rocks. The average thickness of the mantle is 15m, but in some areas may extent to depths of up to 60 m. Groundwater is normally found if the original state of the rock has been deformed either by deep fracturing, weathering, faulting among others (Nur & Kujir, 2006). The presence of groundwater in any given area depends on the thickness and lateral extent of decomposition and where both occur, the groundwater condition is usually very good. The Basement complex is generally a poor source of groundwater because the decomposed mantle is often too thin to harbour large quantities of water and sometimes too clayey to be highly permeable or the joints and fractured zones are poorly developed (Olorunfemi, 1993).

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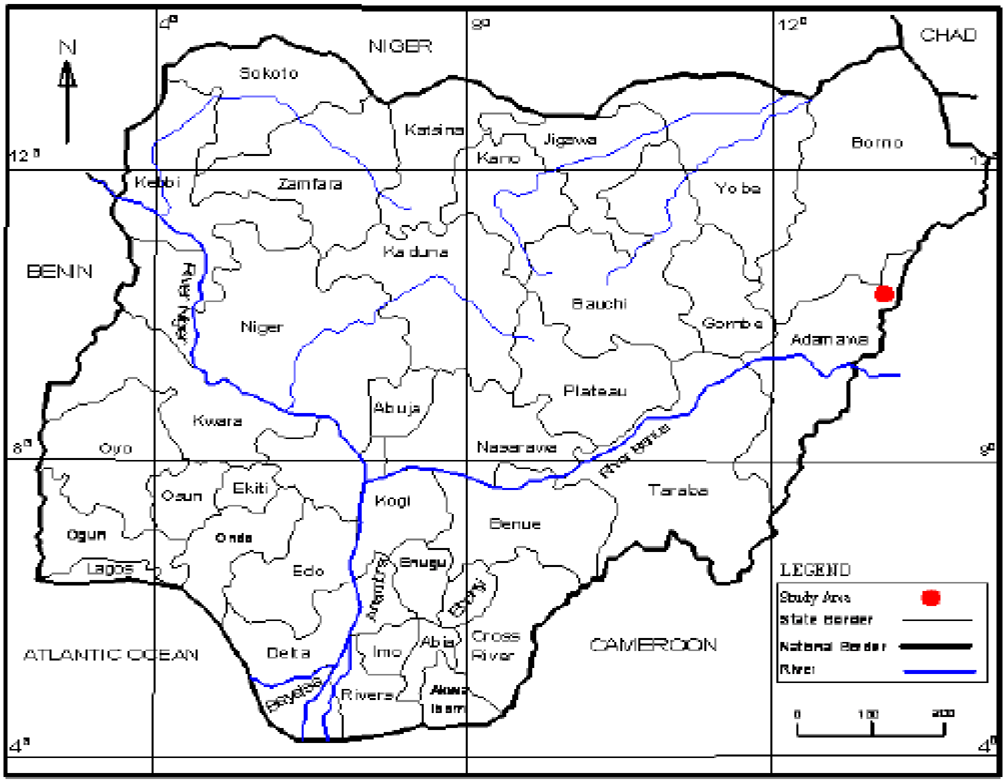

Fig 1: Map of Nigeria showing the study area. Source : (ADSU ,2012)

MATERIALS AND METHOD

The material used in this research was Terrameter SAS 1000, electrodes, wire, umbrella, tape and hammer. The method used was electrical resistivity method (Schlumberger array). Five Vertical Electrical Soundings were carried out on the study area with the maximum electrode spacing of 100m. Measurements of apparent resistivity were made by systematically varying electrode spacing. The midpoint of the array was kept fixed which was Potential electrode while the distance between the current electrodes was progressively increased. In Vertical Electrical Sounding (VES) four steel electrodes were arranged and pinned collinearly into the earth, at first the current electrode was at 1m from the central electrode AB/2 (m) and Potential electrode MN/2 (m) was at 0.2m from the central electrode. When the current electrode (AB/2) is at a maximum 10.0m then potential electrode (MN/2) was changed to 1.5m. This enables current lines to penetrate greater depths, depending on the vertical distribution of conductivity (Lowrie, 2007). Each VES soundings were appropriately recorded as shown in fig 2 below.

