

RESEARCH ARTICLE

GEOPHYSICAL SURVEY FOR GROUNDWATER IN PART OF OBIO/AKPOR LOCAL GOVERNMENT AREA OF RIVERS STATE, NIGERIA

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ABSTRACT

This research is aimed at carrying out geophysical survey for groundwater in parts of Obio/Akpo Local Government Area of Rivers State, Nigeria, using the Schlumberger electrode configuration of vertical electrical sounding (VES) technique. The field data were obtained using ABEM terrameter SAS1000 which was applied on eight VES location, a maximum distance of 300m current electrode spacing was used in the eight vertical electrical sounding points. Data acquired were interpreted using IPIN2Win 2022 version and Surfer13 softwares. The results obtained showed a 4-layers type A curve for Rumuepirikom and Rumuolumini VES locations, 5-layers type A curve for Rumuosi VES location, 4 and 5-layers type H curve for Ozuoba and Eneka VES locations respectively, 5-layers type K curve for Egbelu VES location and 4-layers type HK curve for Rukpoku and Rumuola VES locations. The apparent resistivity values range from 29.3344 – 252898.2075Ωm for Egbelu, 22.6195 – 674.0601Ωm for Rukpoku, 1.0631 – 230.9071Ωm for Rumuepirikom, 29.5833 – 600.8296Ωm for Rumuosi, 32.9867 – 561.5283Ωm for Rumuola, 29.0597 – 458.4212Ωm for Ozuoba, 29.0597 – 134.0413Ωm for Rumuolumini and 71.2094 – 338.1611Ωm for Eneka VES locations, and shows that Rumuepirikom and Rumuolumini are the most groundwater potential zones, thus will yield sufficient groundwater to wells, while Egbelu and Rukpoku are the least groundwater potential zones, thus will not yield sufficient groundwater to wells. The knowledge of this study can be applied in groundwater resources management, hydrological studies and regional town planning programs.

KEYWORD

Geoelectric, Groundwater, Aquifer, Transmissivity, Aquiclude

1. INTRODUCTION

Groundwater is an indispensable nature's hidden treasure, its exploration and exploitation has continued to remain an important issue due to its high demand. It is water beneath the earth's surface in pores and fractures of soil and rocks (McKinney, 2015). Groundwater is ubiquitous but its availability in economic quantity may depend solely on the distribution of the subsurface earth-materials called aquifers. Aquifer being the underground layer of water-bearing zone is also a body of porous rock or sediment saturated with groundwater. Aquifer is described by depth, thickness, transmissivity and hydraulic conductivity through the process of recharge and discharge via water cycle (Onyeweife *et al.*, 2020).

Water occurs naturally as moisture, in the upper part of the atmosphere as dew, on the earth's surface as stream, river, oceans, lakes springs etc, but yet none is much less vulnerable to contamination and hygienic as groundwater because it has an excellent natural microbiological quality and generally adequate chemical quality for most uses (Fetter, 2001).

Geophysical surveys are usually employed to locate potential zones of groundwater. Among the different and active geophysical methods, electrical resistivity prospecting has acquired greatest importance in groundwater investigations and this is due to the fact that, it is the only geophysical method wherein the presence of groundwater affects the physical property measured (Narasimha-Prasad, 2011). The resistivity of water bearing rocks largely depends on the amount of water they contain, the chemical composition and temperature, and the distribution of water.

In addition, this method also provides variety of measuring procedures (in the form of different electrode configurations) that enhance the utility of this method (CGWB, 1995).

Geo-electrical survey involves the detection of the surface effects produced by the electric current in the subsurface. This technique has been used in a wide range of geophysical investigations, permafrost mapping and geological mapping. Electrical methods are generally classified according to the energy source involved, which could be natural or artificial methods (Jatau *et al.*, 2013). Electrical resistivity technique is an effective tool in delineating areas of good potential for groundwater development (Onimisi *et al.*, 2013).

