ISSN No.: 2454- 2024 (online)

International Journal of Technical Research & Science

GEO-ELECTRICAL INVESTIGATION OF GROUNDWATER FOR HAND PUMP BOREHOLE AT GARIN MALLUM ARDO KOLA LOCAL GOVERNMENT AREA, TARABA STATE, NE NIGERIA

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Abstract-This investigation present the result of geophysical study carried out at Garin Mallum in Taraba State. The aim of the investigation is to determine the groundwater potentials of the area for the location of two productive hand pump boreholes for the community. Electromagnetic and Vertical electrical sounding method were used for the investigation using DDC-2B and YDD-B Terrameter respectively. Three geoelectrical layers were identified from the geo-electric characteristics of the area.
The groundwater potentials of the area have been inferred based on the obtained geoelectric response. VES 1 and VES 3 are considered to have the highest water bearing potentials within the area surveyed. They are therefore consequently recommended for the location of the hand pump boreholes.
Key Words: Electromagnetic, Geology, Hydrogeology, Vertical Electrical Sounding and Geo-electric Properties.

1. INTRODUCTION

Within the past decades, the quest for potable water sources has been an important issue to some of the villages and localities in Ardo-kola local government area of Taraba state. The progressive population growth has led to shortages of potable water for this area. Thus, inadequate supply of potable water has been a problem. Surface water, shallow hand dug wells and water collected during rainfall provides the main sources of water in the area.
This report therefore highlights the results of geophysical investigation carried out at Garin Mallum, Ardo Kola Local Government area of Taraba State [Fig.1.1].
Garin Mallum is situated along Jalingo-Bali road. The topography is fairly rugged and its vegetation consists of sparsely scattered deciduous trees and grasses.
The objective of the survey is to identify two most probable sites for the location of hand pump boreholes.
To achieve this, two geophysical methods were adopted. The electromagnetic method was used as a reconnaissance tool to map out areas of high conductivity. The vertical electrical sounding method was adopted as a detailed method to map out those suitable areas that were identified by electromagnetic method.