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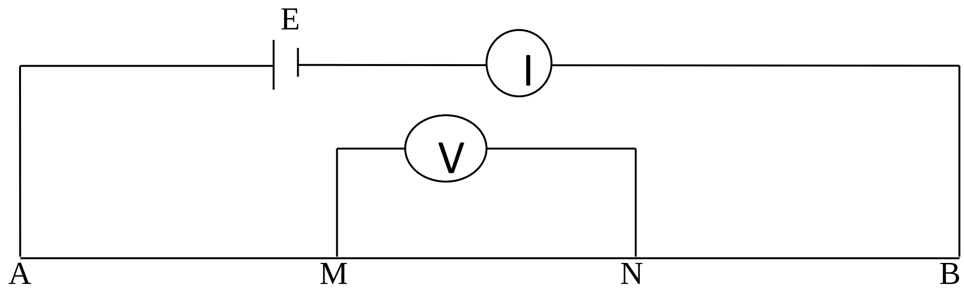

Fig 2: Schlumberger configuration

Apparent resistivity was calculated with equation

$$\rho_a = \frac{KV}{I} = KR \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 1$$

$$K = \frac{\frac{\Pi}{2}\left[\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2\right]}{\left(\frac{MN}{2}\right)} \qquad \ldots\ldots\ldots\ldots\ldots \quad 2$$

and ρ_a is apparent Resistivity
K is Geometric Factor
V is Volt
I is Current
R is Resistance and AB is the Current Electrode Separation.

Data Interpretation

The data were processed by interpex IX 1D Software resistivity data interpretation with the help of Computer, qualitative and quantitative are the two main types of resistivity data interpretation. The qualitative type deals with the determination of number of layers, their thickness, and respective resistivity were employed in this research work with generally low values indicating high conductivities of the subsurface which may be water bearing layers. On the order hand the area under study with high apparent resistivity values indicates the absence of water and possible presence of fresh basement rocks. In order words, areas with low resistivity values are often associated with thick water bearing overburden, usually in weathered, fracture basement.

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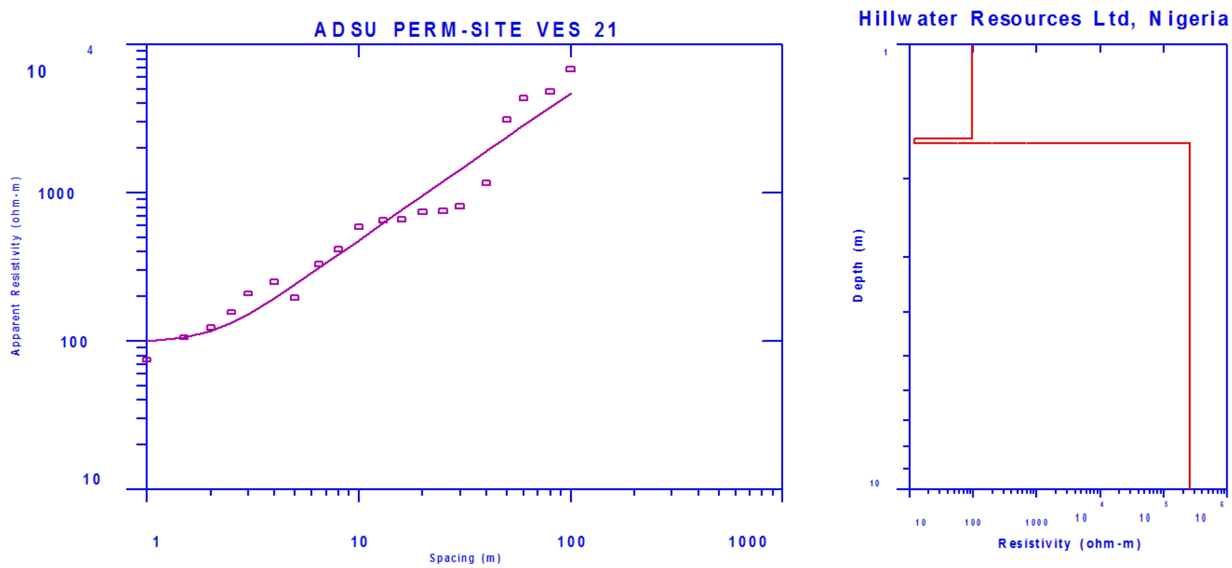
VES NO	NO OF LAYERS	ρa(ohm-m)	Thickness	Depth	Lithology
21	1	90	1.6	-	Top soil
	2	12	0.1	1.6	Weathered basement
	3	250,000	-	1.7	Fresh basement
22	1	500	1.0	-	Top soil
	2	4000	70	1.0	Weathered basement
	3	10,100	-	71	Fresh basement
23	1	100	6.3	-	Top soil
	2	100	9.3	6.3	Weathered basement
	3	1,000,000	-	15.6	Fresh basement
24	1	100	4.3	-	Top soil
	2	7.0	11	4.3	Weathered basement
	3	1,000,000	-	15.3	Fresh basement
25	1	20	20	-	Top soil
	2	6.0	24	20	Weathered basement
	3	1,000,000	-	44	Fresh basement

