GEOELECTRIC EVALUATION OF GROUNDWATER POTENTIAL IN THE SEDIMENTARY REGION OF ABAVO, DELTA STATE AND URHONIGBE, EDO STATE, NIGERIA

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ABSTRACT

Geoelectrical survey using Vertical Electrical Sounding (VES) was carried out at Abavo, Delta State and Urhonigbe, Edo State in order to determine the groundwater potentials of the areas and the lithological settings in terms of aquifer distribution. The Schlumberger electrode configuration was adopted with a maximum current electrode separation of 1.2km. A total of 12 VES, 6 each for the two communities distributed in 12 different locations were carried out. The data was interpreted by computer aided iteration techniques where the geoelectric model parameters and curves were obtained. The result of the interpretation shows three to six distinct geoelectric layers namely, topsoil, laterite, clayey sand, clay, sand and white gravel as the case may be. Locations 1, 2 and 4 at Abavo have very good aquifers with thickness 19.1m, 130.0m and 24.4m respectively while for Urhonigbe, locations 9 and 11 have very good aquifers having thickness of 54.8m and 18.8m respectively. In case of sitting boreholes, these five locations are recommended in the two communities. Some boreholes drilled within these locations correlate very well with VES result.

Keywords: *VES, geoelectric Sections, Lithology, aquifer, resistively, resistivity sounding.*

1. INTRODUCTION

Of all the surface geophysical methods, electrical resistivity has been employed most for groundwater exploration (Egbai, 2011(a). This is because the equipment is portable, simple, field logistics are easy and straight forward and the analysis of data is economical and less tedious than other methods (Zhody et al 1993, Egbai 2011(a). Groundwater is the water that lies beneath the ground surface, filling the pore space between grains in bodies of sediment and elastic sedimentary rocks and filling cracks and crevices in all types of rocks (Plummer et al, 1999). It occurs beneath the surface of the earth within saturated zones where the hydrostatic pressure is equal to or greater than atmospheric pressure. Nearly all the water in the ground comes from precipitation that has soaked into the earth. Observations have shown that a good deal of rainfall runs off over the surface of the ground in rills and streams. Finally, some part of it sinks underground and becomes the groundwater responsible for springs, caves and wells. (Egbai and Asokhia, 1998).

For resistivity measurements, various electrode arrays can be utilized. However, if the earth is assumed to be horizontally stratified, isotropic and homogeneous media such that the change of resistivity is a function of depth, the Schlumberger configuration is the most widely used array. As a result of this, the Schlumberger array has been chosen for the purpose of this research (Egbai and Asokhia, 1998). It has added advantages over other arrangements. The array is less sensitive to the influence of near-surface lateral heterogeneities. Smoothing and interpretation techniques are much more developed than other arrays.

The inhabitants of Abavo and Urhonigbe communities depend mostly on river Orogodo (5km away from the two towns) for drinking and domestic use and there are high cases of water borne diseases, which are as a result of lack of portable drinking water. This current hardship suffered by the two communities is due to increase in population, industrial development, and lack of suitable government policies within the areas have put high demand for water assessment and ground water management. In an attempt to improve the present condition of the communities, this study was embarked upon to obtain an accurate and precise data of the aquifer characteristics to demarcate areas with good groundwater potential. References could be made from the work of the following: Dafny et al 2006, Garey, 2004, Ali et al, 1999, Sharma and Jayashree, 1998 and Egwebe et al 2006.

2. LOCATION

Abavo is located in Ika South Local Government Area of Delta State. It is situated along Agbor-Sapele road some 15km from the town of Agbor. It lies within latitude $6^0 05^1$ and $6^0 20^1$N of the equator and longitude $6^0 00^1$ and $6^0 25^1$E of Greenwich meridian.

