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Evaluation of High Groundwater Potential Zone around the Central Mosque, University of Ibadan, Nigeria

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Abstract

Resistivity survey was carried out to investigate points of high groundwater potential within the premises of the mosque and chapel of resurrection of the institution to provide additional supply of groundwater because the increase in demand for water has led to inadequacy in its supply. Geophysical investigation was carried out using geoelectrical imaging technique to determine high groundwater potential zones of the University of Ibadan. Three Constant Spacing Traverses (CST) and ten Vertical Electrical Sounding (VES) stations were carried out. The model for the earth layer interpretation was done using WINRESIST software. The purpose is to reduce the error to the accepted levels. The analysis showed that the Vertical Electrical soundings: VES 1, 2 and 8 are high groundwater potential zones. Their resistivity ranged from $(46.6 - 262.5)\Omega\text{m}$, $(36.6 - 629.65)\Omega\text{m}$ and $(27.7 - 349.7)\Omega\text{m}$ at depths ranged between $(1.0 - 4.0)\text{m}$, $(0.8 - 15.9)\text{m}$ and $(1.0 - 7.6)\text{m}$ for vertical electrical sounding 1, 2 and 8 respectively. Their thickness ranged between $(1.0 - 3.0)\text{m}$, $(0.8 - 11.6)\text{m}$ and $(1.0 - 6.6)$ respectively.

Keyword: Geoelectrical Imaging, Geophysical Investigation, Geoelectric layer, Groundwater Potential

1. Introduction

Groundwater is the water that exists below the Earth's surface in soil pores and fractures of rock formations. Despite its enormous size, groundwater is an infinite resource with unequal supply. Groundwater occurs in a variety of ways, as diverse as the kinds of rocks they are found in and as complex as the evolution of the earth's crust throughout geologic time. According to Edwin et al., (2017) groundwater demand has increased over the years; this made its consumption and contamination varies in the past century. The groundwater potential of Idi-Ayunre, Ibadan in Oyo State was investigated by Adetoyinbo et al., (2023) using vertical electrical sounding and geographic information system; their analysis shows that the groundwater potential in this study area is low. Adindu, et al., (2021) carried out geoelectric studies in the northern parts of Abia state for evaluation groundwater potentials and vulnerability assessment of aquifer; they concluded that aquifer depth has inverse relation to its thickness. Mufutau et al., (2023) investigated groundwater potential of the Federal University of technology Minna using mix of geological, hydrogeological, and geophysical techniques their results revealed places for borehole drilling as confirmed from granite rocks and thin regolith layer. Adewumi et al., (2023) used geospatial and geo-electrical techniques for groundwater potential, their results confirmed that high groundwater potential align with regions of good potential as depicted on GIS groundwater potential zone map. Oyedele, (2019) investigate groundwater in basement complex terrain of Ado-Ekiti using remote sensing and GIS techniques, the results showed that the groundwater are inadequate in hard rock terrain. Epuh el at., (2020). Investigated groundwater potential in Ikorodu using multi-criteria analysis and remote sensing, it was shown that suitable aquifer in the location fall between 20 m and 120 m. Infiltration of precipitated water, as well as return flows from wastewater and storm water discharges and from leaking water supply networks all contribute to groundwater recharge in urban areas (Olabode and Comte, 2025). There is need for provision of additional source of water for the benefit of large congregation prayer that normally come up

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once a week. Apart from already existing source of water, the research investigated additional possible spot for drilling borehole within the mosque.

2. Material and Methods

2.1 Resistivity Methods

Resistivity is calculated using Ohm's law when dealing with a homogeneous and isotropic material. It is expressed in ohm-meters (Ωm) and is mathematically defined as:

$$\rho = \frac{A}{l} \tag{1}$$

Apparent resistivity is calculated based on the relationship between the measured resistance and the geometry of the electrode configuration. The apparent resistivity is thus obtained
from the general formula;

$$\rho a = KR \tag{2}$$

Where:

$\rho a = \text{Apparentresistivity}(\Omega \cdot \text{m})$

K=Geometric factor (depends on electrode configuration)

R = Measured Resistance (Ω)

2.2 Electrodes Arrangement

The Wenner Array is a popular configuration in electrical resistivity surveys. It is frequently used to identify changes in subsurface resistivity in geophysical investigations. In resistivity surveys, it is one of the most widely used electrode configurations due to its straightforward design and ease of interpretation (Reynolds, 2011). The Schlumberger Array is one of the most popular electrode configurations in electrical resistivity surveys because it can be used to investigate subsurface resistivity with increased sensitivity to vertical changes. It is particularly useful for resistivity sounding, which is the process of examining resistivity variations with depth (Reynolds, 2011).

