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ESTIMATION OF GROUNDWATER POTENTIAL AND AQUIFER PROTECTIVE CAPACITY WITHIN OLD IKENGA HOTEL, NSUKKA, ENUGU STATE, NIGERIA

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ABSTRACT: *A geophysical survey using electrical resistivity method was conducted around Old Ikenga Hotel, Nsukka in Enugu State, Nigeria to investigate the groundwater potential and aquifer protective capacity of the area. The project area lies within latitudes 6°50'4.0''N – 6°57'52.0''N and longitudes 7°21'6.3''E – 7°28'12.0''E, and covers an area of about 89.6 km^2. Vertical Electrical Soundings (VES) were carried out with a digital read out resistivity meter (ABEM SAS 1000). The VES points were marked at 25 m and 75 m along a 100 m line. A total of eight soundings were carried out in the area. The VES data collected were interpreted using INTERPEX software and the results presented in terms of resistivity, thickness, depth and lithology. The lithology was inferred by correlating the result to the lithology log of the borehole drilled in the hotel and the geology of the study area. The VES result shows lithologic layers varying from 4 to 5. Aquiferous sand and Aquiferous sandy shale constitute the aquifer units in the area at depth of 30.26 m to 188.20 m, with their thickness ranging from 30 m to 74 m as shown by their isopach map. The aquifer protective capacity was determined by calculating for longitudinal conductance and matching the values to known standards. The calculated longitudinal conductance varies from 0.0409 to 3.1235 mhos. The interpreted VES results reveal poor, moderate, good and very good aquifer protective capacities of the overburden layers.*

KEYWORDS: Aquifer, Longitudinal conductance, Borehole, Geoelectric section, Vertical Electrical Sounding, Resistivity, Nsukka, Old Ikenga, Aquifer protective capacity.

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INTRODUCTION

Aquifer plays a vital role in sustaining our water resources, providing us with a reliable supply of fresh groundwater. However, it is essential to understand the protective capacity of aquifers and potential for groundwater extraction in order to ensure their long-term sustainability. The protective capacity of an aquifer refers to its ability to safeguard groundwater quality against potential contamination threats. This capacity can vary significantly depending on various factors such as geological characteristics, land use practice and human activities within the study area. Accessing these factors provides valuable insights for effective water resource planning, development and protection within the study area.

The study area is a critical area such that it is an area filled with residential houses, shops and a hotel with a municipal dumpsite located behind the hotel, and it requires a thorough examination of its groundwater potential and aquifer protective capacity. As an important water source for various purposes such as drinking water supply and irrigation, understanding the hydrogeological characteristics is essential for a sustainable and secure water supply in the locality.

This study aims to estimate the groundwater potential within the vicinity of Old Ikenga Hotel by examining various hydrogeological factors. Such factors include the lithology, geological structure and protective capacity of the overburden units against potential contamination threats in the study area. By analyzing these parameters, we can determine the groundwater yield and potential well locations that can provide a reliable water supply for the local community.

This research endeavor will utilize a combination of field surveys and data analysis techniques to estimate groundwater potential and evaluate aquifer protective capacity. The use of electrical methods applied to environmental studies is well documented (Karlik & Kaya, 2001; Aristedemou & Thomas-Betts, 2000). The Werner array is useful for resolving the differing resistivities of the subsurface layers straight down from the midpoint of the array (Olisah & Obiekezie, 2020).

Various researchers have studied the effect of aquifer protective capacity on the groundwater in Nigeria and all over the world. Tahama *et al.* (2019) evaluated the groundwater potential and aquifer protective capacity of the overburden units in trap Covered Dhule District, Maharashtra using Vertical Electrical Sounding and concluded that about 92% of the study area is characterized by moderate to good protective capacity, 4% reveals excellent and 4% poor ratings.

Eugene-Okorie *et al.* (2020) carried out the geoelectrical investigation of groundwater potential and vulnerability at Oraifite, Anambra State and revealed that 90% of the study area has poor aquifer protective capacity. Therefore, these areas are vulnerable to contamination.

Onyenweife *et al.* (2020) estimated aquifer protective capacity at Awka and its environs using Vertical Electrical Sounding and concluded that that aquifers in the study area have better protective capacity of groundwater in comparison to the geological formations. Nine (9) locations, representing 50% of the surveyed area, have aquifer protective capacity rated good while four (4) of the locations, representing 22.2% of the surveyed area, have moderate protective capacity rating.

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Obiajulu and Nwaka assessed the aquifer vulnerability and aquifer protective capacity in some parts of Awka using Vertical Electrical Sounding and concluded that the areas of study have poor, good and moderate aquifer protective capacity and areas with low protective capacity are vulnerable to pollution.

Osele *et al.* (2016) explored the groundwater at Nkwelle Ezunaka using Vertical Electrical Sounding and concluded that the range of values of transmissivity and hydraulic conductivity calculated from VES result indicate that the area is capable of yielding optimum groundwater that will serve for both domestic and municipal purposes.

Nzemeka *et al.* (2023) estimated the groundwater potential and aquifer protective capacity at Agricultural Farm Estate Nkwelle-Ezunaka using Vertical Electrical Sounding and concluded that the study area has a poor aquifer protective capacity and is vulnerable to pollution.

Okonkwo and Ugwu (2015) assessed the aquifer protective capacity within Enugu State University of Science and Technology Agbani, Enugu State using Vertical Electrical Sounding and Dar-Zarrouk parameter and concluded that the aquifer protective capacity within the area is zoned in poor/weak, moderate and good protective capacity.

Okonkwo *et al.* (2017) estimated the aquifer hydraulic properties and protective capacity of overburden units at Nkanu-West Local Government Area, Enugu State using geoelectrical sounding and concluded that aquifer transmissivity and hydraulic conductivity of the area correlate favourably with available borehole data and has a protective capacity rating ranging from good to excellent.

Abdullahi *et al.* (2014) used geoelectrical method in the evaluation of groundwater potential and aquifer protective capacity of overburden units around Opi area in Nsukka, Southeastern Nigeria and their results delineated three to five geoelectric sections in their study area, namely: the topsoil (which consists of lateritic clay), river sand, gravel and clayey sand. The study area indicated moderate protective capacity, hence vulnerable to contamination.

Location and Geology of Study Area

The study area is located off Odenigbo junction and can be accessed through the notable Ezeimo road, Nsukka, Nsukka Local Government Area of Enugu State, Southeastern Nigeria. The area lies between longitudes 7°21'6.3''E – 7°22'12.0''E and latitudes 6°50'4.05''N – 6°50'52.0''N. It spreads over an area of about 89.6 km^2. Nsukka is located in the Northern fringes of Enugu State. It is about 53.5 km North of Enugu metropolis. Nsukka is situated in Enugu North Senatorial Zone and is notable for hosting the popular University of Nigeria, Nsukka. Towns that share a common border with Nsukka are Edem Ani, Alor-uno, Opi, Orba, Ede-Oballa and Obima. Nsukka Local Government Area had an area of 484 km^2 and a population of 309,633 at the 2006 census (National Population Commission of Nigeria, 2006).

