JTRET "Voice of Innovative Minds"
International Journal of Trendy Research in Engineering and Technology
Volume 8 Issue 4 August 2024
ISSN No. 2582-0958

PRELIMINARY ASSESSMENT OF GROUNDWATER POTENTIAL ZONES IN AYEDE-EKITI, EKITI STATE, SOUTHWESTERN NIGERIA USING ELECTRICAL METHODS

Gideon Gbadero[1], Peter Mafimisebi , Grace Martins[3]

[1]Department of Geology, University of Ilorin, Kwara State. Nigeria.
[2]Department of Environmental Engineering and Hydrogeology, Geoearth Project Limited,Lagos. Nigeria
[3]Department of Engineering Geology, RFI Integ Service, Lagos. Nigeria

gideongbadero@gmail.com mafimisebipeter2023@gmail.com

Received 02 June 2024 Received in revised form 08 June 2024 Accepted 09 June 2024

ABSTRACT

An electrical resistivity survey was conducted at different locations within Ayede Ekiti, Ekiti State, Southwestern Nigeria. This is aimed at evaluating groundwater potential zones and aquifer properties within the study area. Data were acquired at four (4) different locations using the vertical electrical sounding method by employing the Schlumberger array configuration. This study utilizes resistivity data processed with IPI2win software to analyze the subsurface geology of a basement complex region. The result of the study showed that qualitatively, three major curve types (A, HA, and H) were observed. Varying curve types, predominantly A curves, were observed across the research area, with notable groundwater potential indicated by H and HA curve types at select points. Through curve matching techniques, three to four distinct geo-electric layers were identified, while the quantitative interpretation resulted in deducing layers with different resistivity and thickness values for each VES(s) of the study area. It was deduced that the VES 2 and 3 zones are connected to a high output of groundwater. However, VES 1 and 4 are characterized by low groundwater potential. This research contributes valuable insights for geological mapping and groundwater resource assessment in complex basement terrains of the study area.

Keywords: Electrical Resistivity Survey, Groundwater Potential Zones, Ayede Ekiti.

I. INTRODUCTION

The increase in human population and agricultural activity in rural and urban areas has resulted in excessive groundwater abstraction to reach the intended goal [1]. Water has always been an essential resource for all living creatures, including humans. We use it to wash, fish, swim, drink, and cook, although not usually simultaneously [2]. [2] also claims that we are around two-thirds water and require it to survive. Water is required by all living creatures in some form or another. Humans have a top-priority demand for safe, high-quality water that is always available to suit both home and industrial needs, resulting in a global boom in water demand. Groundwater has a high potential for prospecting and exploration as a solution to the problem of limited availability of water for a variety of reasons. This has been a necessary and ever-increasing research desire to constantly alleviate this problem among humans. An aquifer's utility as a groundwater source is determined by the porosity of the geologic stratum or layer from which it arose [3]. This aquifer function varies according to location, geological terrain, and other factors. To bridge the gap, in this work, a geophysical electrical resistivity survey employing vertical electrical sounding (VES) was utilized to systematically establish the value of the input parameter in assessing groundwater potential in Ayede Ekiti. As water shortages grow across the world, particularly in developing or third-world nations like Nigeria, the importance of access to water supplies cannot be overstated. Ayede Ekiti is one of the towns with poor pipe-borne water delivery systems [4]. Ayede Ekiti town is in a basement complex location with a documented insufficient supply of water for agricultural and industrial growth [5,6]. The present study involves the use of vertical electrical sounding to understand the hydrogeological condition of the study area [5,6,7]. This will involve the determination of the thickness and resistivity of the subsurface layers, delineating the fracture zones, and establishing the depth of the bedrock, which will be done by governments, people, and non-governmental organizations to understand the

International Journal of Trendy Research in Engineering and Technology
Volume 8 Issue 4 August 2024
ISSN No. 2582-0958

features and nature of the aquifer in the area. This would aid in the provision of high-quality information on borehole placement for adequate water supply and the town's long-term growth.