Table 1: Result interpretation of VES 21 to VES 25



Graphical Representation of VES 21 data

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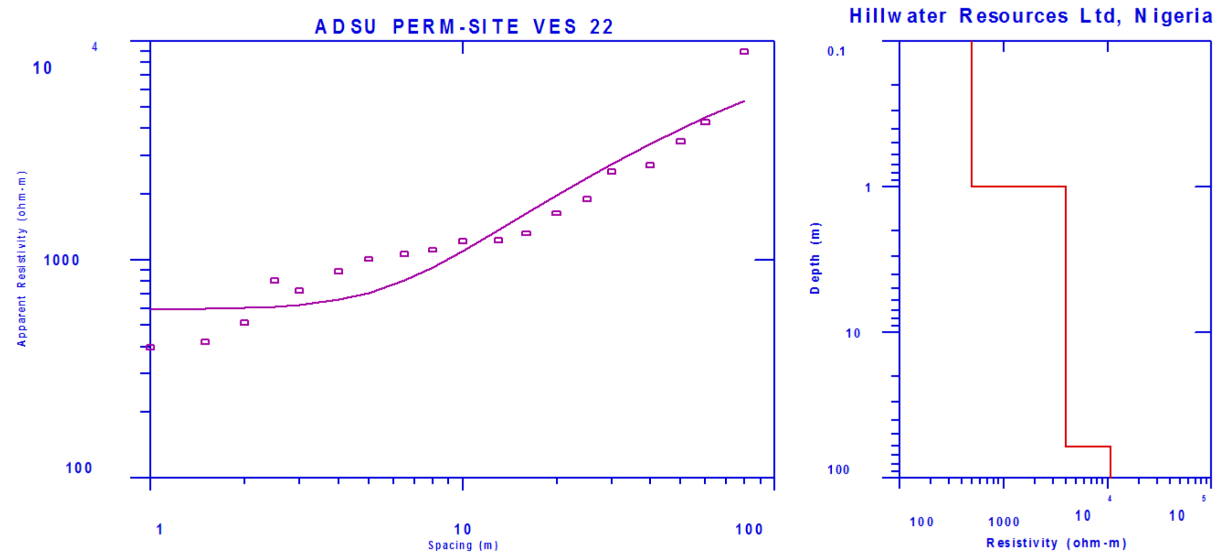
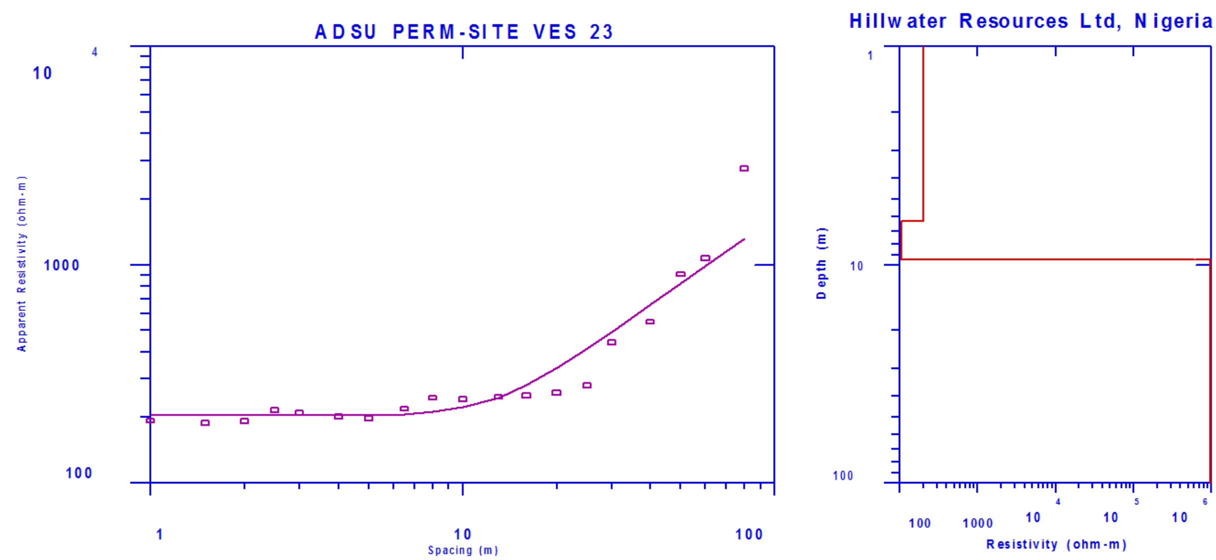