The study area consists of three major geologic formations: the Mamu, Ajali and Nsukka formations, respectively. The Mamu Formation, previously known as Lower Coal measures (Reyment, 1965), consists of fine-medium grained, white to grey sandstones, shaley sandstones, sandy shales, grey mudstones, shales and coal seams. The thickness is about 450 m and it conformably underlies the Ajali Formation. The Ajali Formation, also known as False Bedded sandstone, consists of thick friable, poorly sorted sandstones, typically white in colour but sometimes iron-stained. The thickness averages 300 m and is often overlain by considerable

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thickness of red earth, which consists of red, earthy sands, formed by the weathering and ferroginisation of the formation. The Nsukka formation, previously known as the Upper Coal measures (Reyment, 1965), lies conformably on the Ajali Sandstone. The lithology is very similar to that of Manu Formation and consists of an alternating succession of sandstone, dark shale and sandy shale, with thin coal seams at various horizons. Eroded remnants of this formation constitute outliers and its thickness averages 250 m.

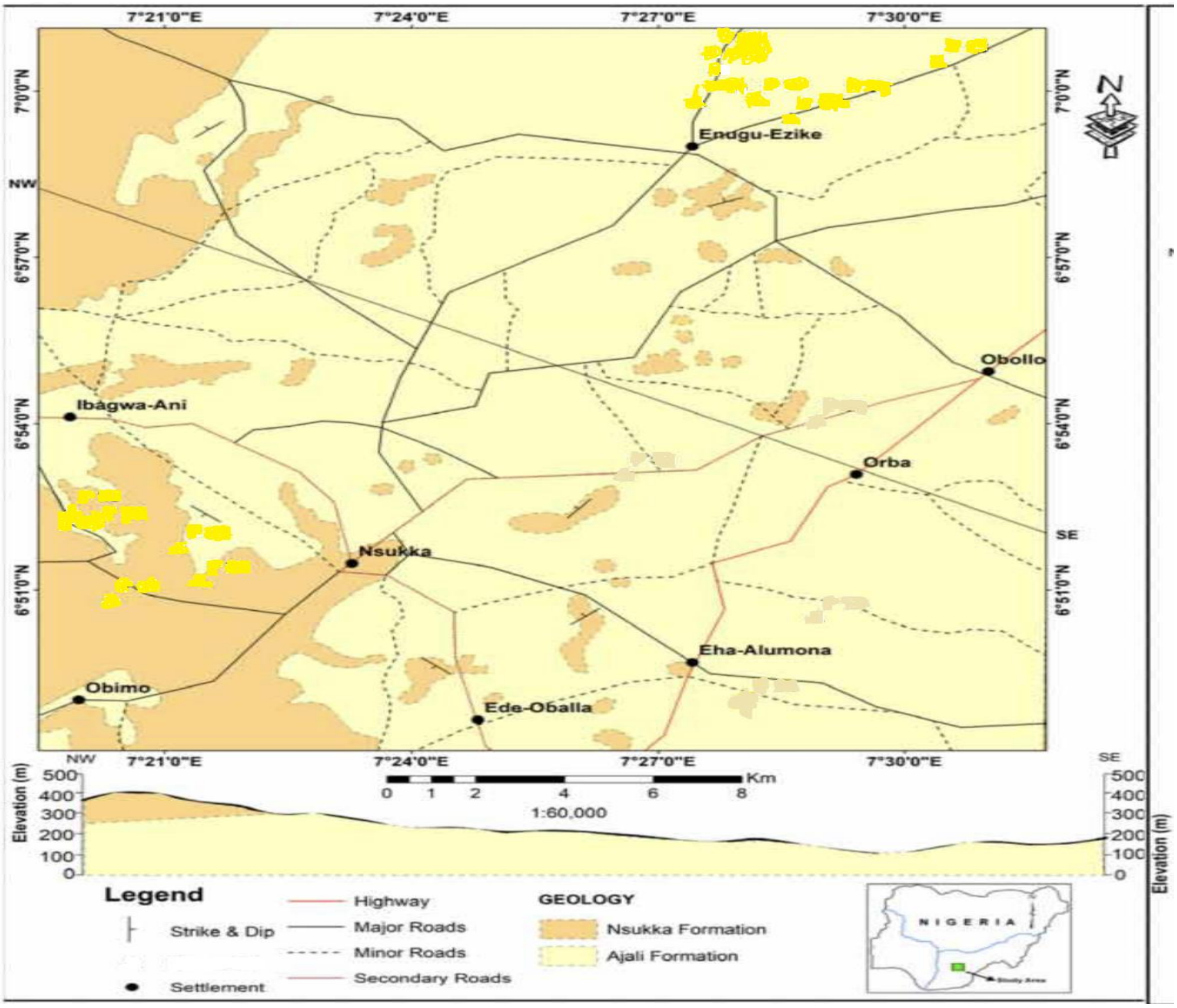

Fig. 1: Geologic map of the study area showing the various geologic formation (www.google.com)

Materials

The main equipment used for this geophysical survey is the ABEM SAS 1000 resistivity meter.

The resistivity meter is equipped with a 12 volts battery, two current transmission cables on reels, two potential cables, four metal electrodes and a salt solution. Other auxiliary equipment for the survey include a Global Positioning System (GPS) for determining the resistivity survey locations and topography, geologic hammers for driving electrodes into the ground, two measuring tapes and cutlasses for clearing the traverses.

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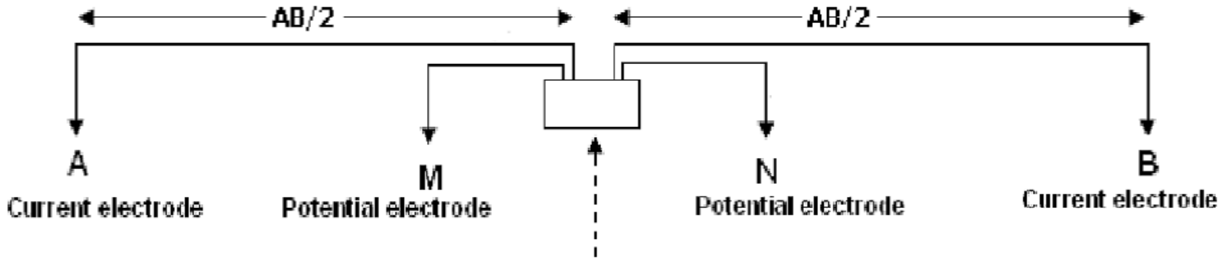
METHODOLOGY

A total of eight (8) Vertical Electrical Soundings (VES) using Schlumbeger array were conducted within the study area. The ABEM SAS 1000 resistivity meter and the 12 volts battery were placed in the centre of the layout. The two inner electrodes are the potential electrodes while the two outer electrodes are the current electrodes as shown in Fig. 2. Four cables were connected to the resistivity meter at the centre of the cable spread and the electrodes were connected at the other end of cables. Current is passed between electrodes A and B and monitored by the potential electrodes M and N. As the distance between A and B is increased, deeper horizon have more effects on the potential between M and N. Also, when sounding with a Schlumberger array, as distance between the current electrodes are increased, the distance between the current and potential electrodes at the center of the array is also increased. It is this increase between the current and potential electrodes at the center of the array that actually matters in depth probing. The reasonable distance between M and N should be equal or less than one-fifth of the distance between A and B at the beginning. The ratio goes up to one-tenth or one-fifteenth depending on the signal strength. The electrode configuration, having a maximum current electrode spread of 800 m, was used with a maximum of 400 m on both sides. The current electrode spacing begins with a distance equal to 2 m and extends up to 400 m while the potential electrode spacing begins with a distance of 0.5m and extends up to 20 m. The $\frac{AB}{2}$ or half current electrode spacing was increased to a maximum of 400 m. In most cases, $\frac{MN}{2}$ or half potential electrode spacing were overlapping two readings. This means that the potential electrodes move only when the potential drops or becomes too small to measure with sufficient accuracy. For the survey, it was not necessary to increase the $\frac{MN}{2}$ distance until the distance $\frac{AB}{2}$ was increased to 9, 75 and 400 meters. At this point, $\frac{\Delta V}{I}$ was measured for both the old and new value of $\frac{MN}{2}$. This procedure permits the detection of near surface inhomogeneities.