2. AREA OF STUDY

Obio/Akpor Local Government area is situated in the Eastern Niger Delta Basin, covers 260km², and is generally a lowland area with average elevation below 30m above sea level. It is located between latitudes 4°45'N and 4°60'N and longitudes 6°50'E and 8°00'E, it is one of the two Local Government Areas in Port Harcourt metropolis, Rivers State. Obio/Akpor is bounded by Ikwerre and Etche to the North, Port Harcourt to the South, Oyigbo and Eleme to the East and Emohua to the West as shown in Figure 1. Obio/Akpor Local Government Area is one of the Agricultural Zones of Agricultural Development Programs of Rivers State (Ibemere and Ezeano, 2014). Crop farming (e.g yam, cassava and vegetables) is the principal source of livelihood. There are also rivers, streams, and creeks which make fishing one of the occupations.

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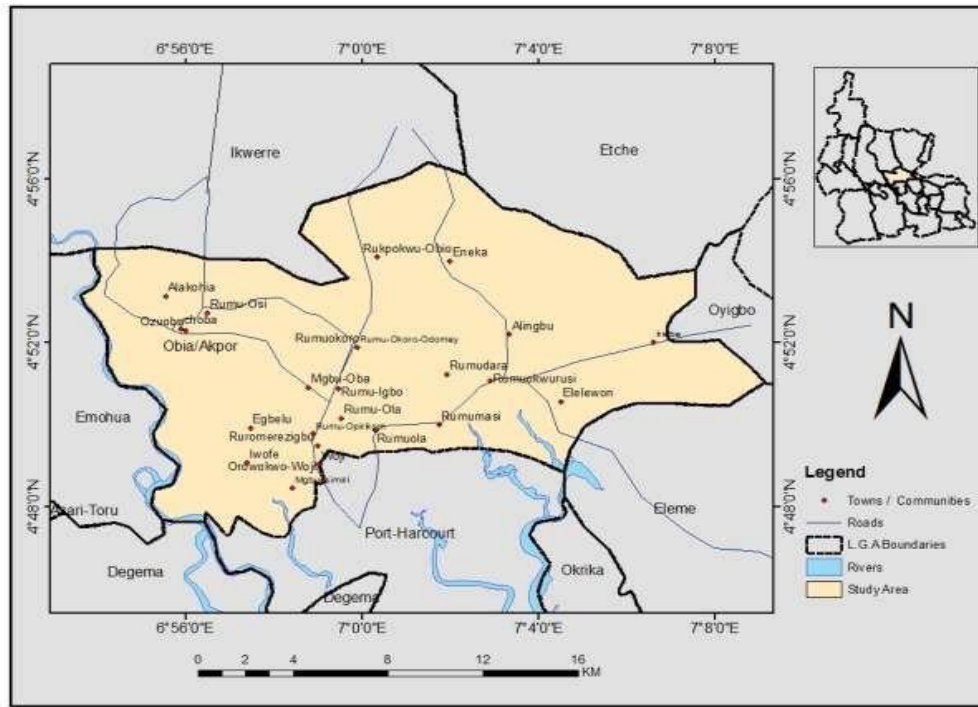


Figure 1: Map of the Area of Study. Source: (Wizor, 2020)

3. MATERIALS AND METHODS

3.1 Materials

Materials used in carrying out the vertical electrical sounding within the study area include: Abem terremater SAS 1000B, a pair of current and potential electrodes, measuring tapes, hammer, reels of wire, 12 volts battery, four interconnected wires, global positioning system (GPS) and field data recording sheet.

3.2 Methods

3.2.1 Vertical Electrical Sounding (VES) Data Acquisition

Vertical Electrical Sounding (VES) using Schlumberger electrode configuration was carried out with the use of Abem terrameter SAS 1000B. The pairs of current and potential electrodes, in line but at different spacing are pushed to about 10cm into the ground, this is to establish close electrical contact with the ground surface.

After taking measurement or the reading on the meter for the values of current and potential difference (voltage) and knowing the Geometric factor for the configuration, the value of the apparent resistivity, (ρ_a) is then calculated using the equation below;

$$\rho_a = \frac{\pi L^2}{2l} \left(\frac{\Delta V}{I} \right) = KR \quad (1)$$

Where $K = \frac{\pi L^2}{2l}$ = Geometric factor

$R = \frac{\Delta V}{I}$ = Resistance

3.2.2 Vertical Electrical Sounding (VES) Data Interpretation

Vertical Electrical Sounding (VES) is one of the most widely used and relevant geophysical techniques for groundwater investigation studies and basement terrains. In geophysical survey for groundwater, the relevance of this technique is based on the resistivity contrast between the weathered layer and the fractured layer of the subsurface which contains water.