In both arrangements, four electrodes are placed along a straight line at equal spacing (a):

- Two current electrodes (C1 and C2) inject a controlled electrical current into the ground.
- Two potential electrodes (P1 and P2), positioned between the current electrodes, measure the resulting voltage difference (ΔV).

The array's geometric factor (K) for Wenner is determined by the electrode spacing and is
expressed as:

$$K = 2\pi a \tag{1}$$

In Schlumberger array, the geometric factor (K) depends on the electrode spacing and is given by:

$$K = \frac{\pi((b/2)2(a/2)2)}{a} \tag{2}$$

Where:

b =Distance between the two current electrodes.

a=Distance between the two potential electrodes

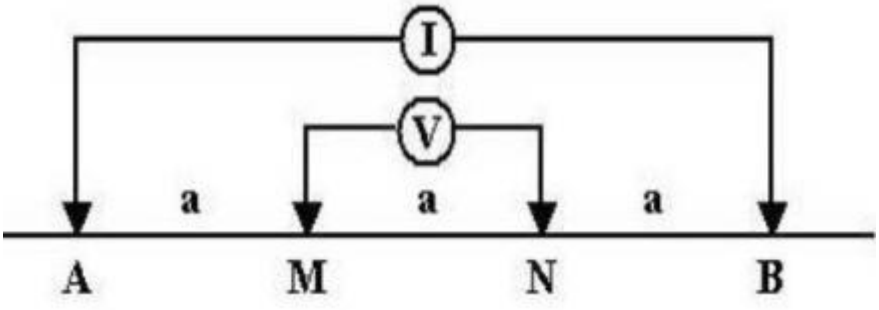

Figure 1: Wenner Array (langeoinstrument.com)

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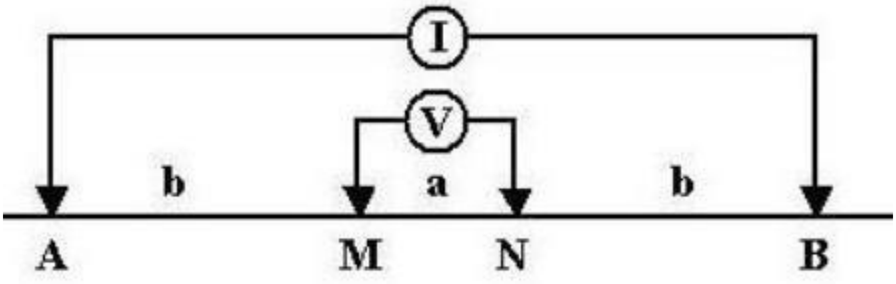
Figure 2: Schlumberger Array (langeoinstrument.com)



2.3 Geology of the Study Area

The study area is located between latitude 7.446°N and longitude $3.899°E$ in the Precambrian Basement Composite terrain of southwestern Nigeria, within the basement complex of southwestern Nigeria which is part of the larger West African Shield (Theophilus et al., 2023). It has tropical rainy and dry climate; the rainy period starts between mid- March to October and dry season is from November to March. The annual rainfall and the maximum temperature in Ibadan are approximately 1230 mm and 32℃, respectively (Aladejana et al., 2018). In Ibadan, some intrusive rocks such as granites and porphyries are found within the metamorphic rocks (Ganiyu et al., 2018).