Graphical Representation of VES 22 data



Graphical Representation of VES 23 data

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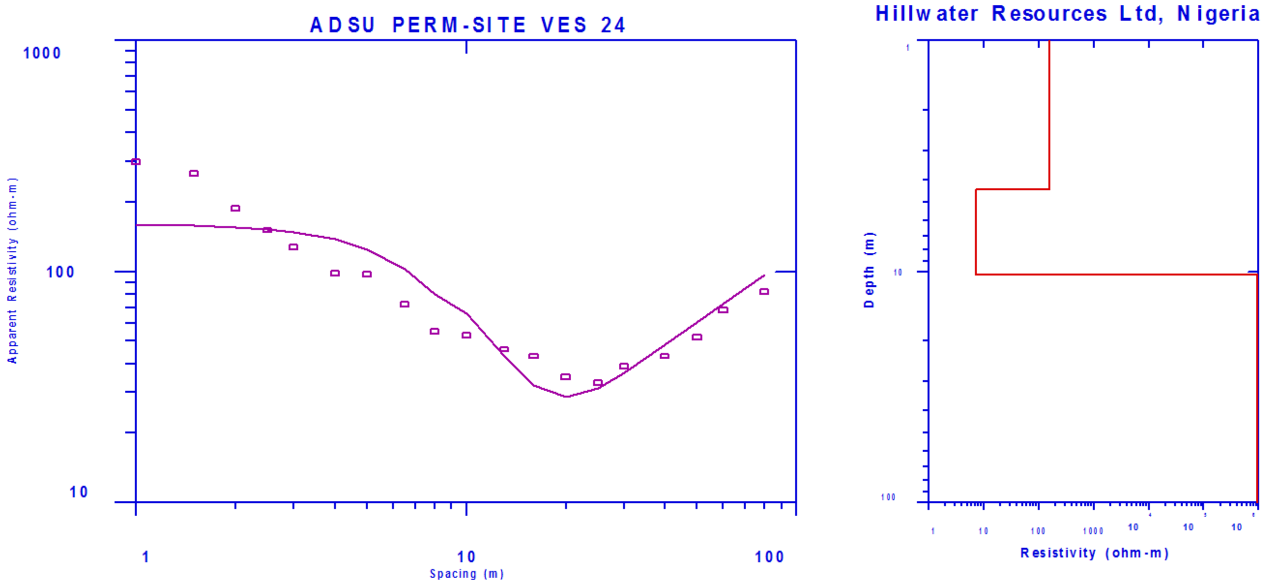
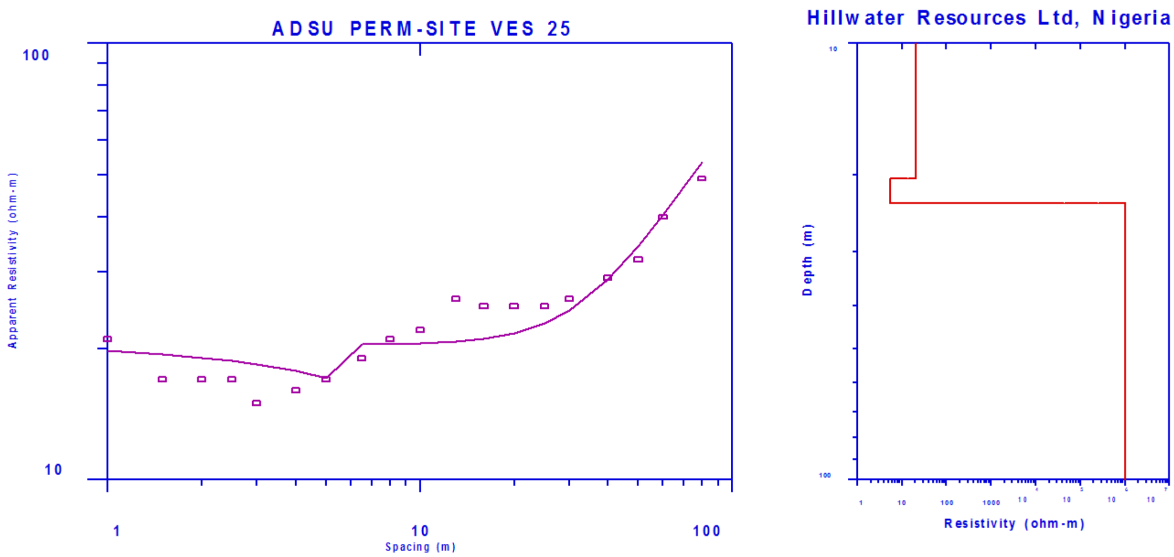