The interpretation of vertical electrical sounding data depends on resistivity contrast, values of the apparent resistivity are plotted against the values of half current electrode spacing ($\frac{1}{2}AB$) and thereafter resistivity curves for each vertical electrical sounding (VES) locations are generated and classified into types. The classification is primarily made on the basis of the shapes of the curves but it relates to the geological situation in the subsurface. The sounding curves differ from location to location due to difference in geology of the area and the graphs give insight or idea of the number of layers of the subsurface explored.

4. RESULTS AND DISCUSSION

4.1 Results

The results of the geophysical survey carried out in the area of study using Schlumberger electrode configuration of vertical electrical sounding (VES) are presented in Tables 1 – 4 for the various points, VES sounding curves are presented in Figures 2 – 5 whereas aquifer resistivity map and aquifer thickness map are shown in Figures 6 and 7 respectively.

Table 1: Results of Vertical Electrical Sounding (VES) of Egbelu

S/N	AB/2 (m)	MN/2 (m)	Geometric Factor, K	Resistance (Ω)	App. Resistivity (Ωm)
1	1.00	0.30	5.2360	5.710	29.8976
2	1.50	0.30	11.7809	2.490	29.3344
3	2.00	0.30	20.9440	1.794	37.5735
4	2.50	0.30	32.7249	1.131	37.0119
5	3.20	0.50	32.1699	1.795	57.7449
6	4.00	0.50	50.2655	0.788	39.6092
7	5.00	0.50	78.5398	1.078	84.6659
8	6.00	0.50	113.0973	0.790	89.3469
9	7.00	1.00	76.9690	1.285	98.9052
10	8.00	1.00	100.5310	1.027	103.2453
11	10.00	1.00	157.0796	0.799	125.5066

Table 1: Results of Vertical Electrical Sounding (VES) of Egbelu					
12	12.00	1.00	226.1947	0.596	134.8120
13	12.00	1.50	150.7964	0.849	128.0261
14	15.00	1.50	235.6194	0.607	143.0209
15	20.00	1.50	418.8790	0.473	198.1298
16	20.00	2.50	251.3274	0.480	120.6372
17	25.00	2.50	392.6991	0.371	145.6914
18	30.00	2.50	565.4867	0.352	199.0513
19	30.00	5.00	282.7433	0.394	111.4009
20	40.00	5.00	502.6548	0.358	179.9504
21	50.00	5.00	785.3982	0.304	238.7611
22	50.00	7.50	523.5988	0.320	167.5516
23	60.00	7.50	753.9822	0.388	292.5451
24	70.00	7.50	1026.2536	0.633	649.6185
25	70.00	10.00	769.6902	0.512	394.0814
26	80.00	10.00	1005.3096	0.574	577.0477
27	100.00	10.00	1570.7963	0.450	706.8583
28	120.00	10.00	2261.9467	0.352	796.2052
29	120.00	15.00	1507.9645	0.358	539.8513
30	150.00	15.00	2356.1945	0.460	1083.8495