Resistivity meter

Fig. 2: Schlumberger Array

The apparent resistivity (ρ_a) values was calculated using Eqn. 1 which is:

$$\rho_a = \pi\left\{\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right\} \text{ x } R \qquad (1)$$

where

$\frac{AB}{2}$ is the half current electrode spacing which extends from 2 m to 400 m on both sides

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$\frac{MN}{2}$ is the half potential electrode spacing which extends from 0.5 m to 20 m

R (Ω) is the resistance values collected from the field using ABEM SAS 1000 resistivity meter

The VES field data were processed using the Schlumberger automatic INTERPEX analysis software, which generates model curves using initial layer parameters. The isoresistivity and isopach maps of the study area were obtained using Surfer 8 software. The Dar-Zarrouk parameters were obtained from the first order geoelectric parameters (layer resistivities and thicknesses). These include the total longitudinal unit conductance (S) and total transverse unit resistance (T). These secondary geoelectric parameters are particularly important when they are used to describe a geoelectric section consisting of several layers (Zhody *et al.*, 1974). For n layers, the total longitudinal unit coductance is

$$S = \sum_{i=1}^{n} \left(\frac{h_i}{\rho_i}\right) \quad (2)$$

The total transverse unit resistance is given as

$$T = \sum_{i=1}^{n} \rho_i h_i \quad (3)$$

where h_i is the thickness of the ith layer and ρi is the resistivity of the ith layer. Using Oladipo and Akintoranwa's (2007) classification, the results of longitudinal conductance was used to classify areas into good, moderate, weak and poor protective capacity as shown in Table 1. The lithology was inferred to the layers from the correlation between the one of the borehole drilled in the study area and the geology of the study area (Ugwu & Ezeh, 2012).

Table 1: Longitudinal Conductance/Protective Capacity Rating (Oladipo & Akintoranwa 2007)

Longitudinal Conductance (mhos)	Protective Capacity Rating
>10	Excellent
5–10	Very good
0.7–4.9	Good
0.2–0.69	Moderate
0.1–0.19	Weak
< 0.1	Poor

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RESULTS AND DISCUSSION

The qualitative interpretation of the profile and depth sounding curve were carried out based on distinctive geoelectric parameters on the number of layers represented by the four types of auxiliary curves (A, H, K and Q). The sounding curve was obtained by plotting a graph of apparent resistivity versus half current electrode spacing. VES 1, 2, 7 and 8 are type AA curves while VES 3, 4, 5 and 6 are type AK curves. VES 2, 5, 6 and 7 have four geoelectric layers while VES 1, 3, 4 and 8 have five geoelectric layers (Fig. 3–10). A summary of qualitative interpretation of VES curves is shown in Table 2 while Table 3 shows a summary of the quantitative interpretation results of the VES.

Table 2: Summary of Qualitative Interpretation of VES Curves

VES	CURVE TYPE	RESISTIVITY PROFILE	NUMBER OF LAYERS
1	AA	$\rho_1<\rho_2<\rho_3<\rho_4<\rho_5$	5
2	AA	$\rho_1<\rho_2<\rho_3<\rho_4$	4
3	AK	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5$	5
4	AK	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5$	5
5	AK	$\rho_1<\rho_2<\rho_3>\rho_4$	4
6	AK	$\rho_1<\rho_2<\rho_3>\rho_4$	4
7	AA	$\rho_1<\rho_2<\rho_3<\rho_4$	4
8	AA	$\rho_1<\rho_2<\rho_3<\rho_4<\rho_5$	5

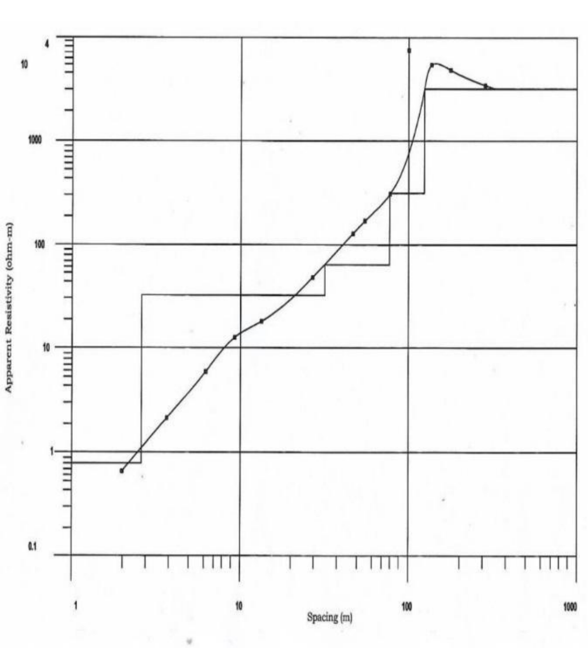

Fig. 3: Interpretation Result of VES 1 Data

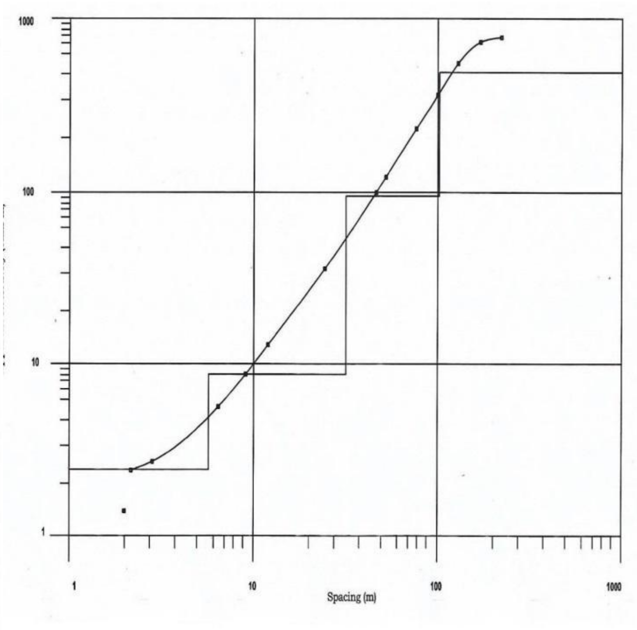

Fig. 4: Interpretation Result of VES 2 Data

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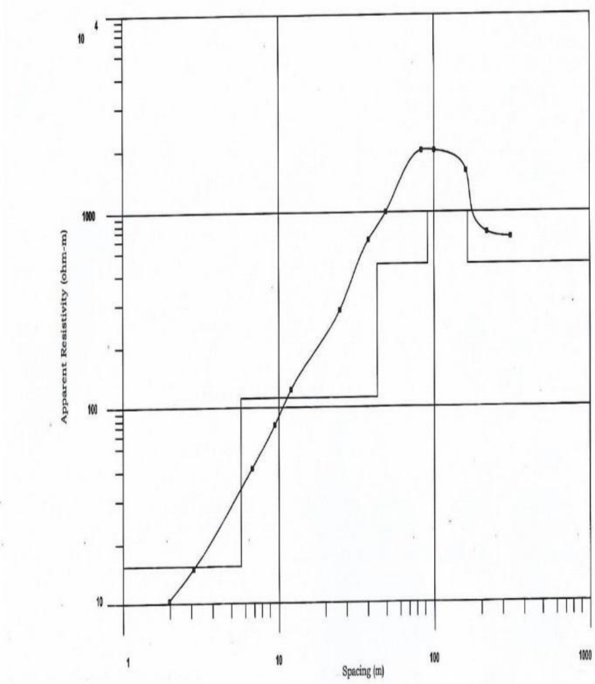