Urhonigbe, on the other hand is located in Orhiomnwon Local Government Area of Edo State. It is situated between Abavo and Umutu both in Delta State. It is about 15km from Abavo and both communities share a common

boundary. It lies within latitude $6^0 44^1$ and $7^0 34^1$N and longitude $6^0 04^1$ and $6^0 43^1$E. These two communities and the VES locations are as shown in figure 1.
The inhabitants of these two communities are mostly dominated by peasant farmers. The area is of equatorial climate made of two main seasons, the dry and wet season. The dry season begins from October and ends in March while the wet season begins from April and ends in September.

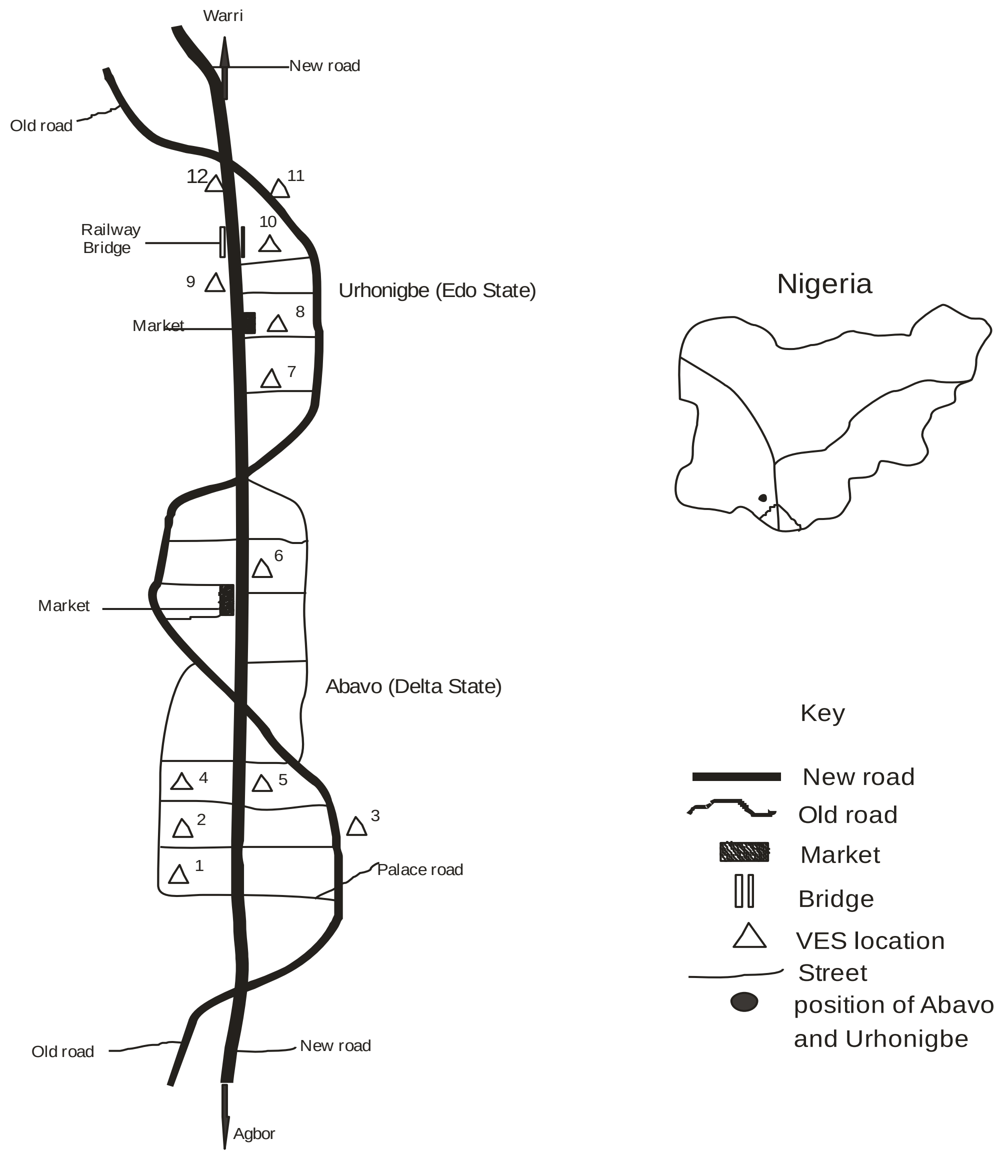


Figure 1: Sketch map of Abavo and Urhonigbe be showing VES locations

GEOLOGY
This could be seen from the work of (Egbai, 2011b)