Table 2: Results of Vertical Electrical Sounding (VES) of Rukpokwu					
S/N	AB/2 (m)	MN/2 (m)	Geometric Factor, K	Resistance (Ω)	App. Resistivity (Ωm)
1	1.00	0.30	5.2360	15.630	81.8687
2	1.50	0.30	11.7809	6.650	78.3429
3	2.00	0.30	20.9440	3.180	66.6019
4	2.50	0.30	32.7249	1.907	62.4064
5	3.20	0.50	32.1699	2.190	70.4521
6	4.00	0.50	50.2655	1.344	67.5568
7	5.00	0.50	78.5398	0.854	67.0729
8	6.00	0.50	113.0973	0.553	62.5428
9	7.00	1.00	76.9690	1.071	82.4338
10	8.00	1.00	100.5310	0.836	84.0439
11	10.00	1.00	157.0796	0.564	88.5928
12	12.00	1.00	226.1947	0.412	93.1922
13	12.00	1.50	150.7964	0.683	102.9934
14	15.00	1.50	235.6194	0.475	111.9192
15	20.00	1.50	418.8790	0.358	149.9587
16	20.00	2.50	251.3274	0.606	152.3044
17	25.00	2.50	392.6991	0.557	218.7334
18	30.00	2.50	565.4867	0.437	247.1177
19	30.00	5.00	282.7433	0.554	156.6398
20	40.00	5.00	502.6548	0.387	194.5274
21	50.00	5.00	785.3982	0.240	188.4956
22	50.00	7.50	523.5988	0.344	180.1179
23	60.00	7.50	753.9822	0.228	171.9074
24	70.00	7.50	1026.2536	0.209	214.4870
25	70.00	10.00	769.6902	0.1379	133.8491
26	80.00	10.00	1005.3096	0.1405	141.2459
27	100.00	10.00	1570.7963	0.139	218.3407
28	120.00	10.00	2261.9467	0.153	346.0778
29	120.00	15.00	1507.9645	0.447	674.0601
30	150.00	15.00	2356.1945	0.274	645.5972

Table 3: Results of Vertical Electrical Sounding (VES) of Rumuepirikom					
S/N	AB/2 (m)	MN/2 (m)	Geometric Factor, K	Resistance (Ω)	App. Resistivity (Ωm)
1	1.00	0.30	5.2360	1.1000	5.7596
2	1.50	0.30	11.7809	2.2300	26.2714
3	2.00	0.30	20.9440	1.1030	23.1012
4	2.50	0.30	32.7249	0.6240	20.4203
5	3.50	0.50	32.1699	0.6610	21.2643
6	4.00	0.50	50.2655	0.3500	17.5929
7	5.00	0.50	78.5398	0.1908	14.9854
8	6.00	0.50	113.0973	0.1083	12.2484
9	7.00	1.00	76.9690	0.1561	12.0149
10	8.00	1.00	100.5310	0.0901	9.0578
11	10.00	1.00	157.0796	0.0093	1.4608
12	12.00	1.00	226.1947	0.0047	1.0631
13	12.00	1.50	150.7964	0.0591	8.9121
14	15.00	1.50	235.6194	0.0199	4.6888
15	20.00	1.50	418.8790	0.0077	3.2254
16	20.00	2.50	251.3274	0.0260	6.5345
17	25.00	2.50	392.6991	0.0100	3.9269
18	30.00	2.50	565.4867	0.0302	17.0777
19	30.00	5.00	282.7433	0.0217	6.1355
20	40.00	5.00	502.6548	0.0152	7.6404
21	50.00	5.00	785.3982	0.0187	14.6869
22	50.00	7.50	523.5988	0.0642	33.6150
23	60.00	7.50	753.9822	0.1079	81.3547
24	70.00	7.50	1026.2536	0.01031	10.5807
25	70.00	10.00	769.6902	0.0336	25.8616
26	80.00	10.00	1005.3096	0.0589	59.2127
27	100.00	10.00	1570.7963	0.0653	102.5729
28	120.00	10.00	2261.9467	0.0743	168.0626
29	120.00	15.00	1507.9645	0.0726	109.4782
30	150.00	15.00	2356.1945	0.0980	230.9071

Table 4: Results of Vertical Electrical Sounding (VES) of Rumuolumini

S/N	AB/2 (m)	MN/2 (m)	Constant (k)	Resistance (Ω)	App. Resistivity (Ωm)
1	1.00	0.30	5.2350	11.70	61.2495
2	1.50	0.30	11.7809	6.39	75.2799
3	2.00	0.30	20.9440	6.08	127.3395
4	2.50	0.30	31.7249	2.80	88.8297
5	4.00	0.50	50.2655	2.26	113.6000
6	5.00	0.50	78.5398	1.36	106.8141
7	7.00	0.50	76.9690	0.633	48.7214
8	8.00	1.00	100.5310	0.834	83.8429
9	10.00	1.00	157.0796	0.484	76.0265
10	12.00	1.00	226.1947	0.314	71.0251
11	15.00	1.50	235.6194	0.274	64.5597
12	20.00	1.50	251.3274	0.132	33.1752
13	25.00	2.50	392.6991	0.107	42.0188
14	30.00	2.50	565.4867	0.077	43.5425
15	40.00	5.00	502.6548	0.099	49.7628
16	50.00	5.00	785.3982	0.037	29.0597
17	70.00	10.00	769.6902	0.056	43.1027
18	80.00	10.00	1005.3096	0.043	43.2283
19	100.00	10.00	1590.7963	0.026	41.3607
20	120.00	15.00	1507.9645	0.06	90.4779
21	150.00	15.00	2356.1945	0.04	94.2478

