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Groundwater Potential Evaluation of Federal Polytechnic Ado–Ekiti Using GRRT–Index

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ABSTRACT

The Vertical Electrical Sounding (VES) data method was used to acquire data in the study area and they are presented as depth sounding curve which is obtained by plotting apparent resistivity values against electrode spacing on a log-log or bi-log graph paper. The processed data were subjected to both detailed interpretations aimed at unravelling the subsurface groundwater potential and aquifer protective capacity of overburden units in the study area. The partial curve matching of the data obtained was done and computer iteration of each VES points was processed, in other to have the geo-electrical parameters of the surveyed area for proper groundwater mapping of the area. Twenty and six VES points was acquired, the curve types are QHA, QHK, QHA, HAK, HKH, AAK, AAA. Layer 1 and 2 has relative high resistance top soil and high resistance lateritic hardpan/sandy clay. In basement complex terrains, the intermediate layer H-type is commonly water saturated and it's often characterized by high resistivity, high porosity, low specific yield and permeability which is good for groundwater. In order to have good understanding of the subsurface geology of the study area, calculations were made via the geological data, relief, resistivity values and thickness parameter obtained in the area in other to generate or obtained the potential map of the study area and this was able to reveal the lateral and subsurface information about the quantity and abundance of groundwater in the area of investigation. Based on these facts, we can conclude that water cannot be gotten from the study area of high resistivity. A similar study reveals that areas with thick overburden cover have high potential for groundwater. Consequently, areas with overburden thickness of 10m and above are good for groundwater development. Contour plot of aquifer resistivity, aquifer depth, aquifer thickness and traverse resistance were constructed.

1. Introduction

Groundwater search is necessary in basement complex because they are mostly found within fracture zones, weathered zone and they are mainly described through the distribution of permeable layers (like sand, gravel, fractured rock) and impermeable or low-permeable layers (like clay, till, solid rock) in the subsurface. The consumption of groundwater has increased and become immensely important for different water supply purposes in urban and rural areas in both developed and developing countries. However, groundwater exploration in hard rock terrain is a very challenging and difficult task, if the promising groundwater zones are associated with fractured and fissured media. In such an environment, the groundwater potentiality depends mainly on the thickness of the weathered/fractured layer overlying the basement. Most groundwater projects done in basement complex have revealed that geophysical survey as a compulsory pre-requisite to any successful borehole drilling project. Electrical Resistivity method involving the VES technique is extensively gaining application in environmental, mining, groundwater and engineering geophysical investigations.

The electrical resistivity method involving the VES technique is extensively gaining application in basement and it is effective in the search and location for a good groundwater.

2. Location and Accessibility of the Study Area

The study area is located at Federal Polytechnic, Ado-Ekiti, Ekiti State. It is accessible through Odo-Ado road, along Ijan-Ekiti. The area is bounded by Easting - E005°17.459[1] and Northing N07°36.117[1], in Universal Traverse Mercator (UTM) Minna Zone 31 as shown in Figs. 1-2. The study area is geographically located within the sub-equatorial climate belt of tropical rain-forest vegetation with evergreen and broad-leaved trees luxuriant growth layer arrangement. The area is characterized by uniformly high temperature and heavy, well distributed rainfall throughout the year. The mean annual temperature is 24 °C-27 °C, while the rainfall, mostly conventional, peaks twice in July and September and varies between 1500 mm and 3500 mm per year.

2.1. Geology of the Study Area

The study area is underlain by crystalline rocks of the Precambrian basement complex of the South-western Nigeria. The fractured bedrock generally occurs in a typical basement terrain in tropical and equatorial regions, weathering processes create superficial layers, with varying degree of porosity and permeability studies have shown that the unconsolidated overburden could constitute reliable aquifer if significantly thick. The lithological units include Migmatic gneiss complex, granitic gneiss and Charnokites. Outcrops of biotite gneiss and granitic gneiss occur in some locations around the western part of the study area. Likewise, some other boulders of granite and charnokites occur at the western flank of the study area.

3. Methodology

Data acquisition utilizes geophysical techniques which are, Electrical resistivity method utilizing vertical electrical sounding; twelve traverses were established for a detailed geo-analysis of the site investigation. Twenty-Six vertical electrical sounding was conducted along the traverses. The current electrode (AB/2) was varied from 1-120m because of the limited space of spreading.