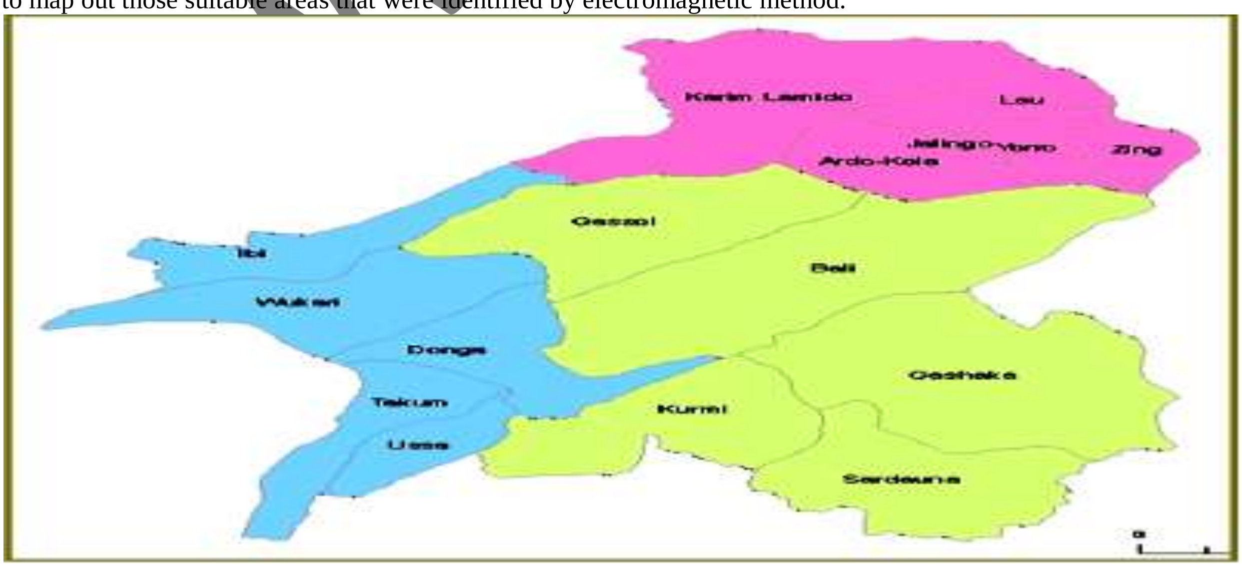

Fig.1.1 Map of Taraba State Showing The Study Area (Ardo-Kola)

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These methods have proven to be effective in the search for water especially in a basement terrain [Ayuni et.al 2017, Nur and Ayuni 2004 and 2011, Aloa et.al 2013].[Neelam and R. S Hooda 2017] using remote sensing, GIS and high resolutions satellite data with the SCS-CN/Geo-informations techniques were able to identify different water conservation structures for domestic and commercial purposes. Likewise [Manku Sadhana and G. Gautham 2017] were able to adopt the remote sensing techniques in groundwater studies.
Three electromagnetic and vertical electrical sounding points were delineated for probing [Fig.1.2] below.