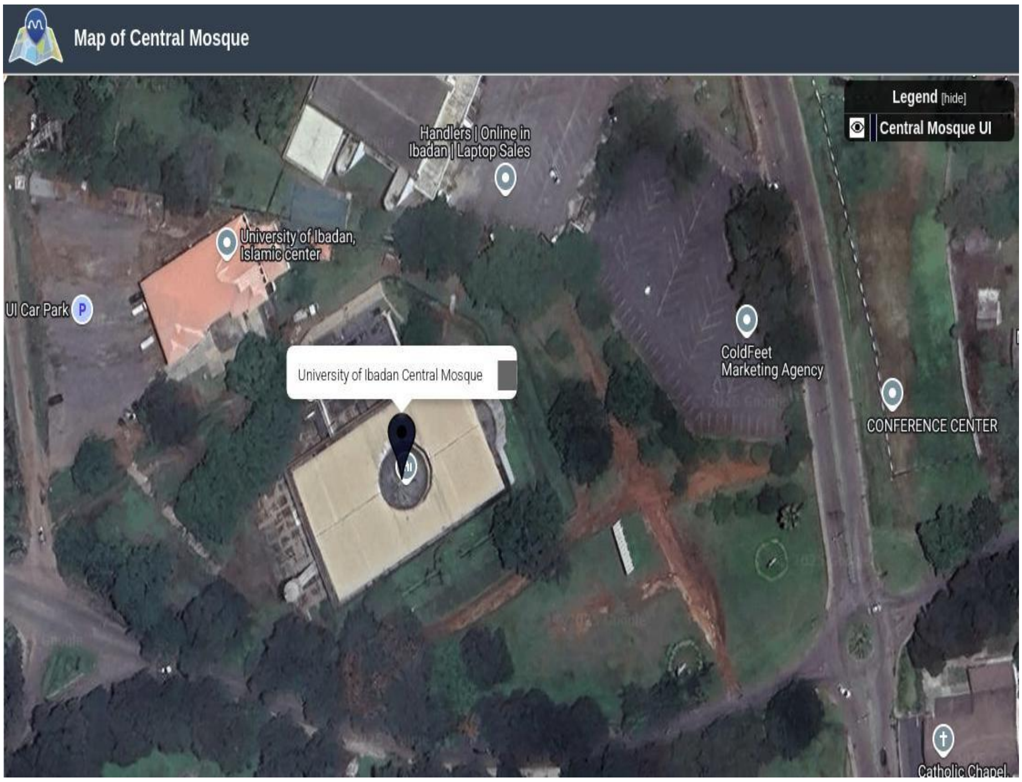


Figure 3: Map of the Study Area

2.4 Geophysical Investigation

A geoelectrical resistivity survey was carried out in the study area using Vertical Electrical Soundings (VES) and Constant Separation Traversing (CST) with the aid of Campus Omega Resistivity Meter.

2.5 Constant Separation Technique (CST)

Three profiles (130 m, 150 m and 130 m) were used at 10 m electrode spacing with Constant Separation Traversing configured using Wenner array. The results from series of CST traverses with fixed electrode spacing are used in the production of resistivity contour maps.

2.6 Vertical Electrical Sounding (VES)

Ten Vertical Electrical Sounding was carried out using Schlumberger configuration, with the current electrode spacing (AB/2) with maximum spread of55m and potential electrode ranging from 0.25 - 2.5m. A controlled current (I) is injected into the ground through the current electrodes (C1, C2).In both CST and VES, the resulting potential difference (V) was measured between the potential electrodes, using the resistivity meter, and the geometric factor (K) and the apparent resistivity (ρa) were calculated using equations: 1 and 3 respectively.

2.7 Dar-Zarrouk (D-Z) Parameters

In geophysical surveys, the Dar-Zarrouk (D-Z) parameters are essential for comprehending the distribution of subsurface resistivity (Yusuf and Abiye, 2019), especially when interpreting Vertical Electrical Sounding (VES) data. These parameters, named after the two researchers Dar and Zarrouk, were introduced as a method to simplify and quantify the resistivity structure of layered geological media. The resistivity and thickness of subsurface layers—two important characteristics that can be obtained from VES data using particular mathematical formulas are the focus of the DAR-ZARROUK parameters. D-Z parameters enable geophysicists to characterize the resistivity structure in terms of a few key quantities that are readily related to geological characteristics, as opposed to depending on full inversion or modeling techniques, which can be computationally demanding and time-consuming.

3. Results and Discussion

Table 1: Geoelectric Parameter of UI Mosque **(**Ewumi et al., 2025**)**

VES No	**Layers**	**Resistivity (Ωm)**	**Thickness (m)**	**Depth (m)**	**Curve Type**	**Lithology**
1		262.5	1.0	1.0		Lateritic top soil
1	2	113.2	3.0	4.0	Q	Clayey-Sandy weathered layer Fractured Bedrock
3		46.4	…	…		
1		629.6	0.8	0.8		Lateritic top soil
22		231.0	3.5	4.3	QH	Sandy-clay weathered layer Fractured basement
3		36.6	11.6	15.9		
4		404.6	…	…		Fresh basement
1		432.2	1.1	1.1		Lateritic top soil
3	2	149.0	4.4	5.4	HK	Sandy weathered layer
3		440.6	10.0	15.4		Weathered basement
4		125.5	…	…		Fractured basement
1		460.0	1.0	1.0		Lateritic top soil
4	2	115.0	10.5	11.5	H	Clayey-sandy weathered layer Fractured basement
3		240.0	…	…		
1		220.0	1.0	1.0		Lateritic top soil
5	2	94.3	21.0	22.0	H	Sandy weathered layer
3		364.0	…	…		Weathered/fractured basement