3. METHOD

The survey area covers an area network shown in Figure 1. The Schlumberger array was adopted for data acquisition because of the deeper penetration and ability of providing information about variation in formations with depth. A maximum current electrode spacing of 1.2km was used for the sounding. By increasing the separation of the current electrodes, the depth penetrated by the current lines increases. The Abem Terrameter SAS 1000B with an inbuilt booster for greater penetration of current was used for taking surface resistivity sounding.
A total of 12 vertical electrical soundings were carried out in 12 different locations made up of 6 each from the two communities.

4. DATA ACQUISITION AND ANALYSIS

The VES curves were obtained by plotting the apparent resistivity against the current electrode spacing which were interpreted by the partial curve matching method and computer iteration technique (Vander Velpen, 1988). Some typical examples of these curves are as shown in Figure 2 and 3 for Abavo and Urhonigbe respectively. The results of the vertical electrical soundings were presented as geoelectric section as shown in table 1 for Abavo and table 2 for Urhonigbe.

Table 1: VES DATA FOR ABAVO

Electrode position	Electrode separation (m) AB/2	Potential electrode position (m)	Geometric Factor K	Apparent Resistivity (ρ_a) VES 1 (Ωm)	Apparent Resistivity ρ_a VES 2 (Ωm)	Apparent Resistivity ρ_a VES 3 (Ωm)	Apparent Resistivity ρa VES 4 (Ωm)	Apparent Resistivity ρ_a VES 5 (Ωm)	Apparent Resistivity (ρa) VES 6 (Ωm)
1	1	0.5	6.28	1727.10	1579.80	781.90	1080.80	362.98	611.00
2	2	0.5	25.13	2311.90	2249.10	995.10	1502.80	429.72	696.10
3	3	0.5	56.55	2391.00	2633.10	874.70	1855.20	586.38	717.80
4	4	0.5	100.53	3759.80	3810.10	1176.70	1316.00	818.31	874.60
5	6	0.5	226.19	5623.41	3664.30	1778.28	1995.26	707.90	1258.93
6	6	1.0	113.10	5623.41	2262.00	1778.28	1995.26	707.90	1258.93
7	8	1.0	201.06	6534.50	3377.80	1087.70	1505.90	571.01	1412.53
8	12	1.0	452.30	9635.90	5011.87	1000.00	2013.10	787.16	1778.28
9	15	1.0	706.86	7244.36	5011.87	1122.02	1995.26	6309.57	1778.28
10	15	2.0	353.43	7244.36	3322.20	1122.02	1995.26	6309.57	1778.28
11	25	2.0	981.75	7363.10	8344.90	1374.50	2817.60	837.43	2258.00
12	32	2.0	1608.50	7079.45	8689.60	1930.20	5275.90	1466.95	3317.90
13	40	2.0	2513.37	6309.57	8689.60	2238.72	7079.46	2739.57	3548.13
14	40	5.0	1005.31	6309.57	8689.60	2238.72	7079.46	1778.28	3548.13
15	65	5.0	2654.65	17782.70	9875.30	2606.90	7079.46	2511.89	3548.13
16	100	5.0	6283.19	112201.85	10690.55	6309.57	5623.41	3162.28	17592.90
17	100	10.0	3141.59	112201.85	10690.55	6309.57	5623.41	3162.28	2697.74
18	150	10.0	7068.58	199526.23	17494.70	9189.10	9189.20	5110.58	35563.30
19	225	10.0	15904.31	251188.64	8912.51	5623.41	11297.96	12771.61	38170.30
20	225	15.0	79052.16	251188.64	8912.51	5623.41	11297.96	151.09	8747.40