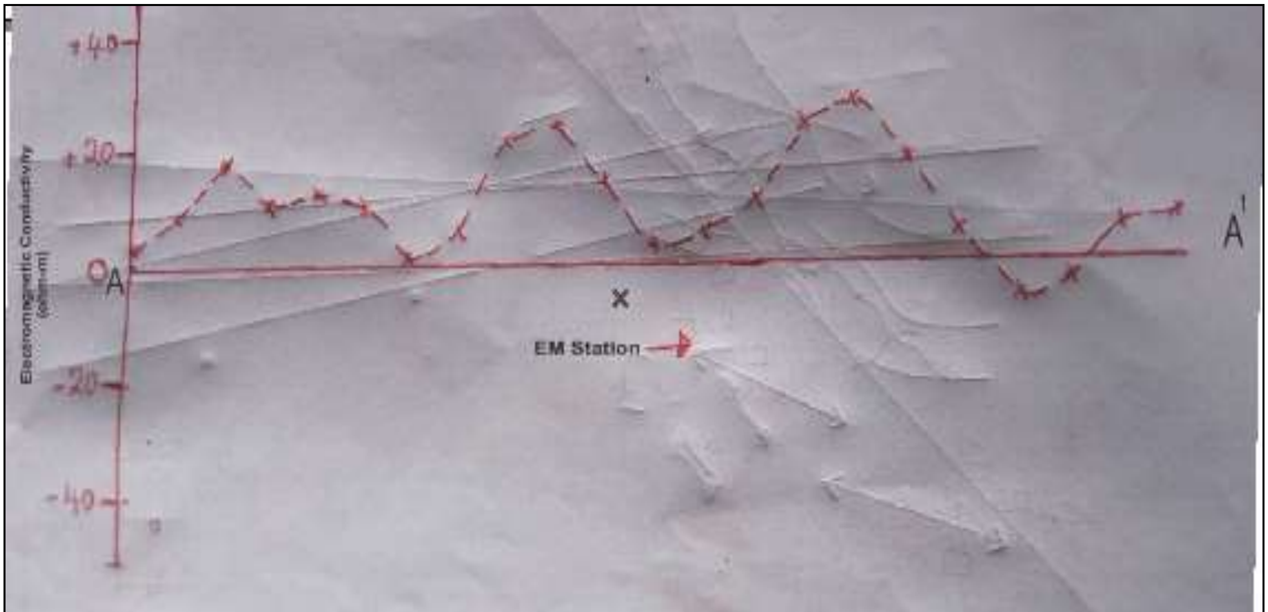

Fig.1.2 EM Profile

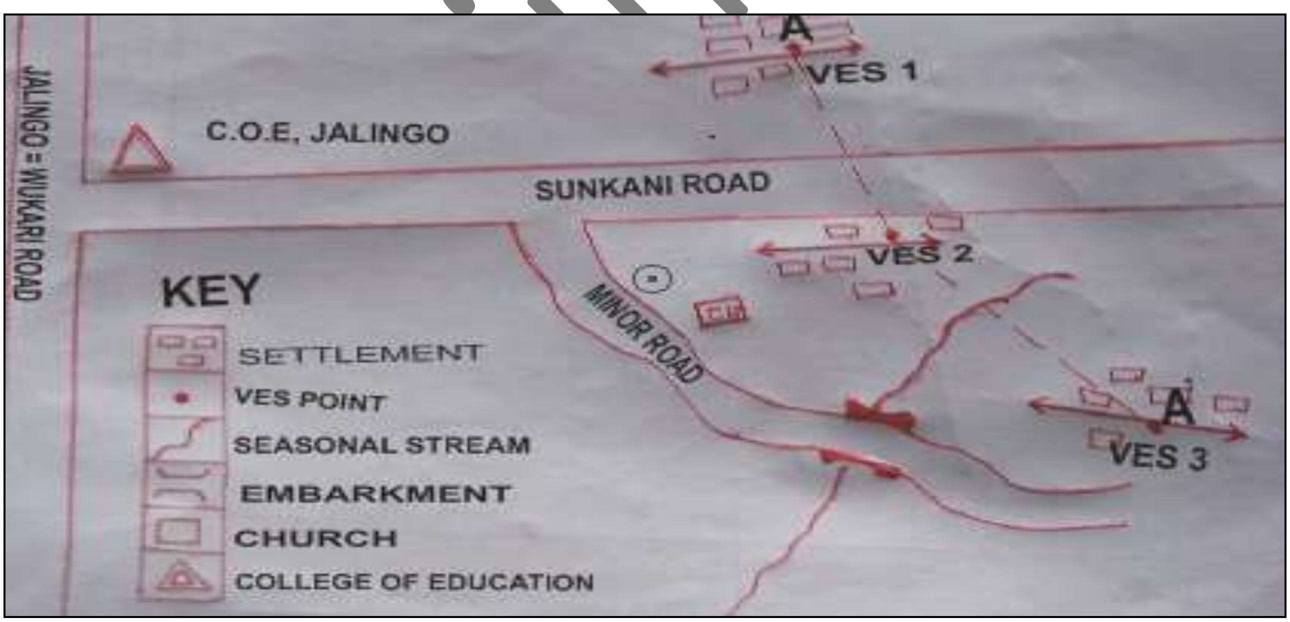

Fig.1.3 Layout Map of The Study Area Showing VES Points

2. GEOLOGYAND HYDROGEOLOGY

Garin Mallum is situated on the Pre-Cambrian/Paleozoic crystalline Basement complex rock of Northeastern Nigeria composing of biotitic granite to gneiss–migmatites complex [Carter et.al 1963]. Minor pegmatite and dolerite dykes also exist in the bedrock. The crystalline basement rocks are overlain by weathered profile of variable thickness. The weathering profile is likely to be gradational from fresh unfractured bedrock at the base through a fractured zone which is usually more than 10m thick, and an increasingly altered zone with increasing clay content upward and thin

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loose soil at the surface [Popoola et.al, 2014].

The highest permeability and porosity is likely to occur in the basal regolith and the upper fractured bedrock. The regolith and fractured bedrock type are therefore the main acquifer type in this geological setting [Olasehinde and Bayewu, 2011].

3. FIELD PROCEDURE

Two geophysical methods – Electromagnetic and vertical electrical sounding method were employed using DDC–2B and YDD-B Terrameter respectively. The measurements were taken along profile AA^1 within the village at station intervals of 10m. The EM conductivity survey was used to identify points for further probing [Fig1.2] above.