II. THE STUDY AREA

The study area is Ayede metropolis, which is one of the towns linking Ekiti and Kwara States, Nigeria, and is bounded by latitudes 7°53'N and 7°54'N and longitudes 5°18'E and 5°22'E. The study area covers an area of about 52 km^2, with the surrounding communities of Imojo, Itaji, Ilafon, and Ishan Ekiti (Fig. 1). There are insufficient pipe-borne water delivery systems in the town, resulting in an inadequate water supply. As a result, people rely on rainwater, surface water, and groundwater for home and agricultural purposes. The research region has a tropical climate and is covered with rain forests. The drainage is mainly dendritic, with hummocky and undulating terrain. The annual rainfall is around 1300 mm, and it is distributed bimodally throughout the hydrologic year. The first peak occurs between June and July, while the second peak occurs between September and October during the rainy season. The two wet seasons are normally separated by a draught (August break), while the dry season is defined by little or no rainfall between November and April [8].

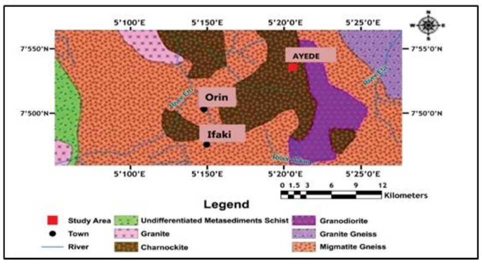

Fig 1. Geological map of Ayede in Ekiti State

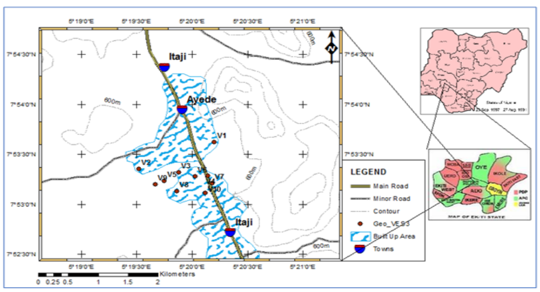

Fig 2. Study Area showing VES locations.

III. HYDROGEOLOGY OF THE STUDY AREA

The rocks of the basement complex terrain are highly impermeable and lack primary porosity, which refers to linked pore spaces produced during rock formation [9]. A rock's porosity and permeability contribute to its hydrogeologic qualities, which are then determined by the size, shape, and arrangement of the grains as well as the mineralogy of the rock [10]. The existence of cracks (secondary porosity), as well as the structure and thickness of the material covering the rocks, influence groundwater storage and potential [6,11]. Fractures in rocks are mostly created by tectonic activity inside the crust. These are significant in basement rocks because they enhance weathering activity [12,13]. The mineralogy of a rock type influences the degree of weathering. Rocks rich in ferromagnesian minerals and feldspars are subjected to a high degree of weathering, resulting in impermeable clay minerals, as opposed to silica-rich rocks, which provide permeable water-bearing sandy and gravely medium [14,15]. The weathered layer and cracked basement are common locations for recoverable groundwater in the basement complex [16]. The detection and delineation of hydrogeological structure typically aid in the finding of groundwater potential zones in typical complicated environments [5, 13].

IV. METHODOLOGY

4.1. Data Acquisition

A geophysical investigation involved the use of the electriacal resistivity method at Ayede Ekiti. In which the vertical electrical sounding (VES) technique was used. A Schlumberger geoelectric sounding array is one of the most widely used configurations. In this case, the potential electrodes (MN) are closely spaced, while the current electrodes (AB) are increasingly spaced, such that MN$\leqslant$ AB/5 [17].

An ABEM terameter and its accessories were used for data collection. This is to measure the resistance of the subsurface layers [18, 19]. The current electrode spacing (AB/2) ranges from 1-100 m, while the potential electrode spacing (MN/2) ranges from 0.5 m to 16 m [20]. A total of four (4) VES points were probed over the entire area (Fig. 2).