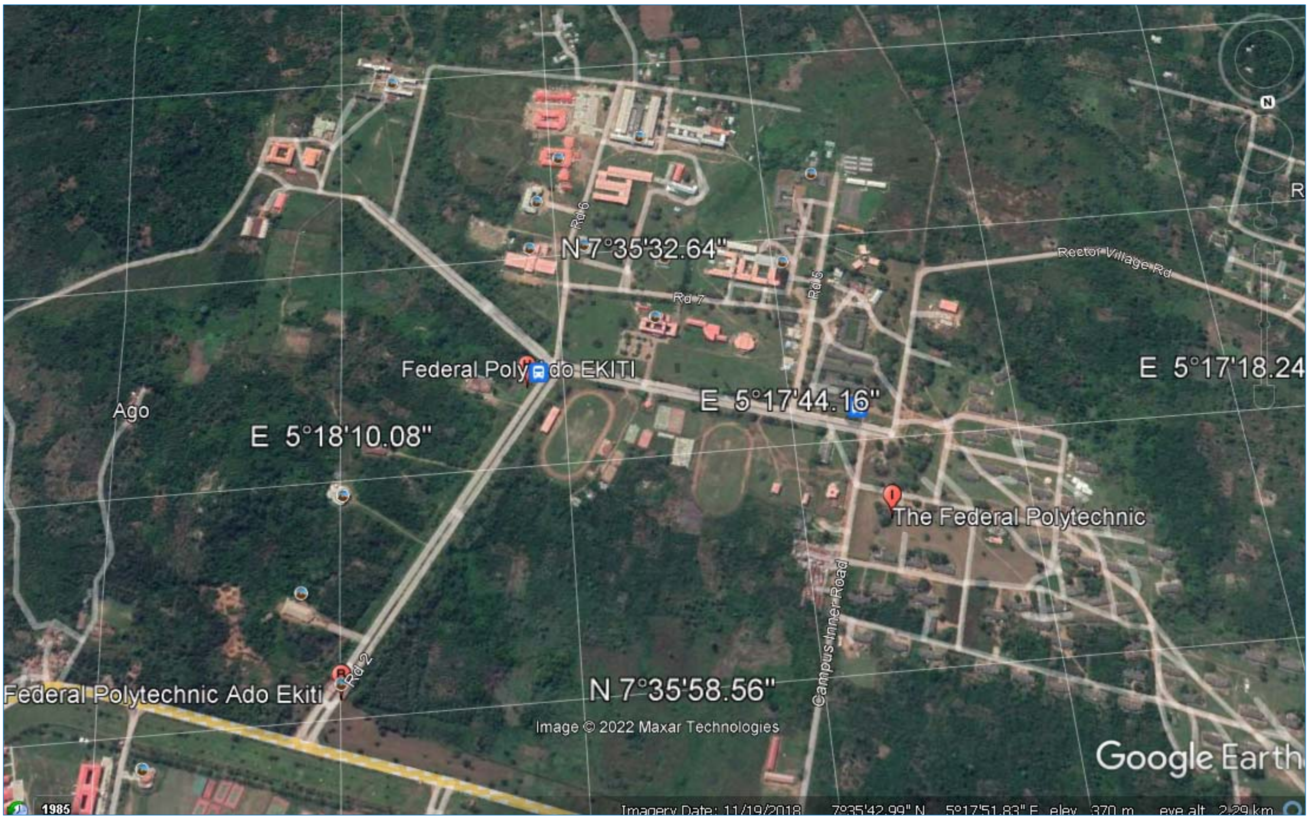

Fig. 1. Location Map of Federal Polytechnic Ado-Ekiti

Resistivity values were obtained by taking readings using Omega resistivity meter, four electrodes and connecting cables. Resistivity readings taking using the Schlumberger array was undertaken by keeping the center of the array fixed and expanding the current electrodes separation, thus obtaining the resistivity readings with depth. DC current was injected into the earth through the current electrodes C1 and C2, while the resulting potential was measured across the potential electrodes P1 and P2 and data were collected in all the area marked on the data acquisition map within the area of investigation (Fig. 3). The resulting potential difference to the current is displayed by the digital resistivity equipment as a resistance. The electrode spacing is progressively increased, keeping the center point of the electrode array fixed. At small electrode spacing, the apparent resistivity is nearly the resistivity of the surface material, but as the current electrodes spacing increase the current penetrates deeper within the subsurface and so the apparent resistivity reflects the resistivity of the deeper layers as well. The apparent resistivity values are obtained by multiplying the measured resistance with an appropriate geometric factor. Different factors affect the resistivity in the subsurface (Telford et al., 1990).

4. Results and Discussions

The apparent resistively values (ρa) were plotted against the current electrodes separation ($AB2/$) on log-log graph papers, in order to generate initial values to use for the computation of analysis and interpretation with a computer iterated software known as RESIST. The results obtained from this study are presented as tables, depth sounding curves and pseudo sections.