Fig. 5: Interpretation Result of VES 3 Data

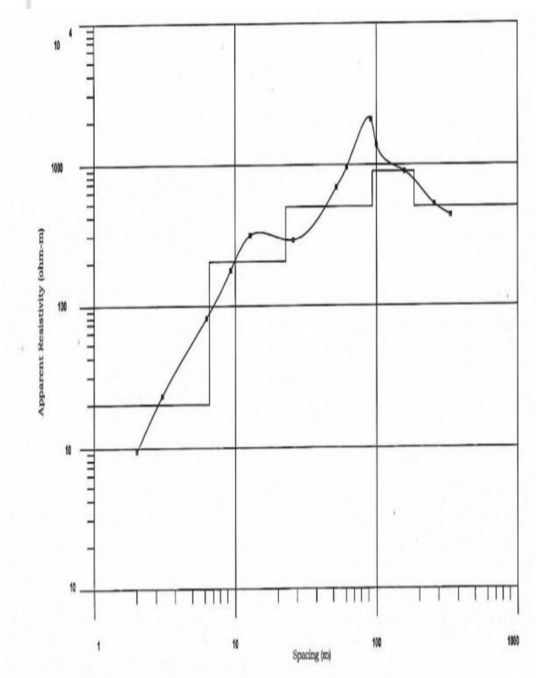

Fig. 6: Interpretation Result of VES 4 Data

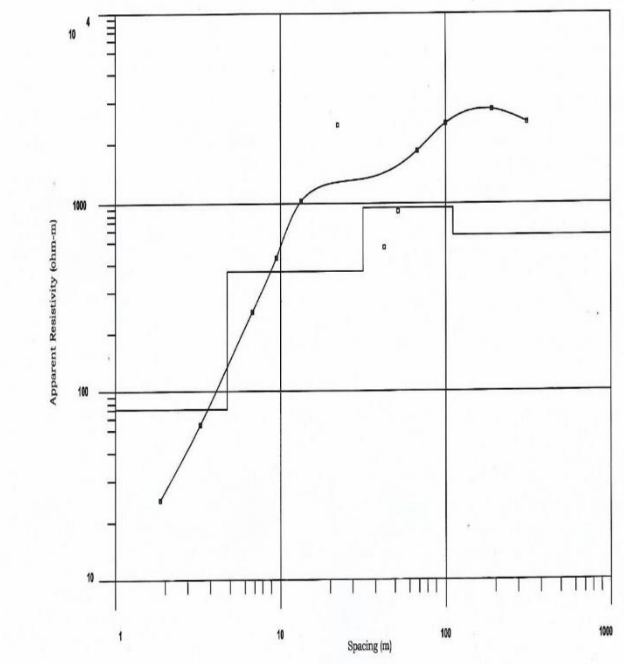

Fig. 7: Interpretation Result of VES 5 Data

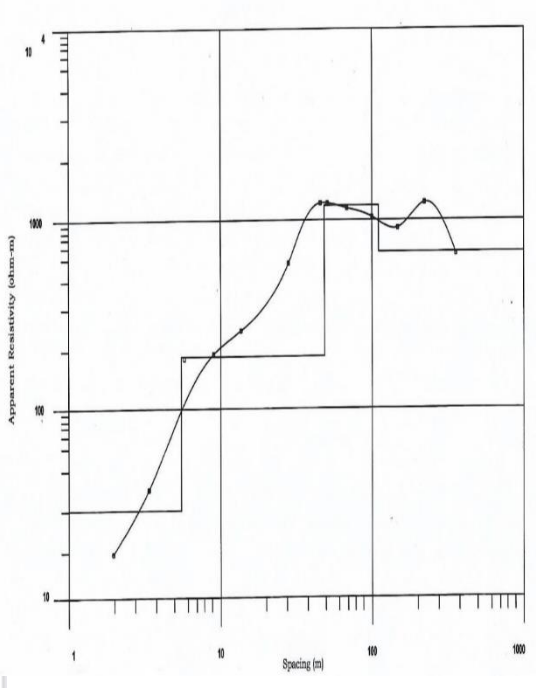

Fig. 8: Interpretation Result of VES 6 Data

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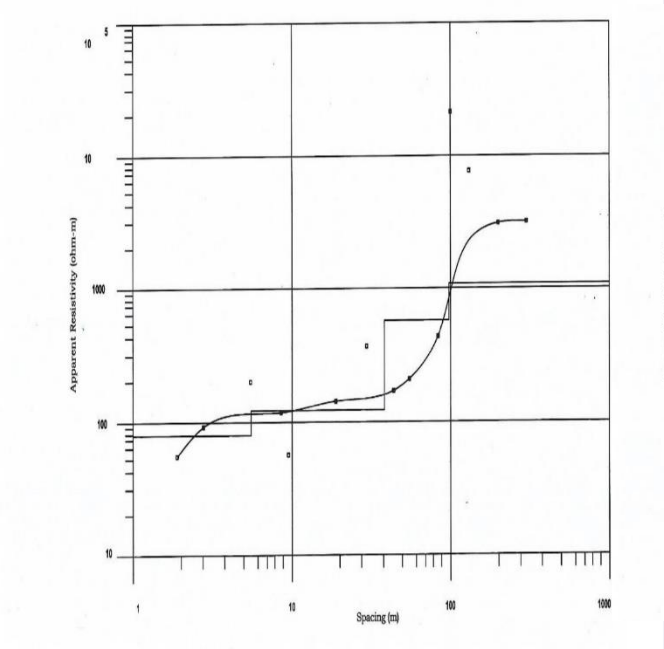