4.2. Computer Iteration Method

This method makes use of a geophysical program named IPI2win. The computer iteration procedure uses computer algorithms and inversion techniques to iteratively estimate the subsurface resistivity distribution based on apparent resistivity measurements. Curve matching becomes difficult when there are several layers; thus, computer iteration software simplifies the understanding of such situations [19]. Field data was entered into the program for modeling. Modeling is the process of simulating the predicted apparent resistivity values for a given subsurface resistivity distribution. The apparent resistivity responses are computed using numerical techniques based on a theoretical model and the anticipated resistivity values of subsurface layers. The program generates synthetic data that would be anticipated if specific geological circumstances were true. The aim is to discover the best-fitting subsurface resistivity distribution that corresponds to the observed apparent resistivity data. This is an iterative procedure in which the computer changes the resistivity values in the original model to reduce the mismatch between the observed and anticipated apparent resistivity values [19]. The technique allows for a maximum inaccuracy of less than 5%. This iteration aids in describing the curve types, which range from H to A, Q, QA, HA, and so on, as well as the number of layers and their apparent resistance.

V.RESULT AND DISCUSSION

A total of four (4) VES locations were sounded within the research region, each employing a Schlumberger array setup. Tables 1 and 2 show the VES values obtained from locations investigated in the study area (Fig. 2).

5.1. Geo-electric Layers and Curve Types

Table 1 shows the data of four VES data recorded from the study area. The resistivity data obtained in the field were processed and evaluated using the geophysical software suite Ipi2win. This is done to identify the underlying layering (geoelectric layers), as well as their depth, thickness, and apparent resistivity values (Table 2). This method is known as curve matching [13,21]. The geo-electric layers (lithology with identical electrical resistivity values) in the research region as a basement complex geology exhibit three to four layers illustrating topsoil, lateritic zone, weathered basement, and fresh basement (Fig. 3a-d). VES points 3 indicate four layers, whereas the remaining VES points show three layers. The curve types in the research region include A, HA, and H curves, with the A curve being the most common.

Table 1: Showing the Resistivity Data obtained from VES 1-4 on Field

AB/2	MN/2	VES-1	VES-2	VES-3	VES-4
1	0.5	83.53	107.22	93.84	69.59
2	0.5	99.90	92.24	84.32	80.30
3	0.5	96.98	68.99	80.58	103.20
4	0.5	103.04	53.78	83.44	121.64
6	0.5	112.53	36.42	95.23	69.78
6	1	103.48	67.29	82.00	134.59
8	1	106.56	79.82	104.55	192.01
10	1	111.37	97.23	140.12	252.90
10	2	98.17	72.73	157.08	157.08
15	2	103.55	77.05	213.82	268.61
20	2	106.50	106.81	213.94	333.01
20	4	88.28	125.51	326.73	46.50
30	4	353.43	353.43	353.43	353.43
40	4	143.88	15858.76	319.19	426.63
40	8	55.92	5582.61	205.15	675.44
50	8	132.05	7333.66	272.43	760.85
60	8	206.40	7082.72	284.16	749.27
80	8	315.42	3204.42	356.88	857.03
80	16	303.48	2576.11	202.32	647.17
100	16	484.00	8639.38	290.60	844.30

Table 2: Summary of Geo-Electric Parameter Obtained

VES No.	Layers No.	Resistivity (Ωm)	Aquifer Thickness (m)	Aquifer Depth (m)	Aquifer Layer (m)	Curve Type	Lithology's
VES 1	1	86.6	2.05	2.05	20.3	A	Top Soil
	2	142	18.2	20.3			Lateritic Soil
	3	474					Fresh Basement
VES 2	1	93.7	2.95	2.95	9.87	H	Top Soil
	2	48.7	6.92	9.87			Lateritic Soil
	3	962					Fresh Basement
VES 3	1	96.3	1.36	1.36	8.57	HA	Top Soil
	2	52.1	3.02	4.38			Lateritic Soil
	3	306	4.18	8.57			Weather Basement
	4	478					Fresh Basement
VES 4	1	71.2	1.95	1.95	5.2	A	Top Soil
	2	203	3.25	5.2			Lateritic Soil
	3	937					Fresh Basement