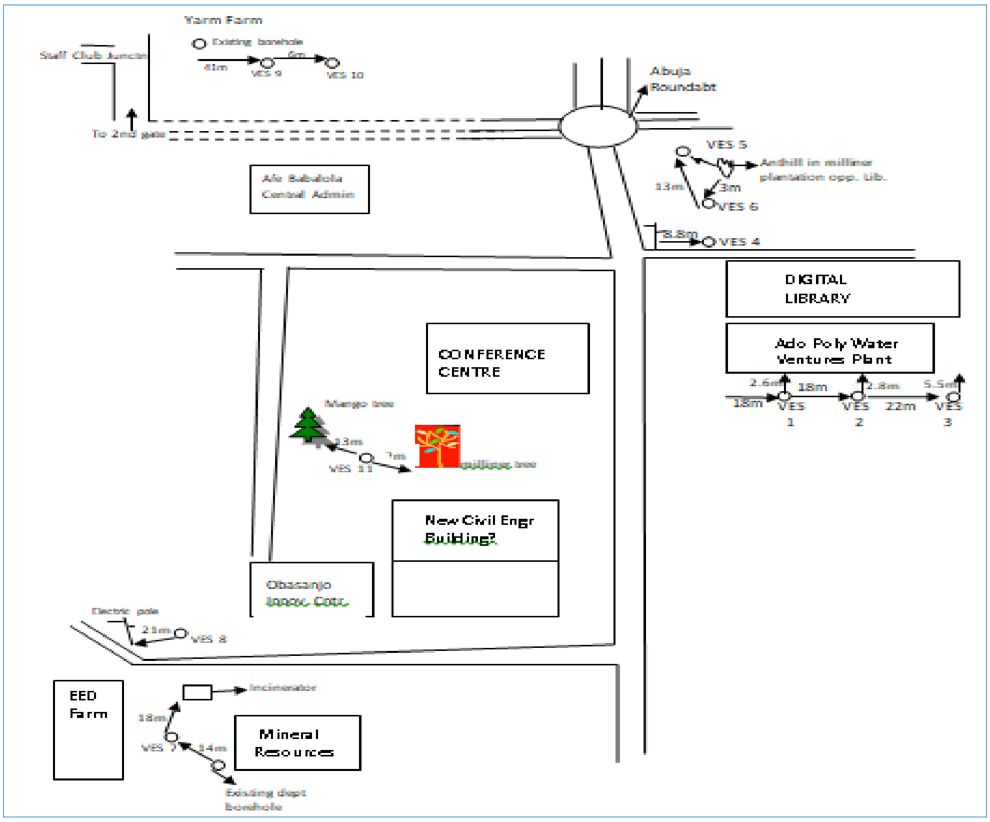

Fig. 2. Simplified topographical map of Ado-Ekiti

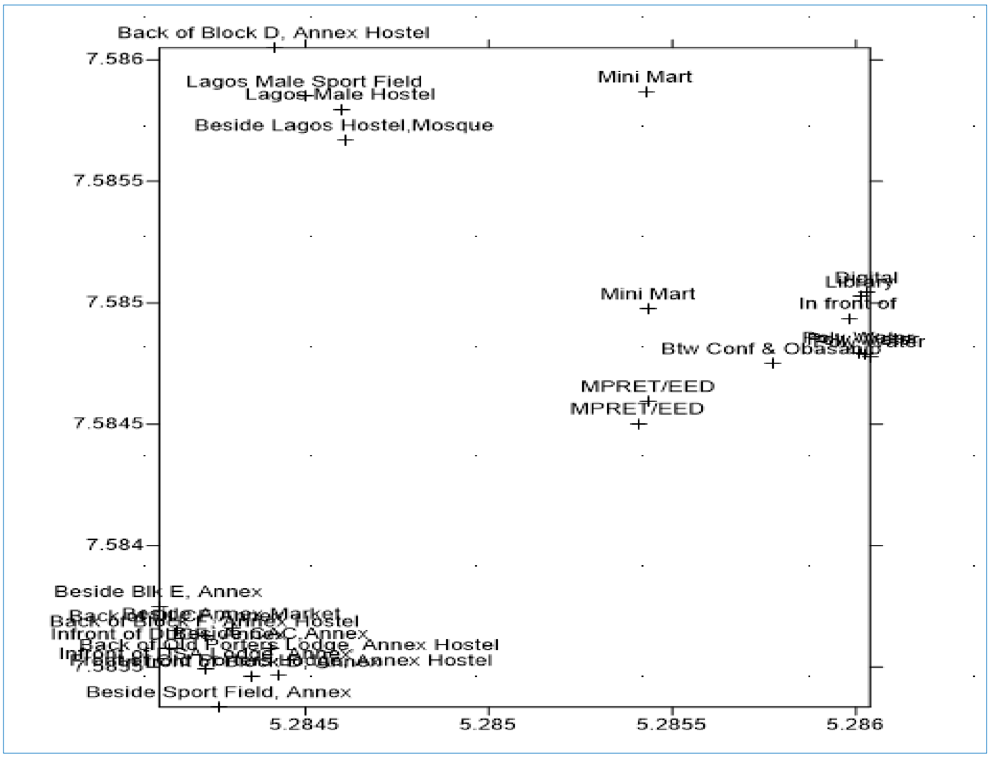

Fig. 3. Data acquisition map of the study area

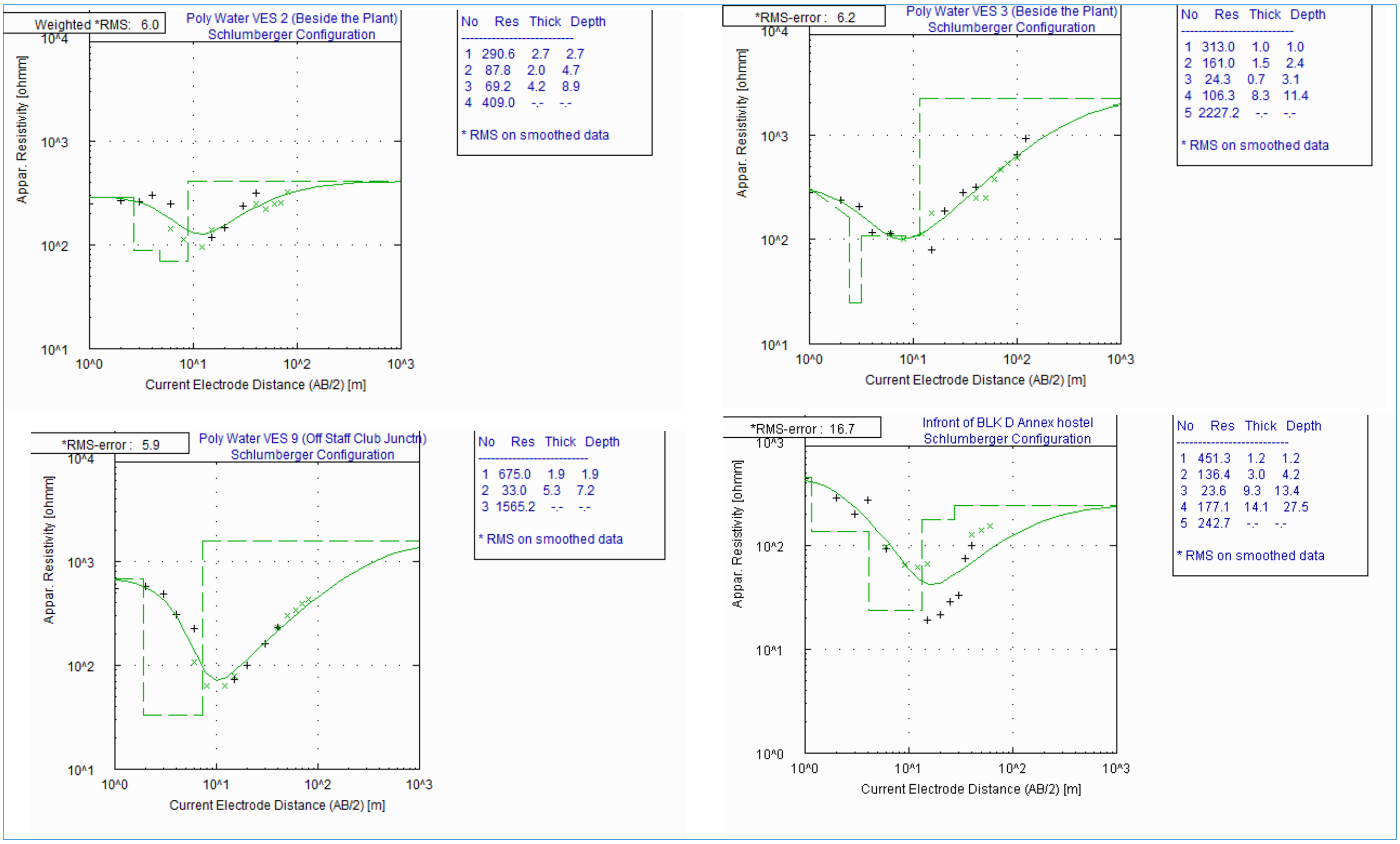

Fig. 4. Selected VES curves from the study area

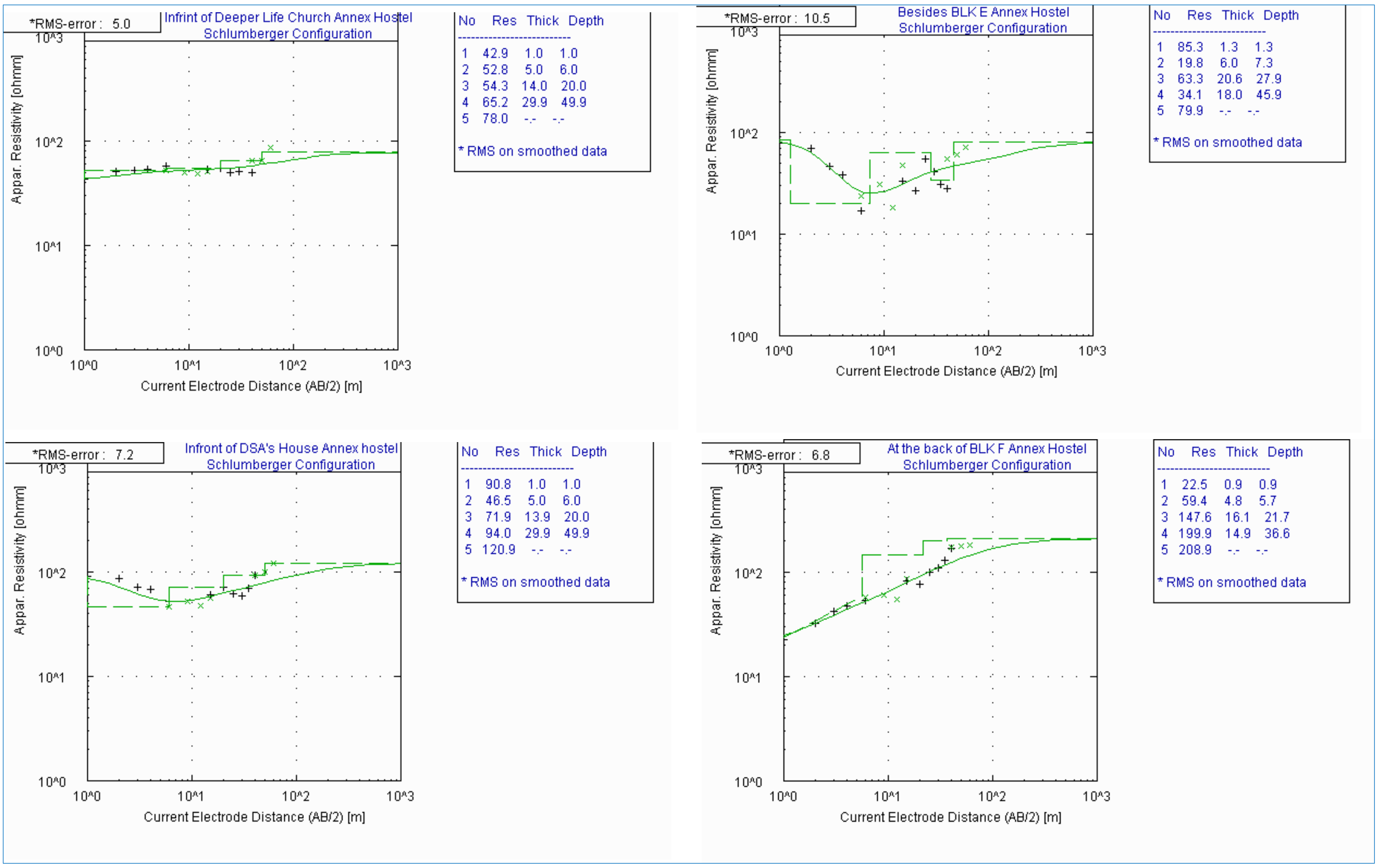

Fig. 5. Selected VES curves from the study area

4.1. Vertical Electrical Sounding Results

A total of twenty-six (26) Vertical Electrical Sounding stations were obtained, analyzed and the results of 26 VES points are presented as: sounding curves and columnar sections and contour maps. The VES data interpretation delineates three to five lithological units. These are the topsoil, lateritic layer, weathered layer and fracture zone, and fresh basement.