	1	257.3	1.0	1.0		Lateritic top soil
6	2	90.9	9.0	10.0	H	Clayey weathered layer
	3	269.9	…	…		Fractured basement
	1	416.8	1.1	1.1		Lateritic top soil
7	2	80.5	10.6	11.6	H	Clayey-sandy layer
	3	320.1	…	…		Fractured basement
	1	349.7	1.0	1.0		Lateritic top soil
8	2	122.2	6.6	7.6	Q	Sandy weathered layer
	3	27.7	…	…		Fractured rock
	1	279.6	1.1	1.1		Lateritic top soil
9	2	60.0	18.8	20.0	H	Clayey-sandy weathered basement
	3	588.4	…	…		Fresh basement rock
	1	364.1	0.9	0.9		Lateritic top soil
10	2	50.0	10.8	11.7	H	Clayey weathered layer
	3	449.3	…	…		Weathered/fractured Basement

The results of the VES and CST are presented in Table 1 and Table 2 respectively. Analysis of the data was done using the inversion software DIPROWin software (for the CST). The resulting psuedo-section was then compared against the list of ground resources and their corresponding resistivity values to determine the area with the greatest water potential. The resulting pseudo- section from data analysis is presented in Figure 3 - 6.

3.1 Aquifer Protection Capacity

The longitudinal conductance of the layers was calculated using the resistivity and layer thickness (Oborie and Udom, 2014); a high longitudinal conductance indicated a relatively high protective capacity.

3.2 Geoelectric Parameter

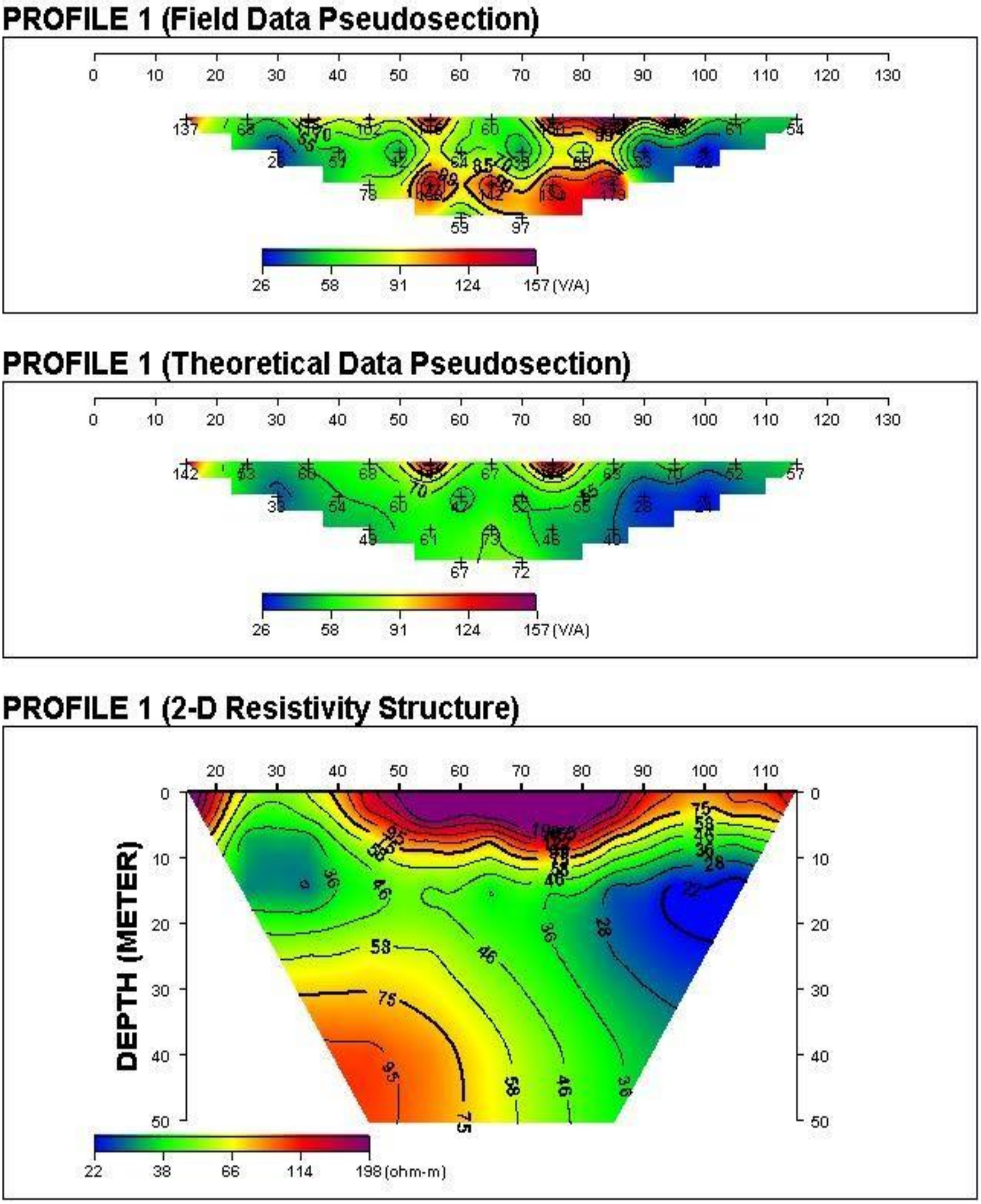
The calculated longitudinal conductance for the study area is presented in the table below:

Table 2: Dar Zarrouk Parameter and Reflection Coefficient

VES Station	Thickness	Overburden	Reflection Coefficient	Longitudinal Conductance
1	1.0 3.0 …	4.0	-0.418	0.030311
2	0.8 3.5 11.6 …	15.9	0.834088	0.332063
3	1.1 4.4 10.0 …	15.5	-0.556615	0.054771
4	1.0 10.5 …	11.5	0.352112	0.093478
5	1.0 21.0 …	22.0	0.588479	0.227238
6	1.0 9.0 …	10.0	0.496120	0.102896
7	1.1 10.6 …	11.7	0.598102	0.134316
8	1.0 6.6 …	7.6	-0.630420	0.056869
9	1.1 18.8 …	19.9	0.814929	0.317268
10	0.9 10.8	11.7	0.799719	0.218471

3.3 2-D Resistivity Structure

Figure 4: 2D Resistivity Structure for Profile 1



PROFILE 1 (Field Data Pseudosection)

PROFILE 1 (Theoretical Data Pseudosection)

PROFILE 1 (2-D Resistivity Structure)

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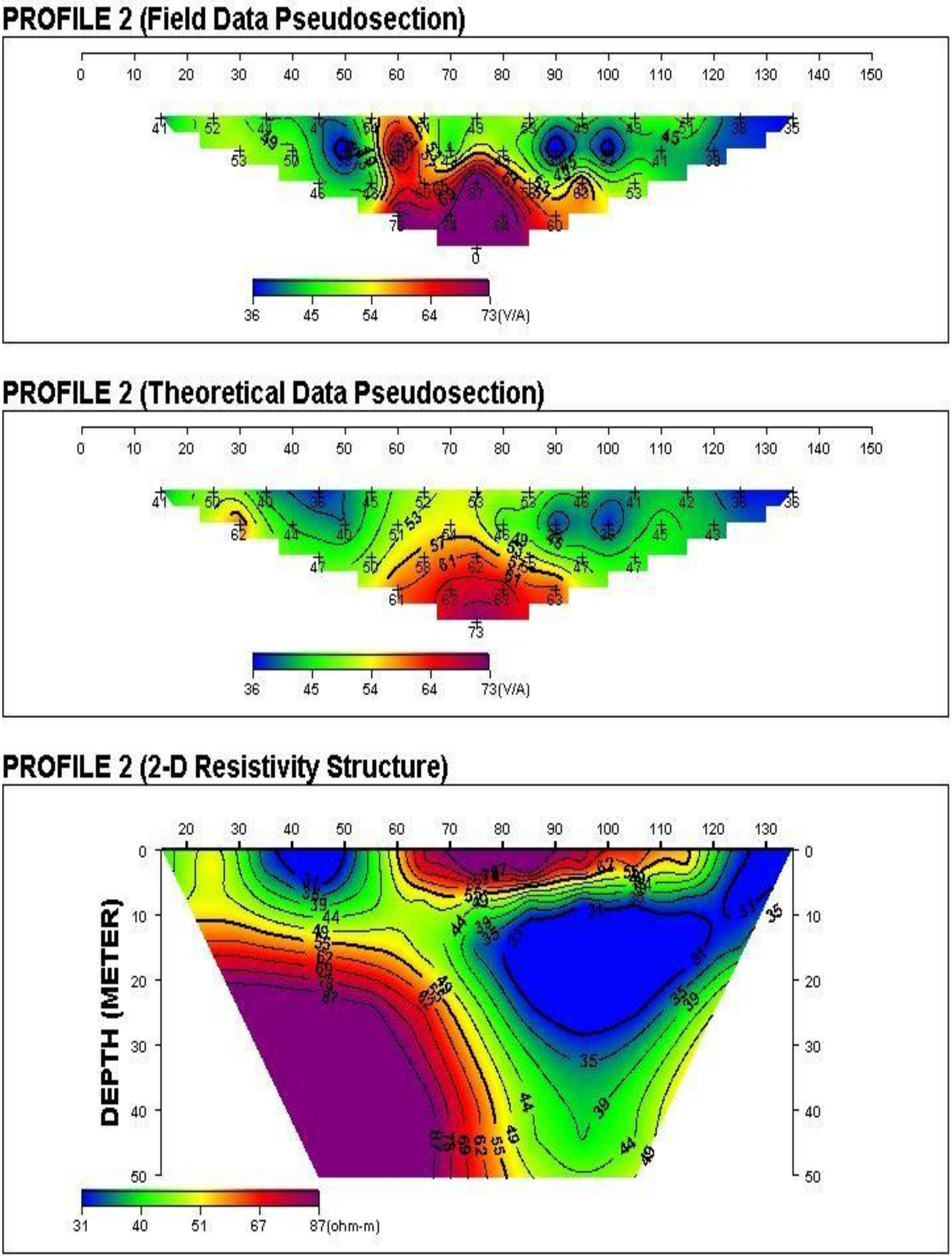
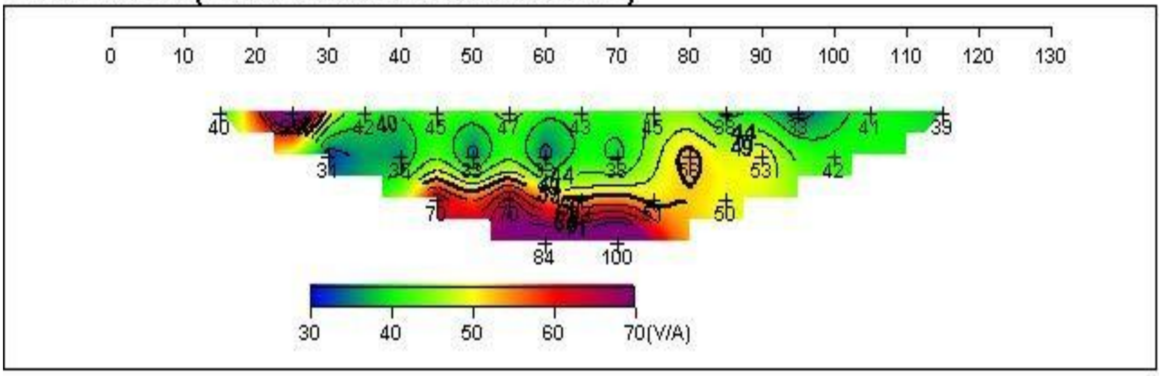

PROFILE 2 (Field Data Pseudosection)

PROFILE 2 (Theoretical Data Pseudosection)

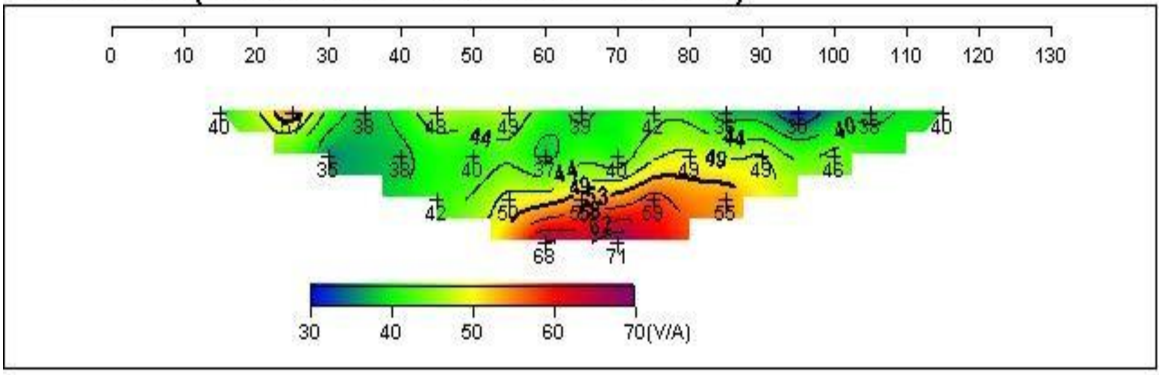
PROFILE 2 (2-D Resistivity Structure)