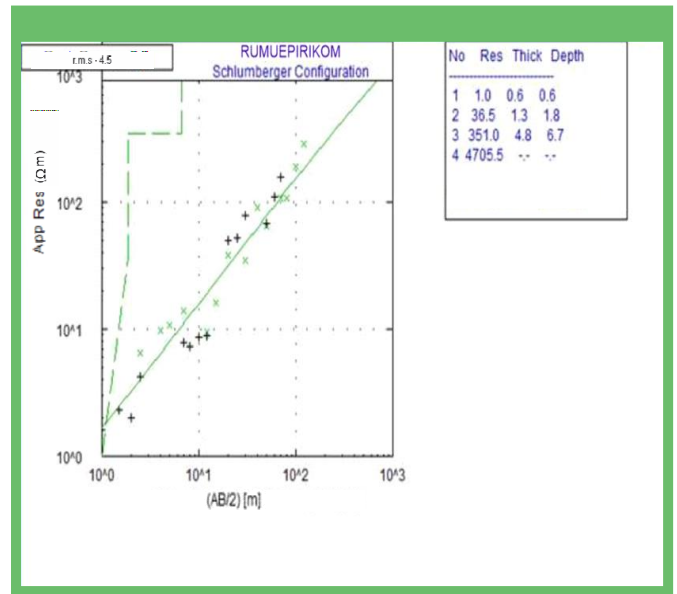


Figure 4: Sounding Curve for Rumuepirikom VES

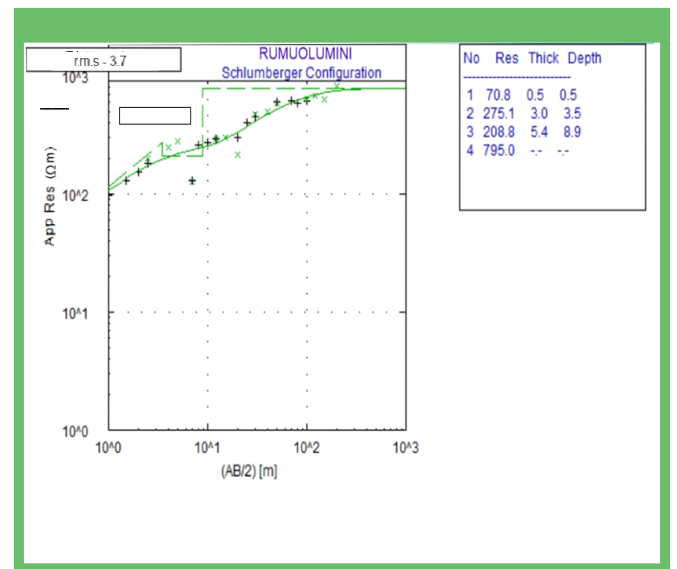


Figure 5: Sounding Curve for Rumuolumini VES

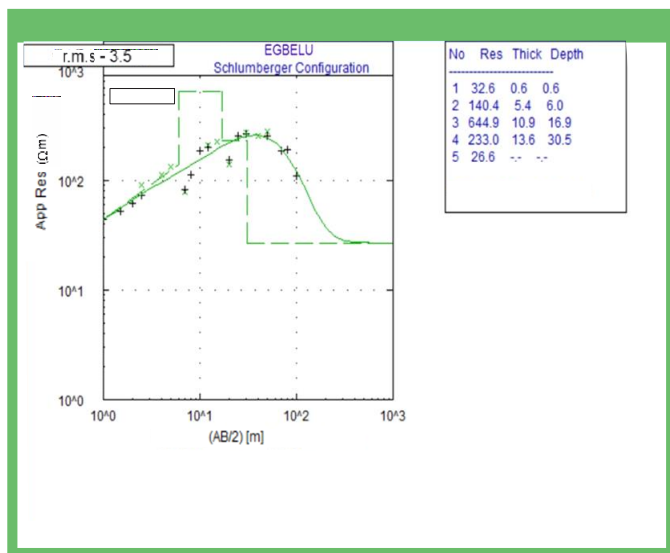


Figure 2: Sounding Curve for Egbelu VES

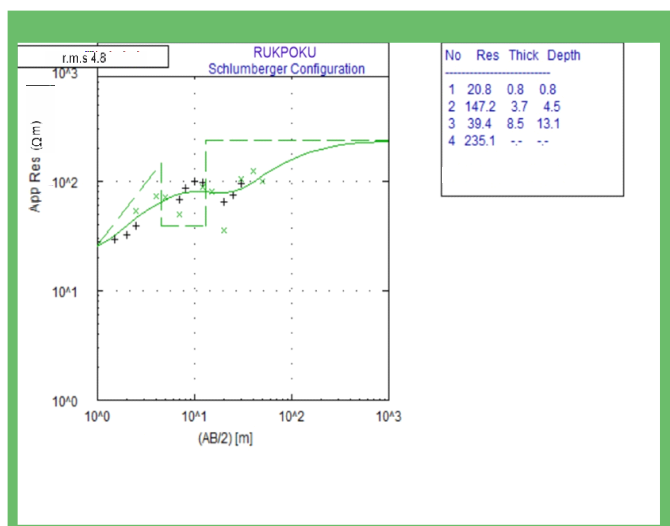


Figure 3: Sounding Curve for Rukpoku VES

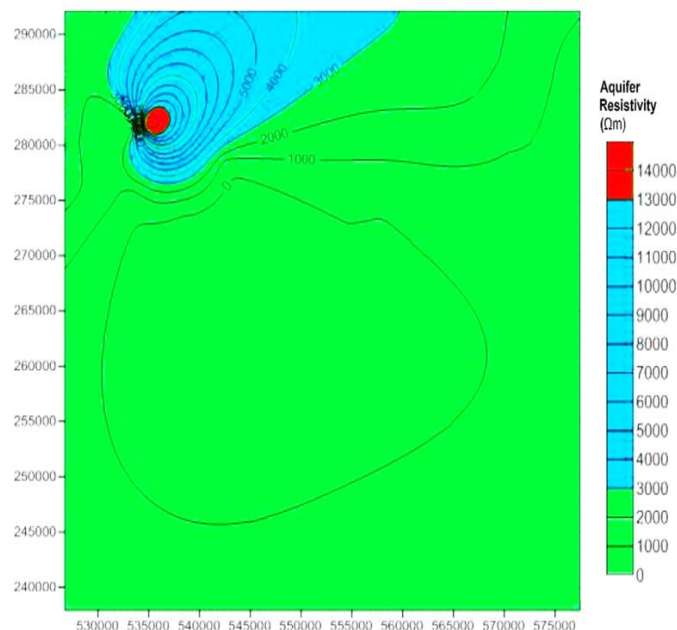


Figure 6: Aquifer Resistivity Map

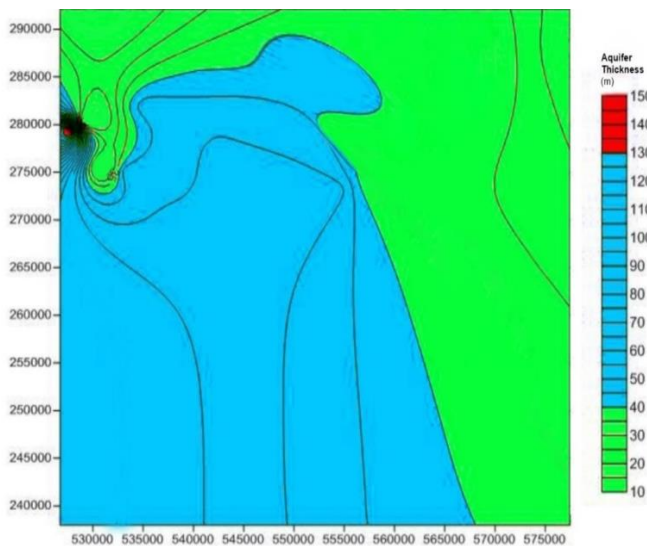


Figure 7: Aquifer Thickness Map

4.2 Discussion

4.2.1 Resistivity of Aquifer of the Study Area

Resistivity is an important parameter while investigating the groundwater potential of an aquifer, as low resistivity indicates the presence of water whereas high resistivity indicates the absence of water. The values of the resistivity of aquifer and the spatial points of the vertical electrical sounding (VES) area were plotted using Surfer13 software and iso-resistivity map showing the distribution of resistivity within the study area was generated (Figure 6). The red coloured areas represent the zones with high resistivity values which indicate zones of low groundwater potential, green coloured areas represent the zone with low resistivity values which indicate the zones with high groundwater potential whereas blue coloured area has moderate groundwater potential.

From the values of apparent resistivity which ranges from 29.3344 – 252898.2075 Ω m for Egbelu, 22.6195 – 674.0601 Ω m for Rukpoku, 1.0631 – 230.9071 Ω m for Rumuepirikom, 29.5833 – 600.8296 Ω m for Rumuosi, 32.9867 – 561.5283 Ω m for Rumuola, 