The results obtained from the quantitative interpretation of the sounding curves were used to generate the groundwater potential map of the site of investigation. The 26 VES sounding curves were classified into seven (7) types: QHA, QHK, QHA, HAK, HKH, AAK, AAA curves. Typical curve types are shown in Figs. 4-5 while the summary of the results i.e. the geo–electric parameters obtained from the VES curves interpretation is presented in Table 1.

Table 1. Hydrogeological interpreted parameters from VES-curve

VES	Layer No	Resistivity	Thickness	Depth	Lithological Unit	Hydrogeological Aquifer Potential
1	1	222.2	2.2	2.2	Lateritic Topsoil	
	2	18.6	7.2	9.5	Clayey formation	
	3	58.1	9.3	18.8	Sandy clay formation	
	4	74.9	12.2	31	Weathered/fracture basement	
	5	145.3	+ +	+ + +	Fresh basement	
2	1	351.6	1	1	Lateritic top soil	
	2	20.9	8.8	9.8	Clayey formation	
	3	17	13.7	23.5	Soft weathered zone Weathered basement	
	4	37.4	17.9	41.4	Fractured/fresh basement	
	5	86.9	+ + +	+ + +		
3	1	453.6	1.7	1.7	Lateritic top soil	
	2	19.6	6.2	7.9	Clayey formation	
	3	105.9	11.7	19.5	Weathered basement, weathered/fracture basement	
	4	109.2	14.7	34.2	Fresh basement	
	5	111.5	+ + +	+ + +		
5	1	967.5	1.2	1.2	Lateritic top soil	
	2	146.8	3.3	4.5	Weathered basement	
	3	51.1	7.6	12.1	Fractured basement	
	4	176.5	23.3	35.4	Fresh basement	
	5	256.2	+ +	+ +	Fresh basement	
6	1	784.6	1.3	1.3	Lateritic top soil	
	2	79	8.1	9.4	Sandy clay formation	
	3	131.1	20.9	30.3	Weathered basement	
	4	146.7	15.1	45.5	Fresh basement	
	5	108.3	+ +	+ +	Fractured/fresh basement	
7	1	508.4	1	1	Lateritic top soil	
	2	64.1	5.5	6.5	Sandy clay formation	
	3	299	19.2	25.7	Fractured/fresh basement	
	4	289.2	19.9	45.6	Fractured basement	
	5	292.9	+ +	+ +	Fresh basement	
8	1	451.3	1.2	1.2	Lateritic top soil	
	2	136.4	3	4.2	Hand pan	
	3	23.6	9.3	13.4	Clayey sand formation	
	4	177.1	14.1	27.5	Weathered basement	
	5	242.7	+ +	+ +	Fresh basement	
9	1	42.9	1	1	Top soil	
	2	52.8	5	6	Sandy clay formation	
	3	54.3	14	20	Weathered formation	
	4	65.2	29.9	49.9	Fractured/fresh basement	
	5	78	+ +	+ +	Fresh basement	
10	1	70.4	1	1	Lateritic top soil	
	2	51.8	5.2	6.2	Sandy clay formation	
	3	70.2	8.9	15.1	Weathered formation	
	4	74	29.2	44.7	Weathered/fresh basement	
	5	103.3	+ +	+ +	Fresh basement	
11	1	85.3	1.3	1.3	Top soil	
	2	19.9	6	7.3	Clayey formation	
	3	63.3	20.6	27.9	Sandy clay formation	
	4	34.1	18	45.9	Soft weathered formation	
	5	79.9	+ +	+ +	Fractured/fresh basement	
12	1	75.7	1.1	1.1	Top soil	
	2	21.7	5.1	6.2	Clayey sand formation	
	3	42.7	17.9	24	Sandy clay formation	
	4	66.1	24.7	48.8	Weathered basement	
	5	81.4	+ +	+ +	Fresh basement	
13	1	90.8	1	1	Top soil	
	2	46.5	5	6	Sandy clay formation	
	3	71.9	13.9	20	Weathered basement	
	4	94	29.9	49.9	Fractured/fresh basement	
	5	120.9	+ +	+ +	Fresh basement	