Fig. 9: Interpretation Result of VES 7 Data

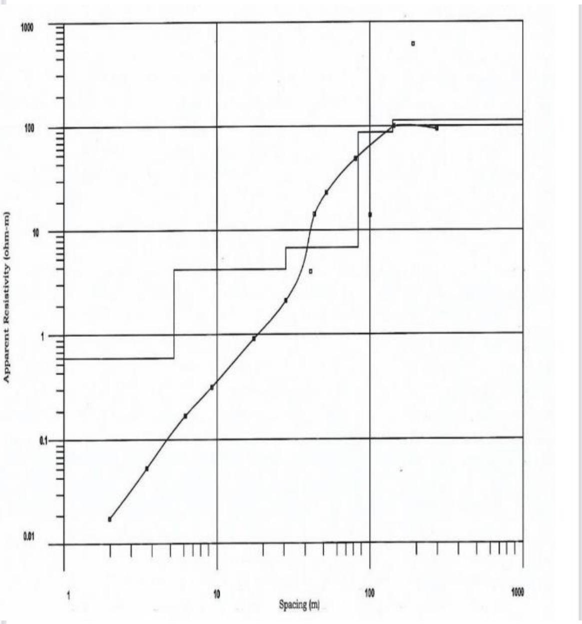

Fig. 10: Interpretation Result of VES 8 Data

Table 3: Summary of Quantitative Interpretation of VES Results

VES	Layers	ρ (Ωm)	Thickness (m)	Depth (m)	Lithology	Longitudinal conductance (S) (mhos)	Transverse resistance (T)	Aquifer Protective Capacity
1	1	0.81	2.53	2.53	Contaminated lateritic clay	3.1235	2.0493	4.5370 (Good)
	2	38.31	27.00	29.53	Clay	0.7048	1034.37	
	3	61.14	43.33	72.86	Shale	0.7087	2649.20	
	4	340.44	56.22	129.08	Aquiferous sand	0.1651	19139.54	
	5	3225.40	∞	∞	Ferroginized siltsone	∞	∞	
2	1	2.40	5.03	5.03	Contaminated lateritic clay	2.0958	12.0720	5.4955 (Very Good)
	2	9.14	24.03	29.07	Clay	2.6291	219.63	
	3	95.00	73.21	102.28	Shale	0.7706	6954.95	
	4	420.25	∞	∞	Aquiferous sand	∞	∞	
3	1	18.33	5.33	5.33	Contaminated lateritic clay	0.2908	97.6989	0.7419 (Good)
	2	120.44	35.44	40.77	Sandy shale	0.2943	4268.39	
	3	530.23	48.33	89.10	Sand	0.0911	25626.02	
	4	1010.30	66.33	155.43	Ferroginized siltstone	0.0657	67013.20	
	5	530.33	∞	∞	Aquiferous sand	∞	∞	

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4	1	20.21	6.54	6.54	Contaminated lateritic clay	0.3236	132.17	0.7392 (Good)
	2	196.40	35.31	41.85	Sandy clay	0.1798	6934.88	
	3	460.15	68.91	110.76	Sand	0.1498	31708.94	
	4	900.34	77.44	188.20	Sandstone	0.0860	69722.33	
	5	440	∞	∞	Aquiferous sand	∞	∞	
5	1	71.94	30.26	30.26	Shale	0.4206	2176.90	0.4206 (Moderate)
	2	369.40	46.49	76.75	Aquiferous sand	0.1259	17173.41	
	3	948.86	69.78	146.53	Sandstone	0.0735	66211.45	
	4	640.44	∞	∞	Sandstone	∞	∞	
6	1	130.33	5.33	5.33	Sandy shale	0.0409	694.66	0.0409 (Poor)
	2	200.87	40.32	45.65	Aquiferous sand	0.2007	8099.08	
	3	1300.30	66.83	112.48	Ferroginized siltstone	0.0514	86899.05	
	4	730.87	∞	∞	Sandstone	∞	∞	
7	1	75.98	5.84	5.84	Shale	0.0769	443.72	0.0769 (Poor)
	2	126.33	30.26	36.10	Aquiferous sandy shale	0.2395	3822.75	
	3	624.55	61.69	97.78	Sandstone	0.0988	38528.49	
	4	1100.20	∞	∞	Ferroginized siltstone	∞	∞	
8	1	90.58	5.45	5.45	Shale	0.0602	493.66	0.2234 (Moderate)
	2	153.50	25.05	30.50	Sandy shale	0.1632	3845.18	
	3	266.14	49.50	80.00	Aquiferous sand	0.1860	13173.93	
	4	785.34	65.34	145.34	Sandstone	0.0832	51314.12	
	5	1120.33	∞	∞	Ferroginized siltstone	∞	∞	

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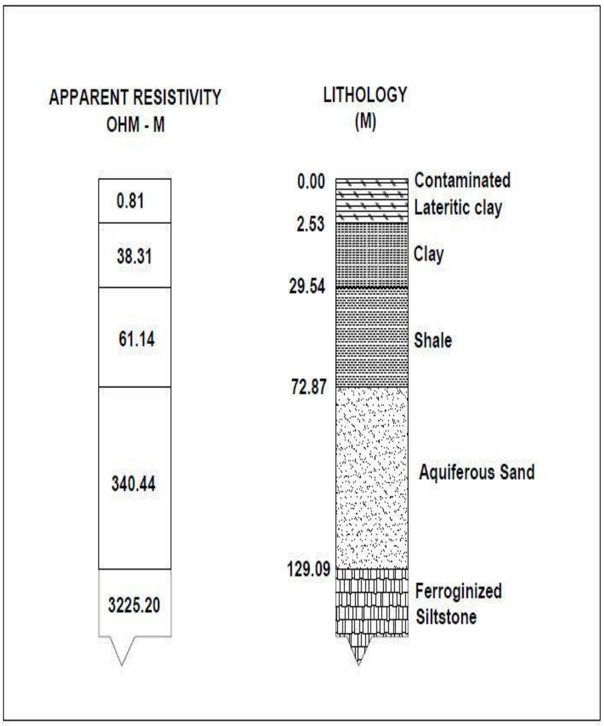

