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Research Article

Delineation of depth of water table and groundwater potentials from geoelectric evaluation in Abavo, Delta State and Urhonigbe, Edo State area of the Niger Delta, Nigeria

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Abstract

A Geophysical Survey using Vertical Electrical Sounding (VES) was carried out in Abavo and Urhonigbe areas in order to delineate the depth of water table and groundwater potentials of the areas. The Schlumberger Electrode Configuration was employed and a total of six (6) VES stations were sounded, three each for the two communities. The data were interpreted by computer Iteration Techniques where geoelectric model parameters and VES curves were obtained. The results showed that the formation of Abavo and Urhonigbe have curve types HK, AA, and AH. Abavo resistivity varies from (304.3Ωm-21090Ωm) with a corresponding thickness of (25m-149m) and at a depth of (29.6m-177m) in layer 3 (VES2). The aquifer layers 3 (VES2) and layer 4 are composed of medium sands to gravelly sands, hence, a good site for borehole development. In Urhonigbe area, location 4 and 5 (layer 4) had a resistivity range of (1028.6Ωm-60886.2Ωm) with aquifer thickness and depth ranging to infinity. The layer composed of coarse grained sands to gravelly sands and it is good for citing a borehole. Location 4 and 5 had a confining bed that can prevent groundwater contaminations. The static water table in Abavo and Urhonigbe varies from (35m-50m) and (30m -40m) respectively. The geoelectric section obtained was correlated with the borehole litho-log of the areas and was found consistent.

Keywords: Lithology, Resistivity, Aquifer, Geoelectric Section, VES.

INTRODUCTION

Water is essential for human existence and its importance for individual health and well-being of a nation cannot be underestimated (Ince et al., 2010). Due to the increase in population and urbanization in the developed and developing countries, there is not only a heavy reliance on groundwater as a primary drinking supply alone but as a supply for both agricultural and industrial use. The acquisition of viable deep well is mainly dependent on the adequate and reliable empirical knowledge of the geology of the area and the depth of aquifer (Okolie et al., 2005). Since the demand for potable water for both domestic and commercial use is remarkably on the increase in Abavo and Urhonigbe areas, it is important that a geophysical survey of the subsurface sequence strata of the porous formation is made to ascertain the depth of aquifer system, depth of water table, geoelectric/geologic stratifications of the near subsurface formations and lithologies, and also the depth of groundwater and aquifer thickness in the study areas. Thus, total of six (6) sounding sites were randomly selected in Abavo and Urhonigbe where Vertical Electrical Sounding (VES) were adopted using Abem Signal Average System (SAS) 1000B Terameter which is capable of displaying the computed resistivity of the formation under investigation. The inhabitants of the study areas 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 is as a result of lack of potable drinking water (Egbai, 2011).

Locations, geology and hydrogeology of the area

Abavo is located in Ika South Local Government of Delta State. It is situated off the new Agbor road about 6km away from the town of Agbor. It lies within latitude 6.11854 N on the equator and longitude 6.18398 E on the Greenwich Meridian. The area is accessible by network of roads. The Sapele-Abraka-Agbor express way is the major road in the area. While Urhonigbe lies between latitude 5.983 N and longitude 6.17252E. It is situated under Ikpoba Okha Local Government of Edo State. Abavo and Urhonigbe consists mainly of coastal plain sands, deltaic sands, fresh water swamps, meandered belts and alluvia sands, all ranging from Oligocene to Holocene. The area is underlain by superficial sediment of Quaternary Age which are loose sand to clayey sand of the Benin formation that overlies the entire onshore or the Niger Delta (Etu-Efeotor and Akpokodje, 1990).

Orogodo River (also called Assimiri River) happens to be the only river that margins between Edo and Delta and it is situated at the western margins of the town. It is a shallow river that empties its sediments into the Ethiope River. Hand dug wells were absent in the areas since the soils have the ability to cave-in when dug manually. Groundwater potentials is high due to the high infiltration rate of rainfall caused by the loose nature of the soil of the area.