14	1	22.5	0.9	0.9	Top soil	
	2	59.4	4.8	5.7	Sandy clay formation	
	3	147.6	16.1	21.7	Weathered basement	
	4	199.9	14.9	36.6	Fresh basement	
	5	208.9	+ +	+ +	Fresh basement	
15	1	133.6	1.3	1.3	Lateritic top soil	
	2	41.8	4.9	6.2	Sandy clay formation	
	3	83.5	11.9	18.1	Weathered basement	
	4	142.4	19.3	37.3	Fresh basement	
	5	165	+ +	+ +	Fresh basement	
16	1	485	1.4	1.4	Lateritic top soil	Poor Potential
	2	243	1.1	2.5	Sandy clay	Fair Potential
	3	29	5.1	7.7	W/Basement	Good Potential
	4	**946**	∞	**>8m**	Fresh basement	Fair Potential
17	1	291	2.7	2.7	Lateritic top soil	Poor Potential
	2	88	2	4.7	Sandy clay	Fair Potential
	3	69	4.2	8.9	W/Basement	Good Potential
	4	**409**	∞	>9m	Fractured basement	Good Potential
18	1	313	1	1	Lateritic top soil	Poor Potential
	2	161	1.5.	2.5	Sandy clay	Poor Potential
	3	24	0.7	3.2	Sandy clay	Fair Potential
	4	106	8.3	11.5	W/Basement	Good Potential
	5	**2227**	∞	**>12m**	Fresh Basement	Poor Potential
19	1	529	1.5	1.5	Lateritic top soil	Poor Potential
	2	26	6.8	7.3	Sandy clay	Fair Potential
	3	**853**	∞	**>7m**	Fresh basement	Fair Potential
20	1	165	1.7	1.7	Lateritic top soil	Poor Potential
	2	76	1.2	2.9	Sandy clay	Fair Potential
	3	15	2.8	5.7	W/Basement	Good Potential
	4	**648**	∞	**>6m**	F/W Basement	Good Potential
21	1	304	1.4	1.4	Lateritic top soil	Poor Potential
	2	41	13.8	15.2	Sandy clay/W BC	Good Potential
	3	**967**	∞	**>15m**	Fresh basement	Fair Potential
22	1	772	1	1	Lateritic top soil	Poor Potential
	2	215	1.4	2.4	Sandy clay	Fair Potential
	3	43	10	12.3	W/Basement	Good Potential
	4	**644**	∞	**>12m**	Fractured basement	Good Potential
23	1	395	1.2	1.2	Lateritic top soil	Poor Potential
	2	31	6.5	7.7	Sandy clay	Fair Potential
	3	**394**	∞	**>8m**	W/Fract basement	Good Potential
24	1	675	1.9	1.9	Lateritic top soil	Poor Potential
	2	33	5.3	7.2	Sandy clay	Fair Potential
	3	**1565**	∞	**>7m**	Fresh basement	Fair Potential
25	1	1161	1.5	1.5	Lateritic top soil	Poor Potential
	2	51	8.2	9.7	Sandy clay/W BC	Fair Potential
	3	**1268**	∞	**>10m**	Fresh basement	Poor Potential
26	1	279	1	1	Lateritic top soil	Poor Potential
	2	456	1.3	2.3	Sandy clay	Poor Potential
	3	107	3.6	5.9	Sandy clay	Fair Potential
	4	28	5.6	**11.4**	W/Basement	Good Potential
	5	**685**	∞	**>11m**	Fresh basement	Poor Potential

4.2. Discussion of Results

4.2.1. Groundwater Potential Map

The groundwater potential map was generated by using the GRRT-index formula in other to know the groundwater distribution rate across the study area. It reveals that there is high to moderate groundwater potential at the South-Eastern, North-Eastern, and it extends to the south-western part of the study area. Towards the North-western and central part of the study area, it can be seen that there the groundwater potential is of low and poor rating (Fig. 6).

4.3. Aquifer Resistivity Map

Aquifer resistivity map depicts the variation in the resistivity of the weathered layers over the study area. The aquifer layer constitutes the main aquifer unit in the study area. Aquifer resistivity at the North-western and North-Eastern part of the study is relatively low. The surveyed area has very high groundwater potential at the southeastern (MPRET Building) part of the map (Fig. 7). The central part of the study area has a medium groundwater potential. The higher the resistivity, the lower the groundwater potential and the lower the resistivity, the higher the groundwater potential.

4.4. Aquifer Thickness Map

The aquifer thickness map reveals the depth to the weathered and aquifer zone beneath the sounding stations (Fig. 8). The aquifer thickness is relatively high at the North-western part of the map and extends to the South-western and central part of the map (around VES 66, 8, 61).

At the Eastern part of the map, it shows that the overburden thickness is closer to the surface (around VES 12, 13, 14, 19 and 20). The higher the overburden/aquifer thickness, the higher the groundwater potential and the lower the overburden/aquifer thickness the lower the groundwater potential, because higher or greater overburden/aquifer thickness is essential for groundwater accumulation.