Fig. 11: Lithologic Log for VES 1

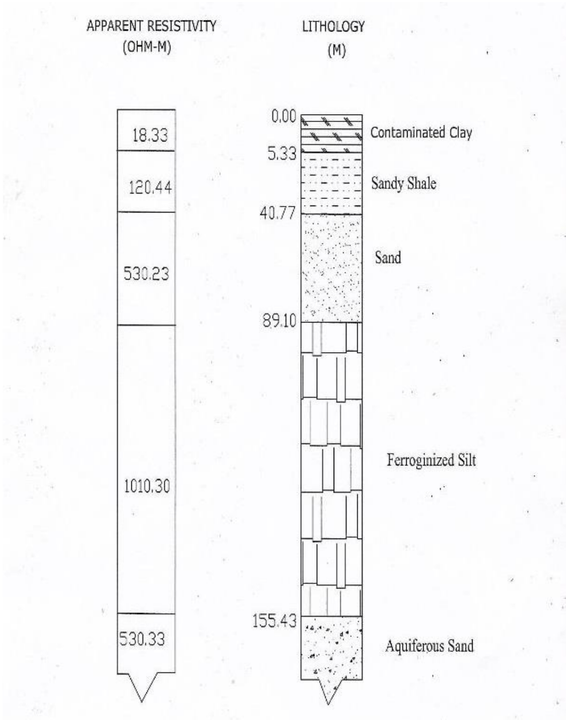

Fig. 12: Lithologic Log for VES 3

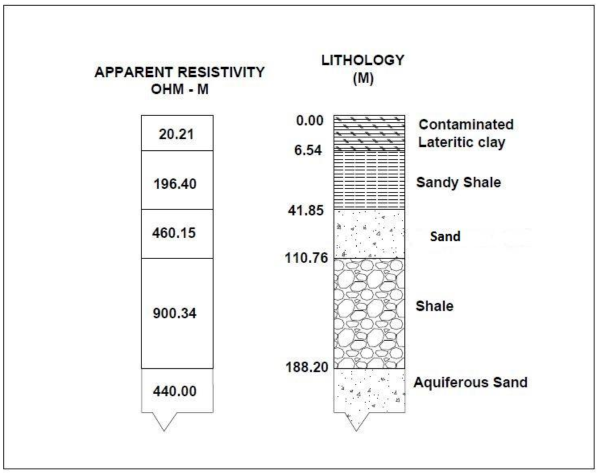

Fig. 13: Lithologic Log for VES 4

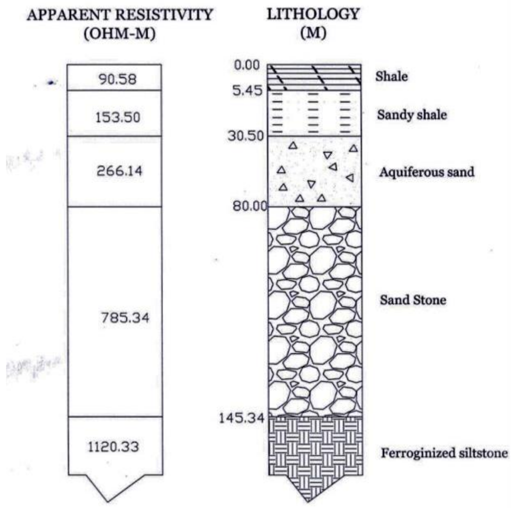

Fig. 14: Lithologic Log for VES 8

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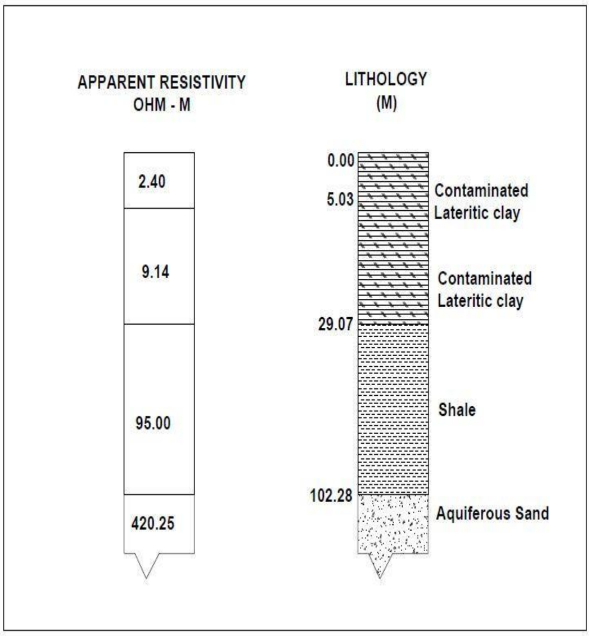

Fig. 15: Lithologic Log for VES 2

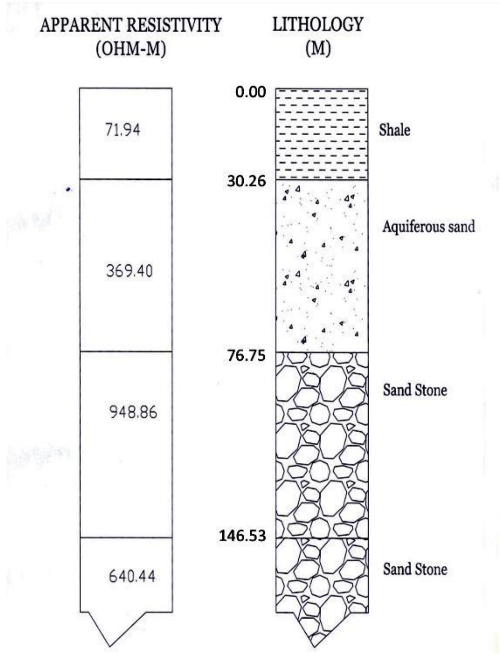

Fig. 16: Lithologic Log for VES 5

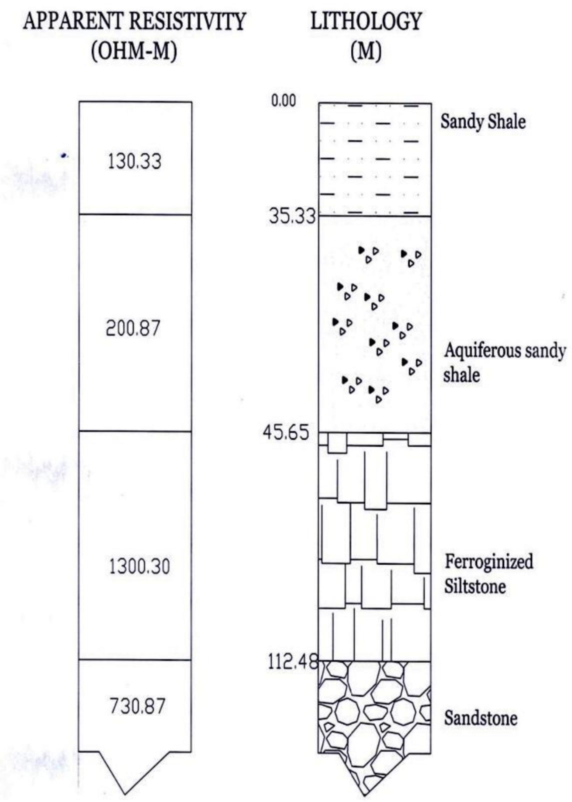

Fig. 17: Lithologic Log for VES 6

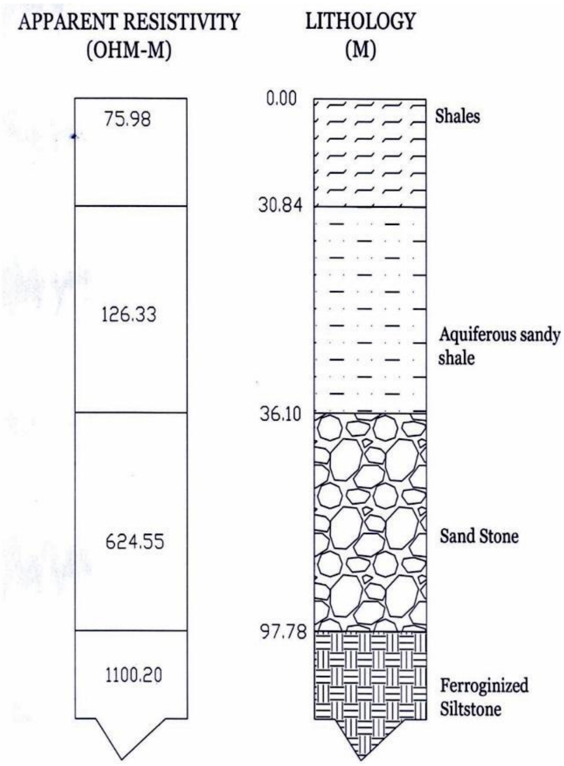

Fig. 18: Lithologic Log for VES 7

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Fig 11–18 show the lithologic logs for the five and four layered VES respectively with lithologic layers namely: Contaminated lateritic clay, Clay, Shale, Sandy shale, Sand, Sandy clay, Sandstone, Ferruginous siltstone, Aquiferous sand and Aquiferous sandy shale. The aquifer layers are aquiferous sand and aquiferous sandy shale. These aquifers are located either at the second, third, fourth or fifth layer (Table 3) in agreement with the result of Oyeku and Eludoyin (2010) and Nzemeka *et al.* (2003). The resistivity of the aquifer layers varies from 126.33 Ωm – 530.33 Ωm (Table 3) with thickness ranging from 30–74 m (Fig. 20). VES 3 and 4 have high aquifer thickness which is a favourable condition for productive and sustainable borehole yield (Ugwu *et al*. 2013). The aquifer protective capacity was determined by calculating the longitudinal conductance and found to vary from 0.0409–3.1235 mhos as shown in Table 3. This range indicates poor, moderate, good and very good aquifer protective capacities, in accordance with Oladipo and Akintoranwa (2007). The isoresistivity map of the area (Fig. 19) shows that VES 2, 3, 4, 7 and 8 located at the northern western and southern parts respectively of the study area have low resistivity values ranging from 200 Ωm to 400 Ωm, and high conductivity values, suggesting an aquiferous zone of aquiferous sand and aquiferous sandy shale respectively, while VES 1, 5 and 6 show high resistivity values ranging from 500 Ωm – 800 Ωm (Fig. 19) as a result of Ferruginous siltstone that capped the area.