29.0597 – 458.4212 Ω m for Ozuoba, 29.0597 – 134.0413 Ω m for Rumuolumini and 71.2094 – 338.1611 Ω m for Eneka VES locations, it shows that Rumuepirikom and Rumuolumini are the most groundwater potential zones, thus will yield sufficient groundwater to wells while Egbelu and Rukpoku are the least groundwater potential zones, thus will not yield sufficient groundwater to wells.

4.2.2 Thickness of Aquifer of the Study Area

Figure 7 shows the aquifer thickness map generated for the area of study, it shows the variation or distribution of aquifer thickness within the area of study.

The aquifers are categorized into three; namely thick aquifer which has a thickness range from 10 – 40m, thicker aquifer which has a thickness range from 41 – 130m and thickest aquifer which has a thickness range from 131 – 160m.

The depth to the aquifer is between 9.1 and 257.4m across the entire area of study. The depth to the aquifer was observed to be shallower at Rumuepirikom, Rumuolumini, Ozuoba and Rukpoku VES locations, with an average depth of about 14.28m. The deepest aquifer is about 257.4m depth and is at Eneka VES location which lie around the zone of the thickest aquifer.

The thickest aquifer in the study area is suitable for the groundwater exploration and exploitation due to its greater depth and is presumably free from sewage and surface contaminations.

4.2.3 Vertical Electrical Sounding (VES) Curves

The vertical electrical sounding (VES) curve types obtained from the study area are 4-layers geoelectric section type A curve for Rumuepirikom and