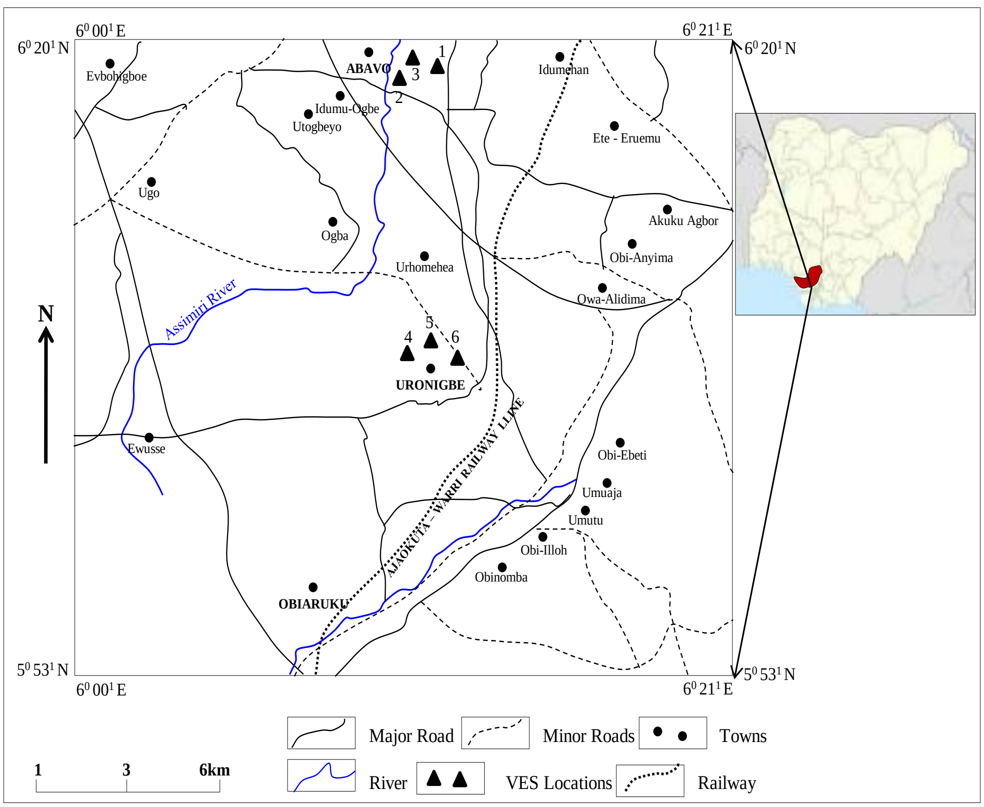
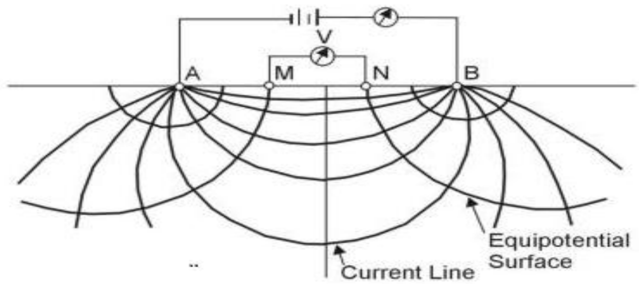


Figure 1. The map of the Study Area

MATERIALS AND METHODS

A standard Schlumberger array was adopted for the VES. Measurements were taken at expanding current electrode distance (A and B), while the potential electrode (M and N) spacing was kept constant for successive measurements and was only adjusted when the voltage reading becomes too small to be accommodated by the instrument sensitivity. The current electrodes were kept fixed and the potentials were expanded in either cases Zohdy, (1997). However, for every measurement, the ratio of potential to current electrode was 1:5. A total of six (6) VES locations were occupied with a maximum current electrode spacing of 500m. The current and potential cables were connected to the Terameter via two plugs into the socket of the instrument. The Terameter was switched on and the potential difference at electrodes, geometric factors and the resistance were recorded. The apparent resistivity (ρ) values were determined, taking the product of the resistance measured on the earth resistivity metre and a geometric factor that is independent on the type of array used. The apparent resistivity equation is shown below.



$\rho_a = KV/I$……………………………………………..1

The geometric factor k, for Schlumberger configuration show below.

$$K = \frac{\pi [AB/2]^2 - [MN/2]^2}{MN} \qquad \text{....................................2}$$

DATA ACQUISITION AND ANALYSIS

The interpretation of field data was got from qualitative and quantitative process of plotting the apparent resistivity against the current electrode spacing that was interpreted by partial curve matching method and computer Iteration techniques using Resist version1to determine the curves type and approximate number of layers (Velpen, 1988). The results of the curves type and VES points were presented in the geoelectric section in figure 2, 3, 4, 5 and 6 and in table 1, 2 and 3 in Abavo and Urhonigbe respectively.