Table 2: VES DATA FOR URHONIGBE

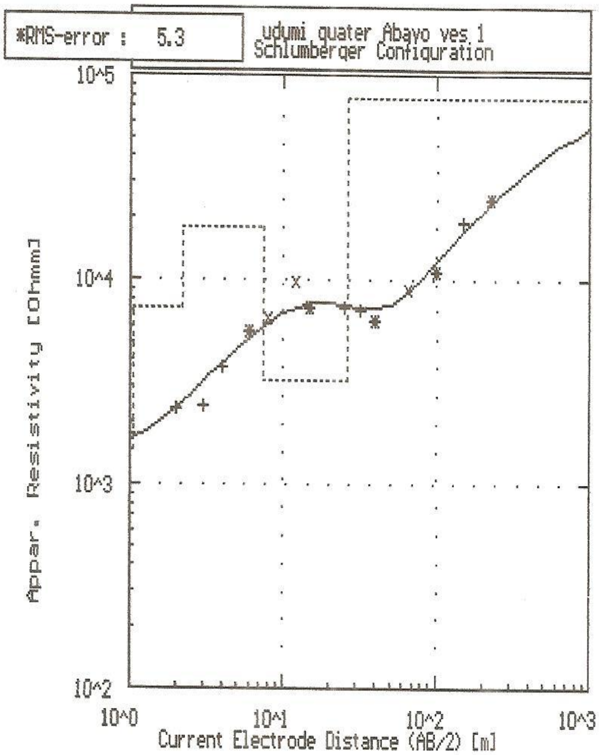
Electrode Position	Electrode Separation AB/2 (m)	Potential Electrode Separation MN/2 (m)	Geometric Factor K	VES7 ρ_a (Ωm)	VES 8 ρ_a (Ωm)	VES 9 ρ_a (Ωm)	VES 10 ρ_a (Ωm)	VES 11 ρ_a (Ωm)	VES 12 ρ_a (Ωm)
1	1	0.5	6.28	439.0	95.0	1374.0	560.0	420.0	120.0
2	2	0.5	25.13	434.0	110.0	1941.0	470.0	550.0	160.0
3	3	0.5	56.55	434.0	106.0	1935.0	439.0	750.0	210.0
4	4	0.5	100.53	325.0	105.0	1946.0	460.0	839.0	216.0
5	6	0.5	226.19	218.0	85.0	1256.0	520.0	951.0	219.0
6	6	1.0	113.10	281.0	83.0	1219.0	520.0	948.0	218.0
7	8	1.0	201.06	165.0	61.0	1219.0	510.0	1000.0	200.0
8	12	1.0	452.39	90.0	43.0	1325.0	508.0	1060.0	240.0
9	15	1.0	706.86	60.0	30.0	1965.0	580.0	1196.0	260.0
10	15	2.0	353.43	54.7	28.0	1695.0	576.0	1200.0	258.0
11	25	2.0	981.0	114.0	18.0	2920.0	796.0	1296.0	320.0
12	32	2.0	1608.50	14.9.0	13.0	3739.0	1000.0	1500.0	380.0
13	40	2.0	2513.57	210.7	19.0	5187.0	1200.0	2000.0	436.0
14	40	5.0	1005.31	387.0	19.0	4846.0	1196.0	1956.	438.0
15	65	5.0	2054.65	594.0	47.0	7021.0	1600.0	3100.0	600.0
16	100	5.0	6283.19	1016.0	115.0	8615.0	2800.0	3000.0	986.0
17	100	10.0	3141.59	933.0	110.0	8590.0	4100.0	4100.0	987.0
18	150	10.0	7068.59	1204.0	161.0	8196.0	5700.0	5697.0	850.0
19	225	10.0	15904.31	1439.0	208.0	5942.0	5698.0	5700.0	285.0
20	225	20.0	7952.16	3771.0	210.0	6110.0	5698.0	6800.0	289.0
21	325	20.0	16591.54	3570.0	300.0	3911.0	6100.0	7900.0	3000.0
22	400	20.0	19634.95	3509.0	380.0	3211.0	5500.0	6897.0	2000.0
23	450	20.0	31808.62	3459.0	420.0	2761.0	5000.0	6800.0	2800.0
24	500	20.0	39269.93	4056.0	510.0	2402.0	4596.0	7000.0	3798.0
25	500	30.0	26179.93	5182.0	1480.0	2374.0	4600.0	6700.0	3798.0
26	550	30.0	31677.72	4523.0		1753.0	400.0		4100.0