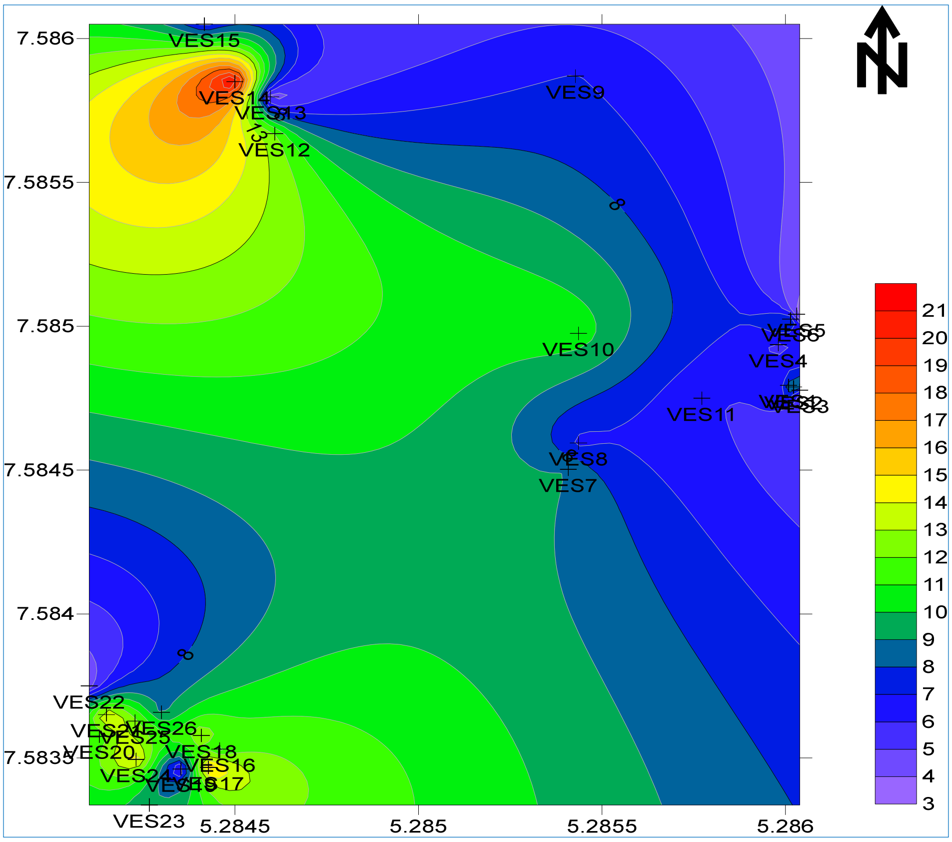

Fig. 6. Groundwater potential map of FEDPOAD using GRRT-INDEX

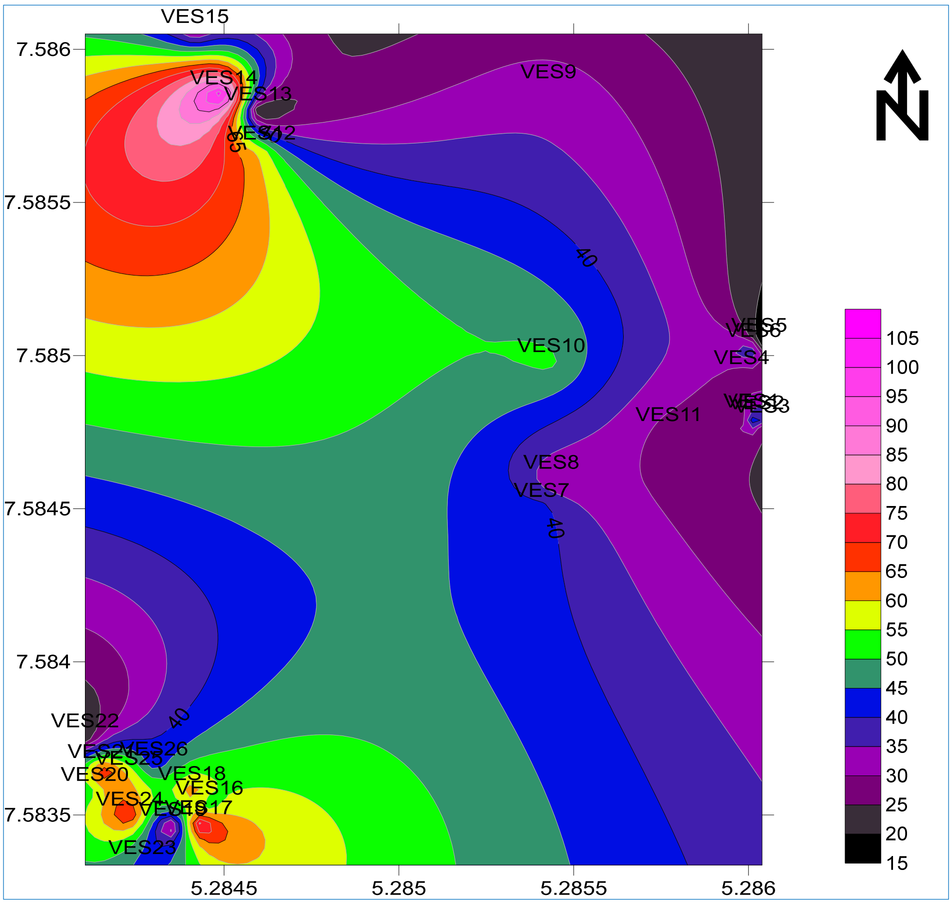

Fig. 7. Aquifer resistivity map

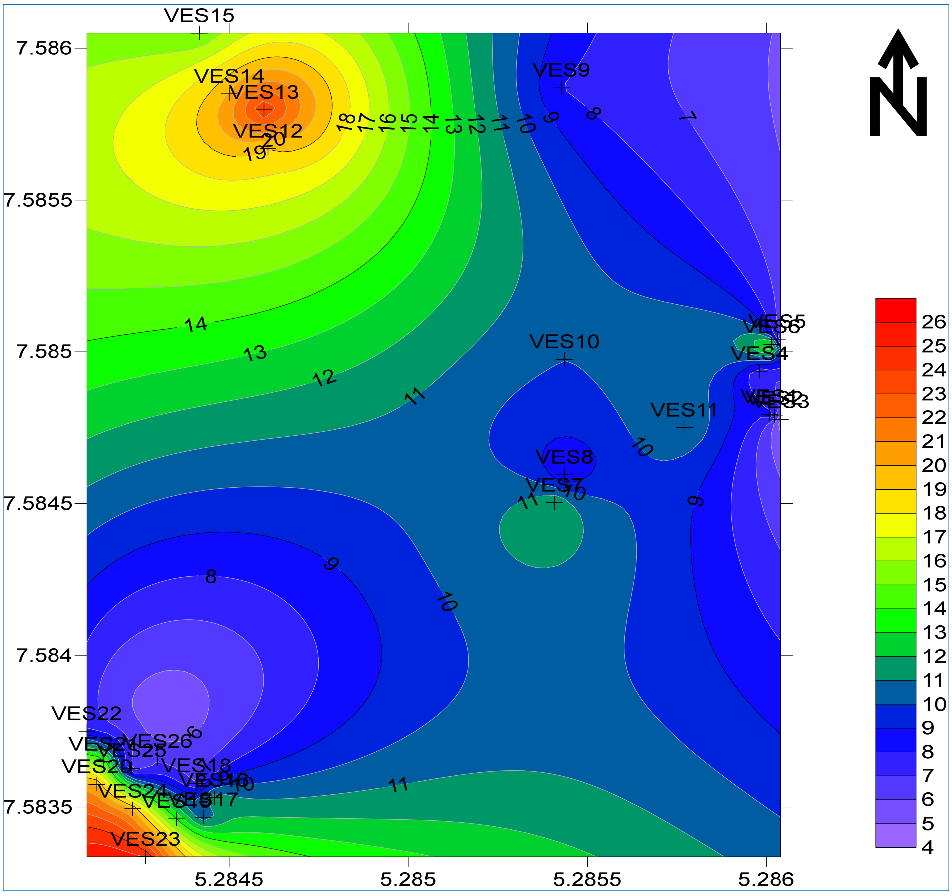

Fig. 8. Aquifer thickness map

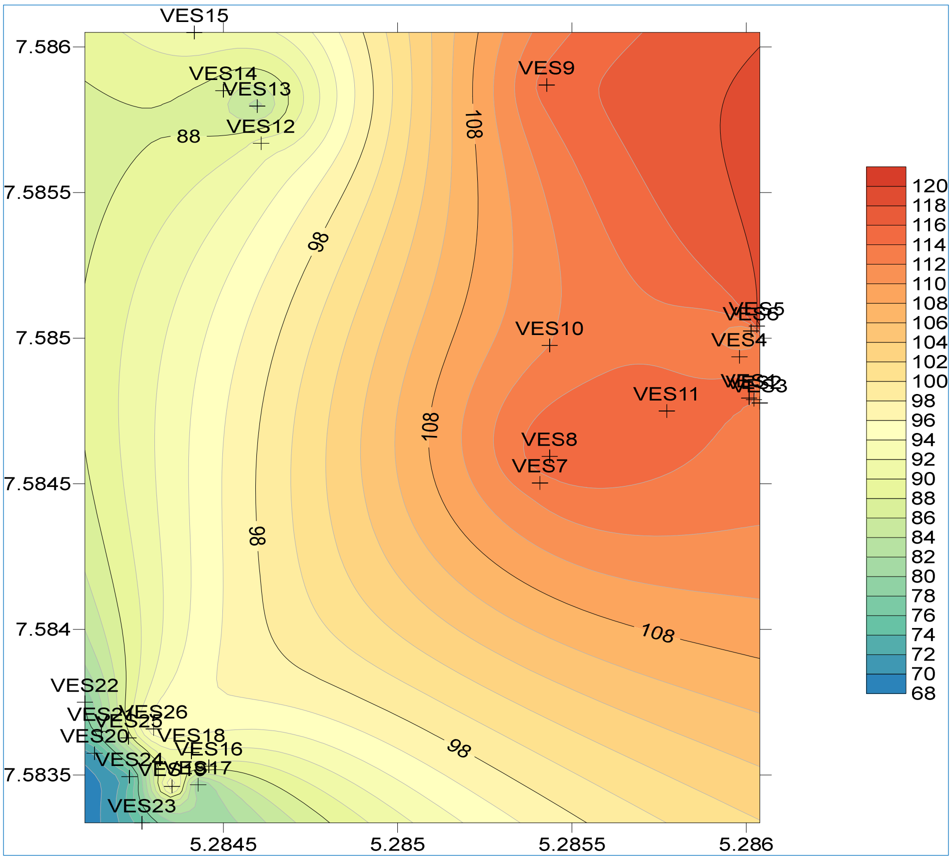

Fig. 9. Bedrock relief map

4.5. Bedrock Relief Map

The bedrock relief map reveals the depth to the fresh bedrock beneath the sounding stations. The bedrock relief is relatively high at the Northeastern part of the map and extends to the Southeastern and central part of the map (around VES 1, 2, 3, 4, 5, 7, 8, 10 and 11) which collaborate with the physical geology of the study area (Fig. 8). At the South-Eastern part of the map, it reveals that there is a valley or depression within that region (around VES 16, 18, 20 and 21)

5. Conclusion

A single geo-electric property is not enough for the prediction of groundwater potential in a basement terrain. Other authors like Chachadi (2005) and Adeyemo (2016) have used geology, resistivity, relief bedrock, and thickness geo-electric parameters rating to ascertain the groundwater potential of some study area. Therefore, the geology, resistivity, relief bedrock and thickness parameters obtained from Federal polytechnic during the survey were used to predict the groundwater potential rating of the study area and it was discovered that the Northeastern part of the survey area has a very high groundwater rating. The southwestern part has good to moderate rating, the central part of the survey area has low groundwater potential, while the North-western part has a poor groundwater rating.

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