Figure 5:2D Resistivity Structure for Profile 2

PROFILE 3 (Field Data Pseudosection)



PROFILE 3 (Theoretical Data Pseudosection)



PROFILE 3 (2-D Resistivity Structure)

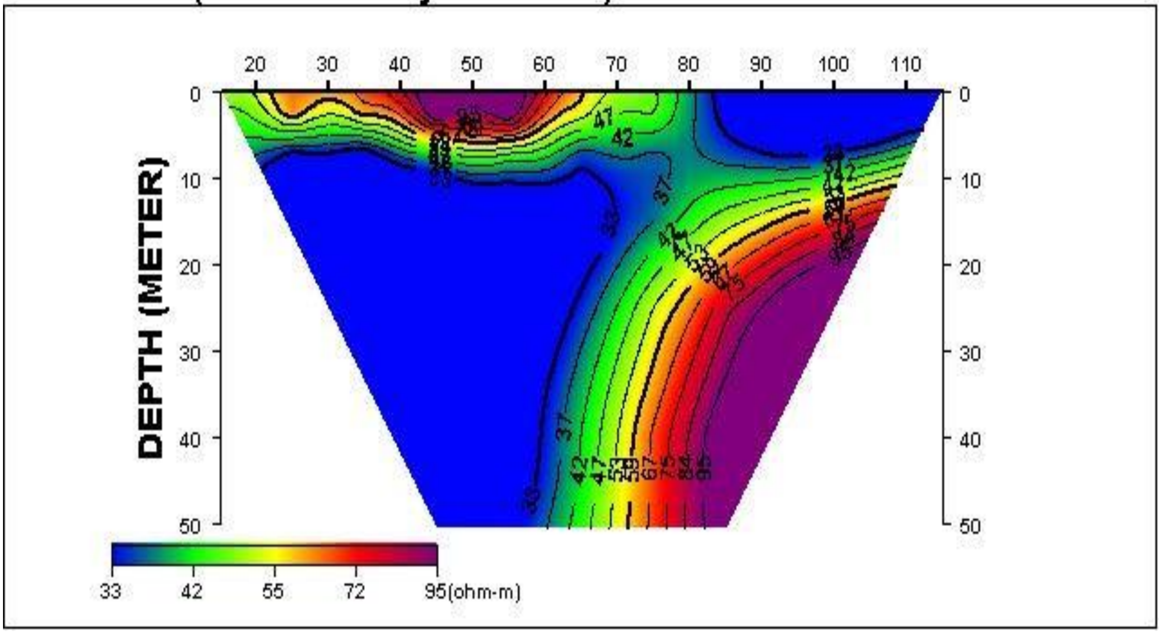


Figure 6: 2D Resistivity Structure for Profile 3

Table 3: Longitudinal conductance and protective capacity rating in the study area Oladapo and Akintorinwa, 2007).

VES Station	Longitudinal Conductance	Protective Capacity Rating
1, 3 & 8	0.030311 – 0.056869	Poor
4, 6 & 7	0.0934780 – 0.134316	Weak
2, 5, 9 & 10	0.218474 – 0.332063	Moderate

5. Conclusion

The results of the VES analysis suggest that weathered layer and fractured bedrock constitute the aquifer units in the study area. The CST readings of the study area suggest predominantly regions of good groundwater potentials along the three traverses. The CST of profile 3 reveals a large region with good groundwater potential closer to the surface and also, directly beneath regions of low potential at about a depth of 8 m. The overburden thickness varied from 4.0 to 15.9 m. The evaluation of aquifers' susceptibility to pollutants through geoelectric parameters showed a poor to medium protective capacity from pollution.

6. Conflict of Interest

There is no conflict of interest among the authors

7. Acknowledgements

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8. Copyright Notice

References

1. Edwin, B., Raj, R., Usha, E., Peter, L., (2017). Groundwater. In book: International Encyclopedia of Geography. IEG-Groundwater-John Wiley Sons. DOI: *10.1002/9781118786352.wbieg0677*

2. Adetoyinbo, Adedeji Adegoke, Bello, Adekunle Kazeem and Fredrick Fiyeboju Magi, 2023; Sub-Surface Characteristics and Evaluation of Groundwater Potential Zones of Idi-Ayunre Southwest, Nigeria. *International Journal of Science Academic Research. Vol. 04, Issue 05, pp.3579-3587*