Table 1. VES data of Abavo and Urhonigbe

Electrode position	Electrode Separation AB/2 (m)	Potential Electrode MN (m)	Geometric Factor K	VES Data for Urhonigbe			VES Data for Abavo		
				Apparent Resistivity Ωm VES1 Express Road (market)	Apparent Resistivity Ωm VES2 close to Adaikpoh house	Apparent Resistivity Ωm VES3 Catholic Church	Apparent Resistivity Ωm VES4 Urhonigbe Primary School	Apparent Resistivit y Ωm VES5 Close to Market	Apparent Resistivity Ωm VES6 Express Road
1	1	0.5	6.28	560	420	112	438	95	1374
2	2	0.5	25.13	470	550	167	434	110	1941
3	3	0.5	56.55	440	737	213	434	110	1935
4	4	0.5	100.53	465	841	217	325	92	1946
5	6	0.5	226.19	514	939	219	218	73	1256
6	6	1.0	113.10	526	982	213	281	85	1219
7	8	1.0	201.06	510	1038	204	165	61	1219
8	12	1.0	452.39	512	1065	339	152	43	1325
9	15	1.0	706.86	558	1162	259	159	31	1965
10	15	2.0	352.43	588	1286	231	176	28	1695
11	25	2.0	981.75	797	1346	316	182	26	2920
12	32	2.0	1608.50	967	1521	382	201	25	3729
13	40	2.0	2513.57	1240	1719	427	210	27	5187
14	40	5.0	1005.31	1021	2046	447	302	34	4846
15	65	5.0	2654.65	1662	2503	603	594	34	7021
16	100	5.0	6283.19	2793	2653	902	1016	47	8615
17	100	10	3141.59	2851	3106	843	933	76	8590
18	150	10	7068.59	4142	4097	856	1204	161	8190
19	225	10	15904.31	5397	5686	2340	2041	171	5942
20	225	20	7952.16	5713	5738	2950	2610	210	6110
21	325	20	16591.54	6170	6835	3019	3042	245	3911
22	400	20	19634.95	4527	7954	2014	3501	382	3211

Table 2. Summary of Geoelectric Section of Abavo and Urhonigbe Location

GEOELECTRIC SECTION OF ABAVO AREA							
VES	No. of Layers	Resistivity (Ωm)	Thickness (m)	Depth (m)	RMS % Error	Curve Types	Lithology
1	1	493.2	2.9	2.9	5.6		Top soil
	2	446.1	10.8	13.7		Hk	Laterite
	3	21090.0	77.o	90.7			(fine grained –medium Sand)
	4	1032.9					(Coarse grained sand to white gravel)
2	1	365.3	0.9	0.9	2.9		Top soil
	2	1271.0	26.5	27.4		AH	Laterite
	3	12487.2	149.6	177.0			(Medium grained to coarse sand)
	4	6752.4					gravel
3	1	120.8	0.9	0.9	7.7		Top soil
	2	260.1	3.7	4.6		AA	Laterite
	3	304.3	25.0	29.6			(Fine grained – gravel)
	4	9228.3					(Medium grained to gravel)
GEOELECTRIC SECTION OF URHONIGBE AREA							
VES	No. of Layers	Resistivity (Ωm)	Thickness (m)	Depth (m)	RMS % Error	Curve Types	Lithology
4	1	467.5	2.5	2.5			Top soil
	2	101.2	9.4	11.9	5.9	HA	Clayey sand
	3	367.0	6.6	18.4			Fine grained sand
	4	60886.2					White gravel
5	1	104.7	4.5	4.5			Top soil
	2	13.3	13.7	18.2	5.2	HA	Clay
	3	761.5	37.9	56.1			(Fine,medium to grave)
	4	3881.8					Gravel
6	1	1839.8	2.8	2.8			Top soil
	2	574.9	3.4	6.2	5.4	HK	Laterite
	3	34894.1	32.1	38.4			Fine, medium to gravel
	4	1028.6					White gravel