Graphical Representation of VES 24 data



Graphical Representation of VES 25 data

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DISCUSSION OF THE RESULT

The geoelectric section of VES 21 indicates three geoelectric layers and it's apparent resistivity curve is the A-Type, with $\rho_1 > \rho_2 < \rho_3$. The first layer has a resistivity of 90 Ωm with thickness of 1.6m in the top soil. The second layer has resistivity of 12 Ωm with the depth of 0.1m at weathered basement. The third layer has resistivity of 250,000 Ωm and it is suspected to be made up of fresh basement.The geoelectric section of VES 22 indicates three geoelectric layers and it's apparent resistivity curve is the A-Type, with $\rho_1 < \rho_2 < \rho_3$. The first layer has a resistivity of 500 Ωm with thickness of 1.0m in the top soil. The second layer has resistivity of 4000Ωm with the thickness of 70m which is to be weathered basement. The third layer has resistivity of 10,100 Ωm at fresh basement.

The geoelectric section of VES 23 indicates three geoelectric layers and it's apparent resistivity curve is the A-Type, with $\rho_1 = \rho_2 < \rho_3$. The first layer has a resistivity value of 100Ωm with thickness of 9.3m at the top soil/mud. The second layer has resistivity of 100Ωm with the thickness of 3.2m at weathered basement. The third layer has resistivity of 1,000,000 Ωm and it is suspected to be fresh basement.

The geoelectric section of VES 24 indicates three geoelectric layers and it's apparent resistivity curve is the H-Type, with $\rho_1 > \rho_2 < \rho_3$. The first layer has a resistivity of 100Ωm with thickness of 4.3m at the top soil. The second layer has resistivity of 7.0Ωm with the thickness of 11m at weathered basement. The third layer has resistivity of 1,000,000Ωm with a thickness and it is suspected to be made up of fresh basement.

The geoelectric section of VES 25 indicates three geoelectric layers and its apparent resistivity curve is the HA-Type, with $\rho_1 > \rho_2 < \rho_3$. The first layer has a resistivity of 20Ωm with thickness of 20m at the clay/laterite. The second layer has resistivity of 6.0Ωm with the thickness of 24m at the laterite /sand stone mixture. The third layer has resistivity of 1,000,000Ωm and it is suspected to be fresh basement.

Implication to research and practice

From the result obtained and discussed above, it was observed that the potential zone for groundwater exploration in the area is only one VES point. This VES point can actually be drilled for bore hole that can supply water to the people living within the area. The purpose of these findings is to locate the area which money can be used to drill bore hole and possibly hand dug well. In practice this VES point can serve as source of water supply if actually drilled.

CONCLUSION

Investigation of Groundwater Potential Zones Using Electrical Resistivity Method was carried out in Mubi South Local Government Area of Adamawa State North Eastern Nigeria to determine the depth to ground water potential zone and geo-electrical parameters. From the result obtained and interpreted, VES 24 has potential for groundwater exploration due to low resistivity and high conductivity in those VES points. Then VES 21, 22, 23, and 25 has no potential for groundwater exploration due to high resistivity values and low conductivity. From the study area, the nature and lithology units are top soil, weathered basement, Alluvium and Fresh basement.

Future Research

For further investigations in the area under study, some other resistivity methods of geophysical survey can be used such as Gradient array, Dipole – dipole array, Pole – dipole array, Square array, Lee array, Offset Wenner and Focused arrays.

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