3. Ganiyu, S. A., Badmus, B. S., Olurin, O. T., & Ojekunle, Z. O. (2018). Evaluation of seasonal variation of water quality using multivariate statistical analysis and irrigation parameter indices in Ajakanga area, Ibadan, Nigeria. *Applied water science, 8, 1-15*

4. Oborie, E., & Udom, G. J. (2014). Determination of aquifer transmissivity using geoelectrical sounding and pumping test in parts of Bayelsa State, Nigeria. Peak Journal of =physical and environmental science research, 2(2), 32-4

5. Oladapo, M. I., & Akintorinwa, O. J. (2007). Hydrogeophysical study of ogbese south western Nigeria. Global journal of pure and applied sciences, 13(1), 55-61.19. Olayinka, A. I. (1992). Geophysical siting of boreholes in crystalline basement areas of Africa. *Journal of African Earth Sciences (and the Middle East), 14(2), 197-2*
6. Reynolds, J. M. (2011). An introduction to applied and environmental geophysics (2nd ed.). Wiley-Blackwell.

7. Aladejana, O. O., Salami, A. T., & Adetoro, O. I. O. (2018). Hydrological responses to land degradation in the Northwest Benin Owena River Basin, Nigeria. Journal of Environmental Management, 225, 300-312.

8. Adindu, R. U., Ehirim, C. N. & Ebeniro, J. O. (2021). Evaluation of Groundwater Potential And Aquifer Protection From Geoelectric Data In Northern Parts Of Abia State, Nigeria *International Journal of Innovative Environmental Studies Research* 9(4): *1-16, Oct.-Dec., 2021 © SEAHI PUBLICATIONS, 2021 www.seahipaj.org ISSN: 2354-2918*

9. Mufutau Owolabi Jimoh [a], Glory Tolulope Opawale [a], Jude Stephen Ejepu [a], Suleiman Abdullahi [a], Okechukwu Ebuka Agbasi [b] (2023). Investigation of Groundwater Potential Using Geological, Hydrogeological and Geophysical Methods in Federal University of Technology, Minna, Bosso Campus, North Central, Nigeria. *Hydro Research, Volume 6, pp 255-268.*

10. Adewumi R., Agbasi O., Mayowa A. (2023). Investigating groundwater potential in northeastern basement complexes: a Pulka case study using geospatial and geo-electrical techniques. *HydroResearch, 6 (2023), pp. 73-88, 10.1016/j.hydres.2023.02.003*

11. Oyedele A.A. (2019). Use of remote sensing and GIS techniques for groundwater exploration in the basement complex terrain of ado-Ekiti, SW Nigeria. *Appl Water Sci, 9 (3) (2019), 10.1007/s13201-019-0917-9*

12. Epuh E.E., Orji M.J., Iyoyojie H.A., Daramola O.E.. (2020). Groundwater potential mapping in Ikorodu, Lagos State, Nigeria, using multi-criteria analysis and hydrogeophysics. *Nigerian Journal Technology, 39 (1) (2020), pp. 278-292, 10.4314/njt.v39i1.31*

13. Olabode, O. F., & Comte, J.-C. (2025). Long-term groundwater security in the fast-growing coastal megacity of Lagos, Nigeria: insights from distributed recharge simulations. Hydrological Sciences Journal. https://doi.org/10.1080/02626667.2025.2505171

14. Taofik Olubunmi Ewumi; Taofik Titus Ogunseye; Adekunle Kazeem Bello; Godwin Babatunde Egbeyale; Kehinde Hussein Adeleke, 2025: Assessment of Groundwater Potential of the University of Ibadan Central Mosque, Southwestern, Nigeria. *International Journal of Innovative Science and Research Technology. Volume 10, Issue 5, PP 3899 – 3907. May – 2025 ISSN No: -2456-2165. Country - India*

15. Theophilus Aanuoluwa Adagunodo [a], Abraham Adewale Aremu [b], Oyelowo Gabriel Bayowa [c], Ayobami Ismaila Ojoawo, Abosede Olufunmii Adewoye, Temiloluwa Ezekiel Olonade (2023). Assessment and health effects of radon and its relation with some parameters in groundwater sources from shallow aquifers in granitic terrains, southeastern axis of Ibadan, Nigeria. *Groundwater for Sustainable Development Volume 21, May 2023, 100930.*

16. Yusuf, M. A. & Abiye, T. A. (2019). Risks of groundwater pollution in the coastal areas of Lagos, southwestern Nigeria (2019). *Groundwater for Sustainable Development Volume 9, October 2019, 100222*