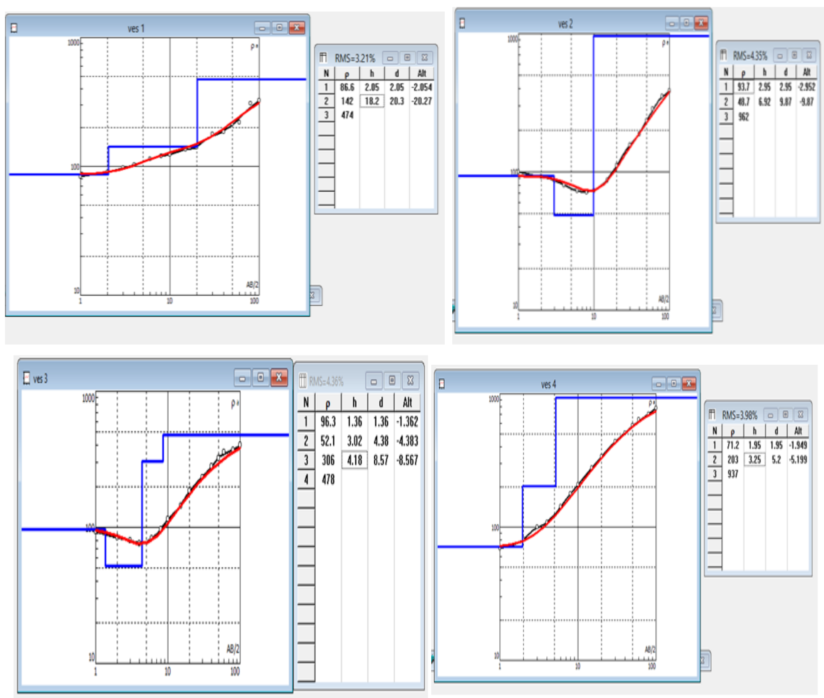

Figure 3: (a) VES 1 showing A curve type, (b). VES 2 showing H curve type, (c). VES 3 showing H curve type, (d). VES 4 showing A curve type.

Vertical electrical soundings (VES) were randomly conducted at four (4) distinct places within the study area and plotted using IPI2WIN software. The data were interpreted and explained as follows:

According to the interpretation, VES 1 is a curve with three geoelectric sections: topsoil, lateritic soil, and fresh basement. It may be deduced that it is not a suitable site for groundwater investigation.

As a H-curve type, VES 2 has three geoelectric sections: topsoil, lateritic soil, and fresh basement, according to Table 3 interpretations. This VES point indicates that there may be potential to explore for groundwater in lateritic soil at a depth of 2.95 m ± 6.92 m.

Topsoil, lateritic soil, weathered basement, and fresh basement are the four geoelectric sections that make up VES 3, a H and A curve type, according to Table 3. The VES point suggests that a weathered basement may have groundwater exploration potential, with a possible depth of 1.36 m ± 4.18 m.

Table 3 interprets VES 4, an A-type curve, as topsoil, lateritic soil, and fresh basement. Therefore, it may be concluded that groundwater exploration is not feasible at this location.

Summary of the curve-matched resistivity values Table 3 demonstrates that the topsoil has apparent resistivity values ranging from 71.2 to 96.3Ωm with a thickness range of 1.36 to 2.95m. The second geo-electric layer, the lateritic zone, has apparent resistivity values ranging from 48.7 to 203Ωm and a thickness of 3.02 to 18.2m. The third geo-electric layer, weathered basement, has resistivity value of 306Ωm and a thickness of 4.18m. The fresh basement's infinity geo-electric layer exhibits resistivity values ranging from 474 to 962Ωm and a thickness of infinity. The weathered layer is assessed to be aquiferous formations, which correspond to the aquifer in the research region, since it includes high-quality groundwater potential.

V. CONCLUSION

The study area has four (4) VES points, three (2) of which have a high potential for groundwater exploration (VES 2, and 3), while VES 1, and 4 do not have potential for groundwater exploration in the study area, so 50% of the VES points are potential areas for groundwater exploration.

REFERENCES

[1] Raghunath, H M., (2006). Hydrology: principles, analysis, design, New Age International Ltd Pub. New Delhi, 2nd Ed.

[2] Chaplin, M.F., (2001). Water: its importance to life, Elsevier Science Ltd, **https://www.researchgate.net/publication/227952758**, p1-7.

[3] Gaikwad, J. S., Pawar, N. J., Bedse, P., Wagh, V., and Kadam, A., (2021). "Delineation of groundwater potential zones using vertical electrical sounding (VES) in a complex bedrock geological setting of the West Coast of India," Modeling Earth Systems and Environment, vol. 1–15.