Table 3: Geoelectric section of Abavo, locations

VES	LAYERS	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology	Curve Type	Rms % Error
1	1 2 3 4 5	1463.80 7300.20 18115.80 3207.40 77498.30	1.00 1.20 5.20 19.10	1.00 2.20 7.40 26.50	Top soil Laterite Sand Coarse grained sand White gravel	KA	5.30
2	1 2 3 4 5 6	1466.10 4497.80 2714.30 32838.70 1414.80 44473.00	0.90 8.30 2.20 41.80 130.00	0.90 9.20 11.40 53.20 183.20	Top soil Laterite Fine sand Sand Coarse grained sand White gravel	AH	7.10
3	1 2 3 4 5 6	699.00 1593.20 700.60 8815.80 1108.30 8364.10	0.90 2.50 8.00 110.10 17.00	0.90 3.40 11.40 121.50 138.50	Top soil Laterite Clayey sand Fine grained sand Sand White gravel	KHA	8.80
4	1 2 3 4 5 6	922.00 2939.90 876.70 16727.90 2435.20 91044.50	0.70 1.20 4.10 24.40 43.10	0.70 1.90 6.00 30.40 73.50	Top soil Laterite Clay Fine grained sand Clayey sand White gravel	KHA	6.50
5	1 2 3 4	203.10 127.30 1298.40 100000.00	0.10 0.10 10.90	0.10 0.20 11.10	Laterite Clcay White sand White gravel	A	10.90
6	1 2 3 4	188.20 1062.70 102.00 20408.10	0.50 8.80 0.90	0.50 9.30 10.20	Top soil Laterite Clay White gravel	KA	6.90