The EM conductivity survey was used to identify points for further probing. The depth of penetration of an electromagnetic field depends upon frequency and the electrical conductivity of the medium through which it is propagating. The depth of penetration'd' can be defined as the depth at which the amplitude of the field 'Ad' is decreased by a factor e^{-} compared with its surface amplitude Ao.

$$Ad = Aoe^{-1} \qquad 3.1$$

Thus

$$d = \frac{503.8}{\sqrt{\sigma f}} \qquad 3.2$$

Where'd' is in meters, the conductivity 'σ' of the ground is in (Sm^{-1}) and frequency f of the field is in (Hz).

Equation (3.2) represents a theoretical relationship. An effective depth of penetration (Ze) is define, which represents the maximum depth at which a conductor may lie and still produce a recognizable electromagnetic anomaly.

$$Ze = \frac{100}{\sqrt{\sigma f}} \qquad 3.3$$

This relationship is approximate as the penetration depends upon such factors as the nature and magnitude of the effects of near surface variations in conductivity. The frequency dependence of the depth of penetration places constraints on the EM method.

The soundings for this study were therefore employed for depth probing. Full Schlumberger electrode configuration AB=5MN was used with maximum electrode separation of 100m.

4. DATA PROCESSING

The data obtained from the EM measurements were computed and the profile plotted [Fig.1.2] above. The obtained profile shows the lateral variation in the horizontal conductivity of the subsurface formation. Generally high conductivity zones are of interest in groundwater exploration. Such zones were identified and mark for vertical electrical soundings [Fig.1.3] above.

The VES data obtained were plotted on a bilogarithmic paper and interpreted using partial curve matching technique with two layer master curves and auxiliary point charts published by [Mooney and Wetzel, 1956]. The obtained geoelectric models were used as starting points for computer modeling to obtain the best- fit models [number of layers, resistivity and thickness of each layer] for the field curves.

The computer programme [Schlumberger Sounding Data Processing and Interpretation Programmed by U.S.Geologi cal Survey] used is based on a concept presented by Denver, Co. 1990. The purpose of which is to compute a layered earth model whose theoretical apparent resistivity curves agrees as closely with as possible [in al at least square sense] with the field curve. The formula used for this is readily available at [Mbonu et.al 1991 and Nur et.al 2001]. The summary of the result obtained from the computer interpretation of three VES points are presented in [Table-1.1] below, while the sounding curves/earth model for VES points 1, 2 & 3 are presented respectively.

Table-4.1 Summary of Result Obtained From Computer Interpretation of Three VES Points

	Thickness		**Depth**		**Apparent Rsistivity**			**Fittng Error**
VES No.	H1(m)	H2(m)	D1(m)	D2(m)	P1(Ωm)	P2(Ωm)	P3(Ωm)	%
1	2.057	18.37	2.057	20.42	224.58	85.342	8448.9	1.86
2	1.86	12.49	1.86	14.35	193.12	48.296	4781.3	11.96
3	1.97	15.15	1.97	17.13	318.24	102.72	1.16.9	8.30

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International Journal of Technical Research & Science