[4] Ige O. O., and Olasehinde, P. I., (2011). Preliminary Assessment of Water Quality in Ayede-Ekiti, Southwestern Nigeria, Journal of Geology and Mining Research, Vol. 3(6), http://www.academicjournals.org/jgmr, pp. 147-152.

[5] Ige, O.O., Adunbarin, O.O., Olaleye, I.M., (2021). Groundwater potential and aquifer characterization Within Unilorin campus, Ilorin, Southwestern Nigeria, using Integrated Electrical Parameters, International Journal of Energy and Water Resources, https://doi.org/10.1007/s42108021-00160-2, p1-18.

[6] Ige, O. O., Ameh, H. O., Olaleye, I. M., (2021). Borehole inventory, groundwater potential and water quality studies in Ayede Ekiti, Southwestern Nigeria, Discover Water, Springer, https://doi.org/10.1007/s43832-020-00001-z, p1-20.

[7] Olatunji, J.A., Omonona, O. V. and Odediran, O. A., (2017) Electrical Resistivity Investigation of the Groundwater Potential In parts of Kwara State Polytechnic, Ilorin, Nigeria, Global Journal of Pure and Applied Sciences Vol. 23,157-166, https://dx.doi.org/10.4314/gjpas.v23i1.16, p1-17.

[8].Ayoade, J.O., (1977). Evaporation and Evapotranspiration in Nigeria. Journal Tropical Geology, 44, p1–19.

[9] Falconer, J.D., (1911). The geology and geography of Northern Nigeria. Macmillan, London, 135pp.

[10].Billing, M.P., (1972). Structural Geology. In:Eaglewood Cliffr. N., third ed. Prentice-Hall. 1972.

[11].Offodile, M.I., (1983). The occurrence and exploitation of groundwater in Nigeria Basement Complex. J.Mining Geol. 20 (3), 131–146.

[12] Ezeh, C.C., (2012). Hydrogeophysical studies for the delineation of potential groundwater zones in Enugu state, Nigeria.Int. Res. J. Geol. Min. 2 (5), 103-112.

[13]. Al-Garni, M.A. (2009) Geophysical Investigations for Groundwater in a Complex Subsurface. Terrain, Wadi Fatima, KSA: A Case History. Jordan Journal of Civil Engineering, 3, 118-136.

[14] Bowden, P., van Breemen O, Hutchison, J., Turner D.C., (1976) Palaeozoic and Mesozoic age trends for Some ring complexes in Niger and Nigeria. Nature 259:297–299.

[15] Graham, M. T., Dochartaigh, B. E., Ball, D. F., and MacDonald, AM. (2009). Using Transmissivity,Specific Capacity and Borehole yield data to assess the productivity of Scottish aquifers. The Quarterly Journal of Hydrogeology and Engineering Geology 42:227–235.

[16] Ayolabi, E. A., (2005). Geoelectric evaluation of groundwater potential: a case study of Alagbaka primary school, Akure, Southwest Nigeria. Publications of the Indian Geological Society, 66, 491–495.

[17] Oladunjoye, M., and Jekayinfa, S. (2015). Efficacy of Hummel (modified Schlumberger) arrays of VerticalElectrical Sounding in Groundwater Exploration: a case study of parts of Ibadan Metropolis, Southwestern Nigeria. International Journal of Geophysics, 2015(2):1-24. https:// doi. Org/ 10. 1155/ 2015/ 612303.

[18] Olorunfemi, M. O., and Fasuyi, S. A. (1993). Aquifer types and the Geoelectric/ Hydrogeologic Characteristics of part of the Central Basement terrain of Nigeria (Niger State). African Earth Sciences Journal, 16, 309–317.

[19].Verma, S.K and Pantulu, K.P.(1990). Software for the interpretation of resistivity sounding data for groundwater exploration. National Geophysical Research Institute, Hyderabad India.

[20] Maillet, R., (1947). The fundamental Equation of Electrical Prospecting. Geophysics 12:529–556.

[21] Zohdy, A. A. R., Eaton, G. P., & Mabey, D. R. (1974). Application of Surface Geophysics to Groundwater Investigations.Techniq. Water Resources Investigations of UD Geol. Sur. Washington, p. 66.