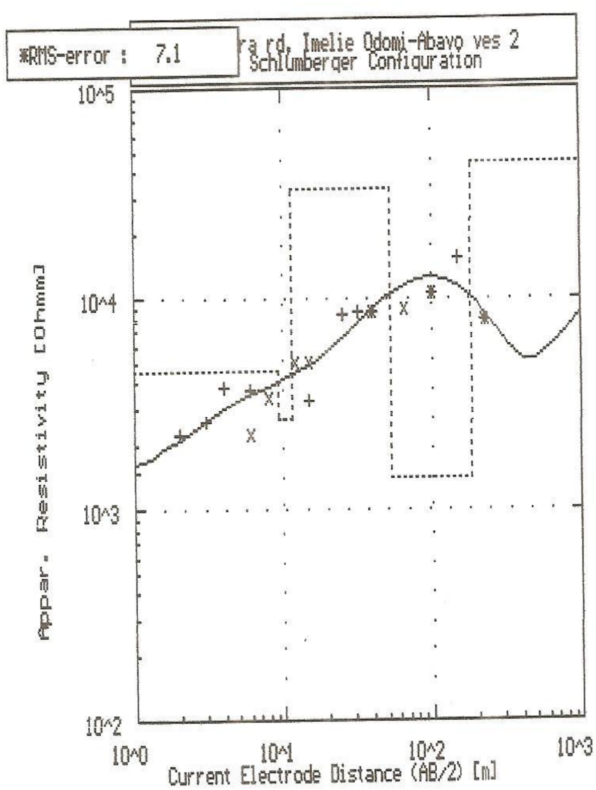
TABLE 4: SUMMARY OF COMPUTER ITERATION AND GEOCLECTRIC SECTION OF URHONIGBE

VES	LAYERS	Resistively (RM)	Thickness (M)	Depth (M)	Litho logy	Curve type	RMS% Error
7	1 2 3 4 5	469.7 151.7 28.2 699.9 56675.0	2.2 3.6 2.1 10.0	2.2 5.8 7.9 17.9	Top soil Clayey sand Clay Fine grained sand White gravel	$\rho_1>\rho_2>\rho_3<\rho_4<\rho_5$ QA	6.0
8	1 2 3 4	107.9 5.3 102.8 52234.7	4.8 6.0 5.4	4.8 10.8 16.2	Top soil Clay Clayey sand White gravel	$\rho_1>\rho_2<\rho_3<\rho_4$ HA	10.9
9	1 2 3 4 5	1252.0 3379.7 415.6 19604.7 1204.3	0.7 1.3 2.5 54.8	0.7 2.0 4.5 59.3	Top soil Laterite Clay White sand Clayey sand	KHK $\rho_1<\rho_2>\rho_3<\rho_4>\rho_5$	2.9
10	1 2 3 4 5	597.6 347.6 623.0 146.0 7622.9	0.8 1.2 3.7 2.4	0.8 2.0 5.7 8.1	Top soil Clayey sand Fine grained sand Clay White sand	$\rho_1>\rho_2<\rho_3>\rho_4<\rho_5$ HKH	5.3
11	1 2 3 4	368.3 1112.6 5418.0 9299.9	0.8 14.9 18.8	0.8 15.7 34.5	Top soil Laterite Sand White gravel	$\rho_1<\rho_2<\rho_3<\rho_4$ A	3.7
12	1 2 3	175.1 715.3 10000.0	7.7 98.0	7.7 105.7	Top soil Clayey sand White gravel	$\rho_1<\rho_2<\rho_3$ A	17.0



No	Res	Thick	Depth
1	1463.8	1.0	1.0
2	7300.2	1.2	2.2
3	18115.8	5.2	7.4
4	3207.4	19.1	26.5
5	77498.3	-.-	-.-

* RMS on smoothed data

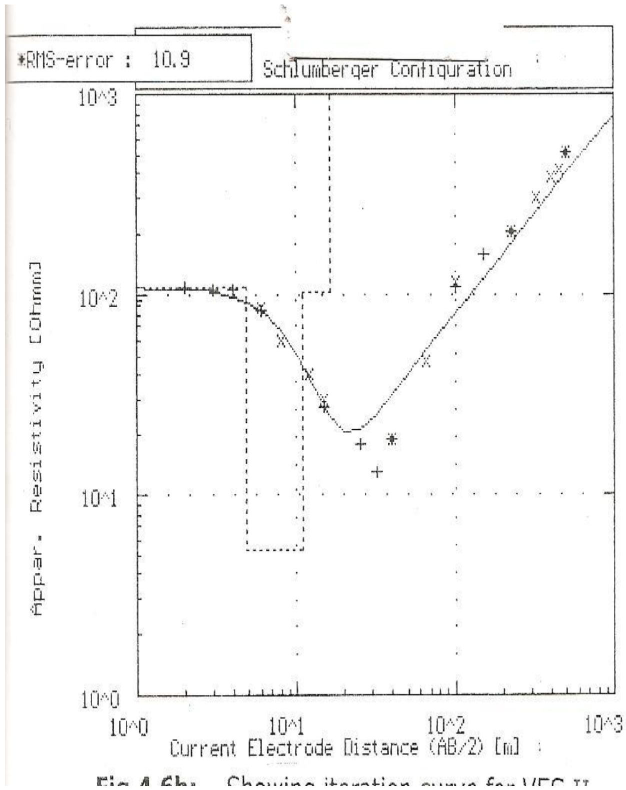


No	Res	Thick	Depth
1	1466.1	0.9	0.9
2	4497.8	8.3	9.3
3	2714.3	2.2	11.5
4	32838.7	41.8	53.3
5	1414.8	130.0	183.2
6	44473.0	-.-	-.-