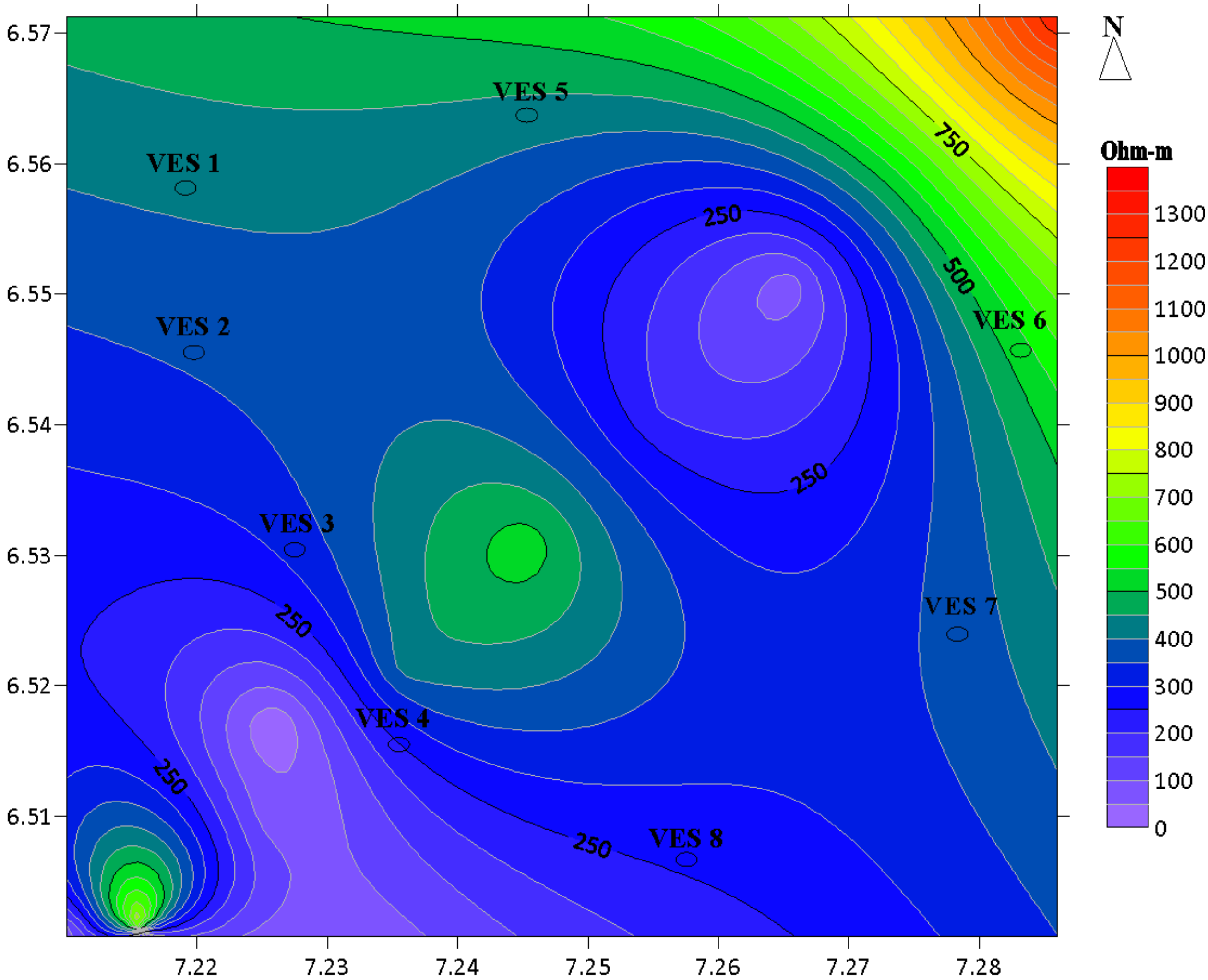

Fig. 19: Isoresistivity Map of the Study Area

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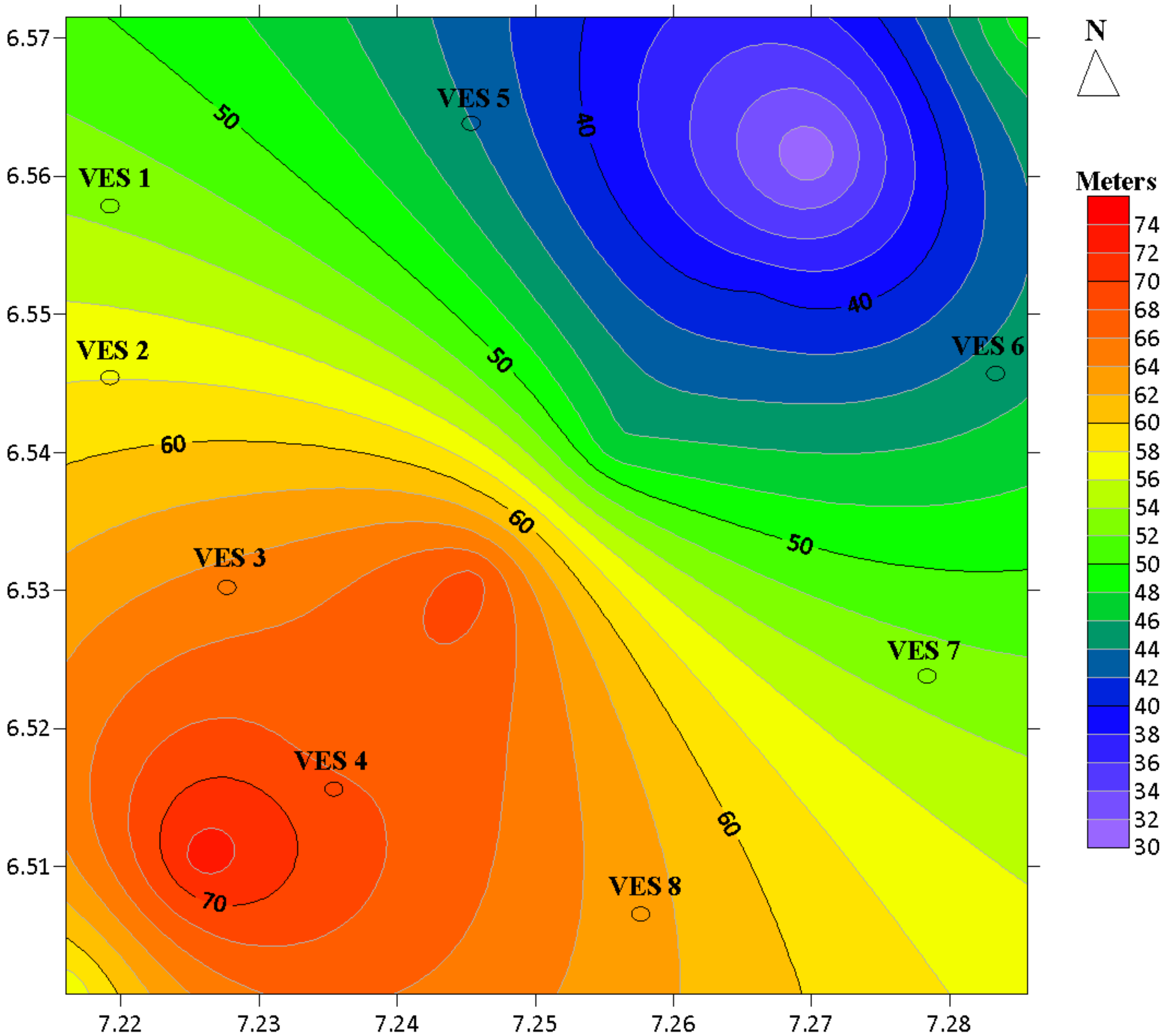