Rumuolumini VES locations, 5-layers geoelectric section type A curve for Rumuosi VES location, 4 and 5-layers geoelectric section type H curve for Ozuoba and Eneka VES locations respectively, 5-layers geoelectric section type K curve for Egbelu VES location and 4-layers geoelectric section type HK curve for Rukpoku and Rumuola VES locations (Figures 2 – 5).

5. CONCLUSION

Base on the results obtained from this research, the following conclusions are drawn:

- i. Water boreholes drilled within Rumuolumini and Rumuepirikom areas will yield sufficient groundwater due to high potential nature of the aquifer and this could be compensated by high level of groundwater recharge whereas water boreholes drilled within Egbelu and Rukpoku areas will not yield sufficient groundwater due to low potential nature of the aquifer.
- ii. The depth to the aquifers of Rumuepirikom, Rumuolumini and Ozuoba were observed to be shallower. This is due to the presence Rivers within those VES locations.
- iii. The depth to the aquifer of Eneka was observed to the deepest and lies around the zone of location of thickest aquifers.
- iv. The results of resistivity of aquifer categorisation made in this research also agrees with that of Akintorinwa (2015), which states that 'Zones where resistivity ranges from 100 to 250 Ω m, is classified as high groundwater potential, zones with resistivity range from 250 to 500 Ω m are classified as medium groundwater potential while zones with resistivity >>500 Ω m are classified as low groundwater potential'

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