* RMS on smoothed data

Figure 2: VES curves for Abavo locations

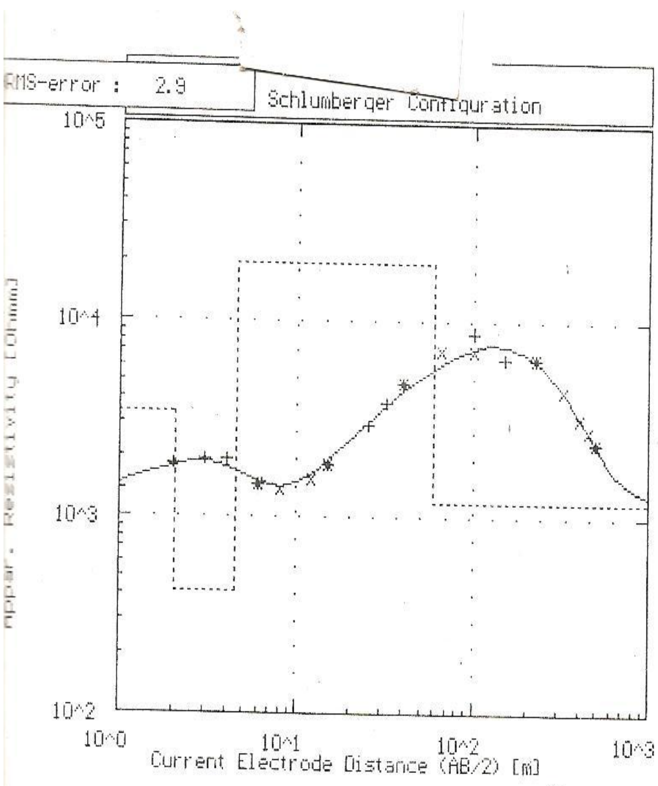
Urhonigbe VES 8



No	Res	Thick	Depth
1	107.9	4.8	4.8
2	5.3	6.0	10.9
3	102.8	5.4	16.2
4	52234.7	-.-	-.-

* RMS on smoothed data

Urhonigbe VES 9



No	Res	Thick	Depth
1	1252.0	0.7	0.7
2	3379.7	1.3	2.0
3	415.6	2.5	4.6
4	19604.7	54.8	59.4
5	1204.3	-.-	-.-

* RMS on smoothed data

Figure 3: VES curves for Urhonigbe locations

5. RESULTS AND DISCUSSION

The results of the survey are presented in tables 1,2,3,4 with their respective curves shown in figure 2 and 3. The interpretation of the vertical electrical sounding curves show that of KA, AH,
KHA, A, KA, QA, HA, KHK, and HKA types. The iterated results analyzed show that the layers vary generally from three to six and root mean square percentage error from 2.9 to 17.0

Location 1 at Abavo is made of 5 layers with resistively ranging from 1463.8 Ωm to 77498.0Ωm with thickness varying from 1.0m to 19.1m. It is made of topsoil, laterite , sand, coarse grained sand and white gravel. The aquifer is located in the fourth layer with thickness 19.1m at a depth of 26.5m.

Location 2, 3 and 4 at Abavo are made of 6 layers with AH,KHA and KHA curve types respectively. The resistivity for these locations vary from 1414.8Ωm to 4447.0Ωm with thickness 0.9m to 130.0m for location 2, 699. 0Ωm to 8815.8Ωm with thickness 0.9 to 17.1m for location 3 while locations 4 vary from 876.7Ωm to 91044.5Ωm with thickness 0.7m to 43.1m.These locations are made of topsoil, laterite, sand fine grained sand, clay and white gravel. The aquifers for location 2 and 3 are within the fifth layer while location 4 has its aquifer located in the fourth layer. The thickness o f the aquifer for these locations are 130.0m, 17.0m and 24.4m at a depth of 183.2m, 138.5m and 30.4m respectively.