Fig. 20: Isopach Map of Aquifer Layers at Various VES Points

CONCLUSION

In this study, the groundwater potential and aquifer protective capacity of the overburden units around Old Ikenga hotel, Nsukka, Enugu State was investigated by conducting eight vertical electrical soundings. The results show that VES 1, 3, 4 and 8 have five lithologic layers while VES 2, 5, 6 and 7 have four geoelectric layers. The subsurface sequence comprises the contaminated lateritic clay, clay, shale, sandy shale, sand, sandy clay, sandstone, ferroginized siltstone, aquiferous sand and aquiferous sandy shale. The aquiferous sand and aquiferous sandy shale layers constitute the aquifer units in the area, with depth ranging from 36.10 m to 129.08 m, and thickness varying from 30 m to a maximum of 74 m. VES 3 and 4 have been identified as the best locations for productive and sustainable borehole yield because of their high aquifer thicknesses. The longitudinal conductance also varied from 0.0409 mhos to a maximum of 3.1235 mhos.

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This study also reveals that areas where VES 6 and 7 were conducted are underlain by materials of poor protective capacity, areas where VES 5 and 8 were conducted are characterized by materials of moderate protective capacity, and areas where VES 1, 3, 4 and 2 were conducted are also characterized by materials of good and very good protective capacity respectively. Areas with poor and moderate protective capacities are vulnerable to pollution that may arise from runoff water, sewage and indiscriminate waste disposal in the study area while areas with good and very good protective capacities are considered to be safe from pollution. The findings of this study will offer valuable guidance for stakeholders including local governments, water resource management agencies and the community, to make informed decisions regarding sustainable water resource management and protection strategies.

Thus, the information obtained from this study can serve as a baseline data for pre–drilling estimation of the yield of any prospective borehole in the area.

REFERENCES

Abdullahi, N.K., Udensi, E.E., Iheakanwa, A. and Eletta, B.E. Geoelectrical Method Applied to Evaluation of Groundwater Potential and Aquifer Protective Capacity of Overburden Units. *British Journal of Applied Science & Technology*. 4(14), 2024-2037, 2014.

Aristedemou, E. and A. Thomas-Betts. DC resistivity and induced polarization investigations at a waste disposal site and its environments. J. Appl. Geophys., 44: 275-302, 2000.

Eugene-Okorie, J. O., *Obiora*, D. N., *Ibuot*, J. C. and *Ugbor*, D. O. Geo Electrical investigation of groundwater potential and vulnerability of Oraifite, Anambra State, Nigeria. Journal of applied water science 10:233, 2020.

Karlik, G. and A.M. Kaya. Investigation of groundwater contamination using electric and electromagnetic methods at an open waste-disposal site: A case study from Isparta, Turkey. Environ. Geol., 40(6): 725-731, 2001.

Nzemeka O. C., Ugwu G. Z. and Onyishi G. E. (2023). Groundwater potential and aquifer protective capacity at Nkwelle – Ezunaka farm estate, Southeastern Nigeria. Journal of Geology and Mining Research 15 (1): 10-24, 2023

Obiajulu O.O. and Nwaka E.G. Aquifer vulnerability assessment in some parts of Awka, Southeastern Nigeria. IOSR Journal of Applied Geology and Geophysics 10(2): 20 – 25, 2022.

Okonkwo A.C., Ezeh C.C. and Akaerue E.I. Estimation of Aquifer Hydraulic properties and protective capacity of Overburden units from Geoelectrical sounding: case of groundwater aquifer, Nkanu – West LGA, Enugu, Nigeria. Elixir Earth Science 107: 47366 – 47370, 2017.

Okonkwo A.C. and Ugwu G.Z. Determination of Dar-zarrouk parameters for prediction of Aquifer protective capacity: A case of Agbani Sandstone Aquifer, Enugu State, Southeastern Nigeria. International Research Journal of Geology and Mining 5(2):12-19, 2015

Oladipo MI, Akintorinwa OJ. Hydrogeophysical Study of Ogbese Southwestern, Nigeria. Global J Pure and Applied Sci. 13(1) 55-61, 2007.

Olisah, N.C., Obiekezie T.N. An investigation of groundwater contamination around Nsukka municipality dumpsite using resistivity method. Scienceopen (1):22 – 33, 2020.

Onyenweife, G. I., Nwozor, K.K., Nwike, I.S., Onuba, L.N., Egbunike, M.E., and Anakor, S.N. Application of Electrical Resistivity Method in Estimating Aquifer Protective Capacity

Article DOI: 10.52589/AJENSR-NO8MPITK
DOI URL: https://doi.org/10.52589/AJENSR-NO8MPITK

of Awka and its Environs, Anambra State, Nigeria. International Journal of Innovative Environmental Studies Research 8(4):1-17, 2020

Osele, C. E., Onwuemesi, A.G., Anakwuba, E.K. and Chinwuko A.I. Application of vertical electrical sounding (VES) for groundwater exploration in Onitsha and environs, Nigeria. International Journal of Advanced Geosciences 4(1):1 – 7, 2016

Oyeku, O. T. and A. O. Eludoyin Heavy metal contamination of groundwater resources in a Nigerian urban settlement. African Journal of Environmental Science and Technology 4 (4): 201-214, 2010.

Reyment, R.A. Aspects of the Geology of Nigeria: The stratigraphy of the Cretaceous and Cenozoic deposits, Ibadan University Press, Ibadan, 145, 1965

Tahama, K., Gupta, G. and Krishnamacharyulu, S.K.G. Estimation of secondary geophysical indicators to demarcate sea water intrusion in parts of Konkan coast, Maharashtra. Journal of Applied Hydrology. 5(31):1-4, 2019.

Ugwu, G.Z. and Ezeh C.C. Estimation of aquifer characteristics using vertical electrical sounding (VES) data from Enugu State University of Science and Technology, Agbani, Nigeria. Int. J. Phys. Sci. 7(49): 6255−6262, 2012

Ugwu, G.Z., Ezema, P.O. and Ugbomeh, C.C. Geoelectrical determination of groundwater potentials of Ughelli, Delta State, Nigeria. Asian Journal of Science and Technology. 4(5):077, 2013

Zohdy A.A.R., Eaton G.P. & Mabey D. R. Application of surface geophysics to groundwater investigations. United State Geophysical Survey, Washington, 1974.

Article DOI: 10.52589/AJENSR-NO8MPITK
DOI URL: https://doi.org/10.52589/AJENSR-NO8MPITK