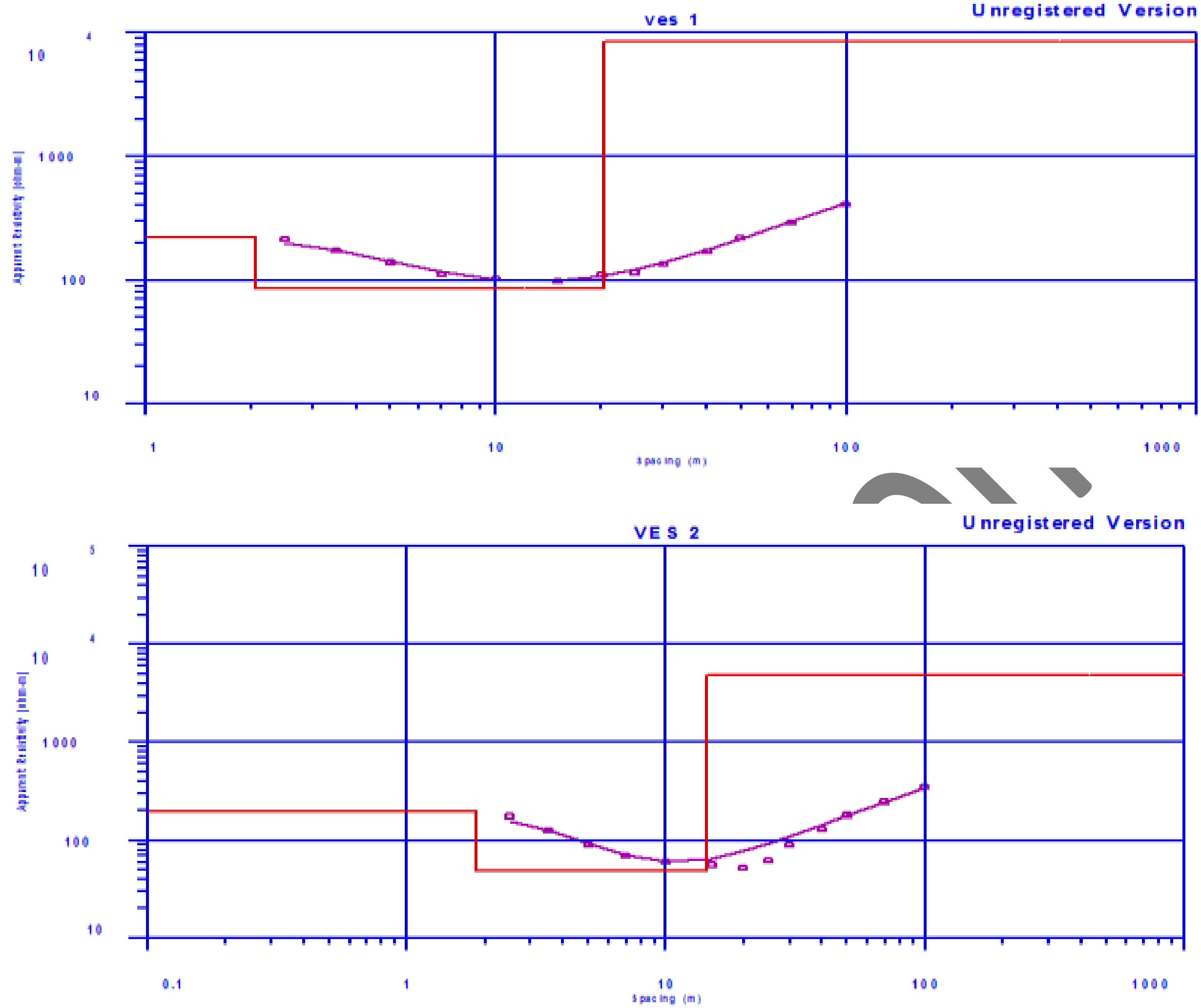

Fig. 1.4 Sounding Curve/Earth Model Obtained From VES 1&2

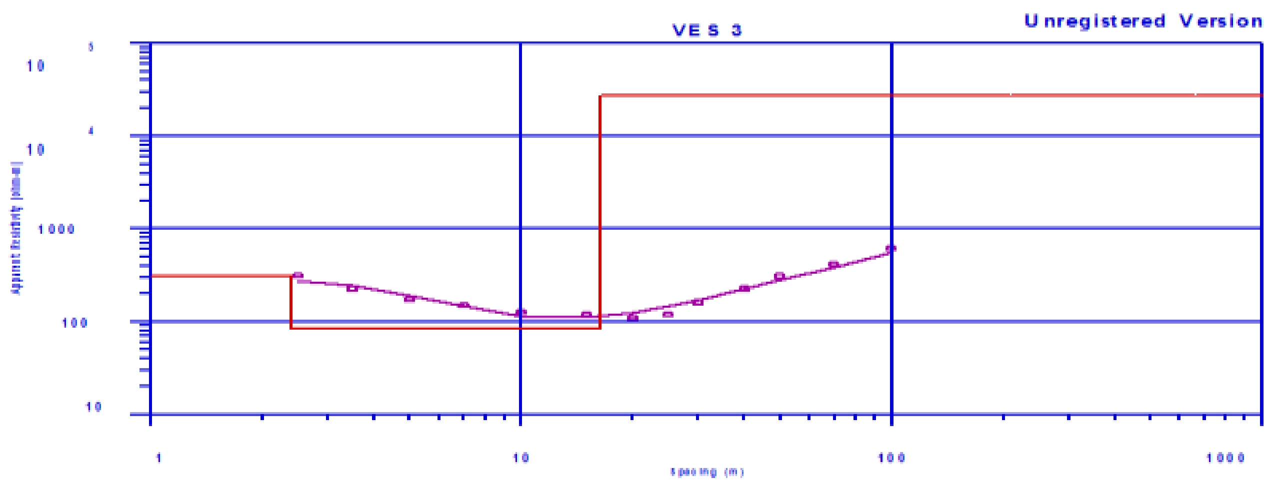

Fig. 1.5 Sounding Curve/Earth Model Obtained Fron VES 3

The program starts with a trial model supplied, and then successfully modifies the layers and resistivities to improve the agreement. The process continues automatically until either the main square errors falls below a specific cut off values (supplied as input) of the process has gone through a user selectable number of the interactions. The input to the Programme consists of the parameters for layered earth model including the assured number of the resistivity (R) and the layer thickness (H).

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5. RESULT AND INTERPRETATION

5.1 Geo-electric Deductions

The obtained results were used to infer the lithologic sequence anticipated to be penetrated while drilling at each of the VES points. Three main geo-electric layers were identified [Table-5.1]. The upper most layer (layer 1) has a thickness ranging between 1.86-2.06m and a resistivity which varies between 193.12-318.24Ωm, the first layer overlies (layer 2) with a thickness of between 12.49-18.37m and a resistivity in the range 48.27-102.72Ωm. Layer 3, whose thickness could not be determined and has a resistivity in the range 1016.9-8448.9Ωm, underlies layer 2.

Table-5.1 Averages of Layer Thickness and Resistivity

Layers	Average thickness (m)	Average Resistivity (Ωm)
Layer 1	1.86 - 2.06	193.12 - 318.24
Layer 2	12.49 - 18.37	48.27 - 102.72
Layer 3	00	1016.9 - 8448.9

5.2 Hydrogeological Analysis

Layer one (1) is a superficial layer of topsoil and highly weathered rocks. Layer two (2) is a layer of weathered and fractured basement complex rocks. The last layer whose resistivity could not be determined is considered to be the fresh basement complex rocks.

At the site like all other basement complex rocks areas, favorable conditions for accumulation of groundwater include thick layer of weathered to fractured bedrock. The groundwater potential of an area can therefore be inferred from its resistivity. The second layer is considered to be the aquiferous layer in the area.

CONCLUSION AND RECOMMENDATION

The geophysical investigation established three main lithologic sections in the area and indentified the second layer as the main water bearing layer. The survey also revealed that within the area surveyed, point VES 1 and VES 3 has the highest water bearing potentials and are consequently being recommended for the sighting of the hand pump boreholes in the area. Minimum depths ranging between 25-30m are recommended for the boreholes to ensure that the groundwater potentials of the points are fully exploited. A careful and accurate geologic logging of the borehole should be undertaken during the drilling to ensure that the acquifer is accurately identified and properly screen.

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