Location 5 and 6 at Abavo are made of 4 layers with resistivity vary from 127.3Ωm to 100,000.0Ωm at a depth of 0.10m to 10.9m for location 5 while location 6 has resistivities vary from 102.0Ωm to 20, 408.1Ωm at a depth of 0.5m to 8.8m. The aquifers for these two locations are embedded in the third layer with thickness of 10.9m and 0.9m at a depth of 11.1m and 10.2m respectively for location 5 and 6.

Location 7, 9 and 10 at Urhonigbe are of 5 layers made of QA,KHK and HKH type curves respectively. The resistivity of these location vary from 28.2Ωm to 699.9Ωm, 415.6Ωm to 19604.7Ωm and 146.0Ωm to 7622.9Ωm with thickness 2.2m to 10.0m, 0.7m to 54.8 and 0.8m to 3.7m respectively for locations 7, 9 and 10. The aquifer for these locations have thickness of 10.0m at a depth of 17.9m in the fourth layer for location 7, 54.8m thickness at a depth of 59.3m in the fourth layer for location 9 while location 10 has thickness and depth at infinity.

Locations 8 and 11 are of 4 layers made of HA and A curves type. The resistivity for these locations ranges from 5.3Ωm to 52234.7Ωm with thickness from 4.8m to 6.0m at a depth of 4.8m to 16.2m for location 8 while location 11 is of resistivity ranging from 368.3Ωm to 9299.9Ωm with thickness varying from 0.8m to 18.8m at a depth of 0.8m to 34.5m. The lithology for this locations are mainly top soil, laterite, clay, sand and white gravel. The aquifer for location 8 has thickness of 5.4m at a depth of 16.2m while location 9 has thickness of 18.8m at a depth of 34.5m

Location 12 has three layers made of A type curve. The resistivity for the three layers are 175.1Ωm, 715.3Ωm and 100000.0Ωm with thickness 7.7m and 98.0m at a depth of 7.7m and 105.7m respectively. The lithology is of top soil, sand and white gravel. The aquifer in this location is at a depth of 105.7m.

Locations 1, 2 and 4 at Abavo show very good aquifer where boreholes could be sited with thickness 19.1m, 130.0m and 24.4m respectively. Of all these location 4 is the best having a depth of 30.4m. For Urhonigbe, locations 9 and 11 have the best aquifer and boreholes could be sited in these locations.

A reliable interpretation was made by having a look at the lithological borehole descriptions and geophysical well logs within these areas of surveys. This was purely in conformity with the vertical electrical survey results.

6. CONCLUSION

Vertical Electrical Sounding using Schlumberger electrode configuration was conducted at Abavo and Urhonigbe to determine the underground water potential and the lithological setting in terms of aquifer distribution. The study has shown that the communities are underlain by 3 to 6 geoelectric layers within the depth penetrated. The research has enabled the determination of the depth to water table, aquifer thickness, and sub-surfaces geology of the study area thus revealing its groundwater distribution as well as its potential as a substitute or compliment to the surface water resources from River Orogodo and rain water.

The results of the research have shown that location 4 has the best aquifer of thickness 24.4m at a depth of 30.4m for Abavo while for Urhonigbe, locations 9 and 11 have the best aquifer of thickness 54.8m and 18.8m at a depth of 59.3m and 34.5m respectively. For maximum yield boreholes should be sited in locations 4, 9 and 11 for both communities.

Locations 6, 8, 10 and 12 where some abortive boreholes are located and aquifers not well defined, these is need to increase the array spread for greater current penetration and deeper penetration beyond the depth of these locations. This is because there is tendency for aquifer bearing formations to be discovered beyond 10.2m, 59.3m, 8.1m and 105.7m for these four locations since there is an increasing value of apparent resistivity obtained from the curves.

7. ACKNOWLEDGEMENT

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