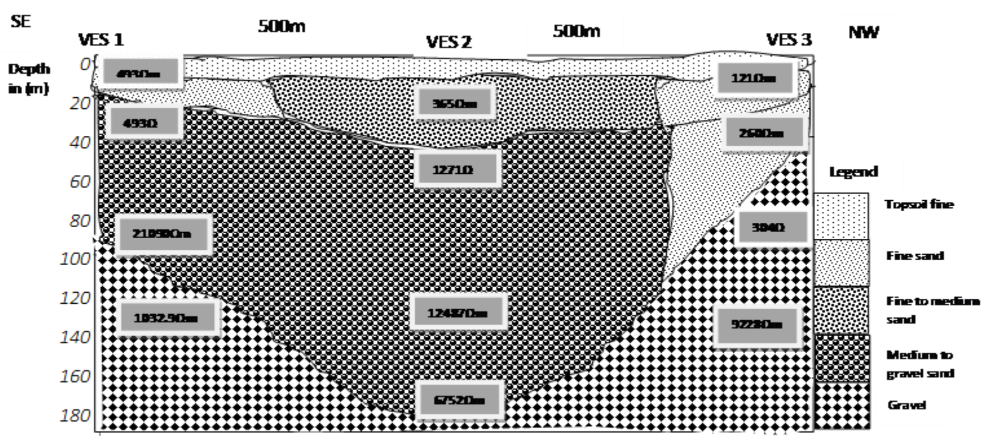


Figure 2. litho-Section of the Subsurface Variation of Abavo Area

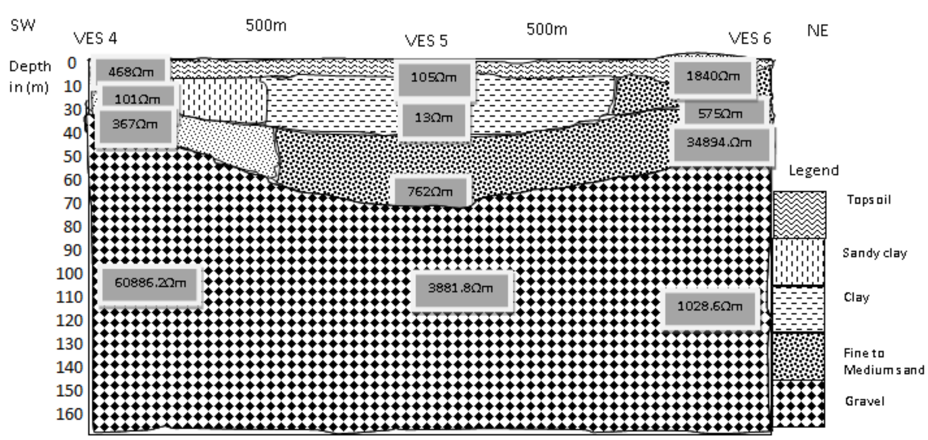


Figure 3. Litho-Section of the subsurface Variation of Urhonigbe Area

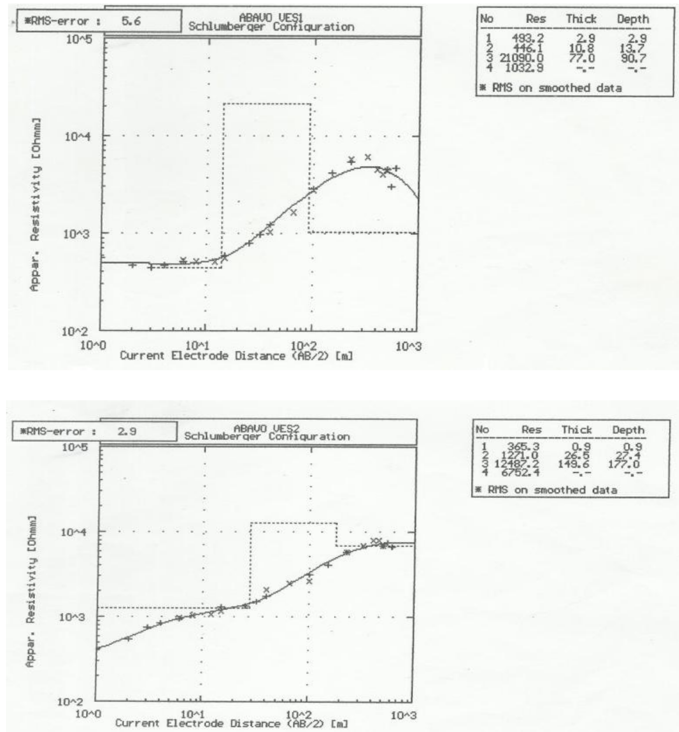


Figure 4. Iterated field Curve for VES 1 and 2

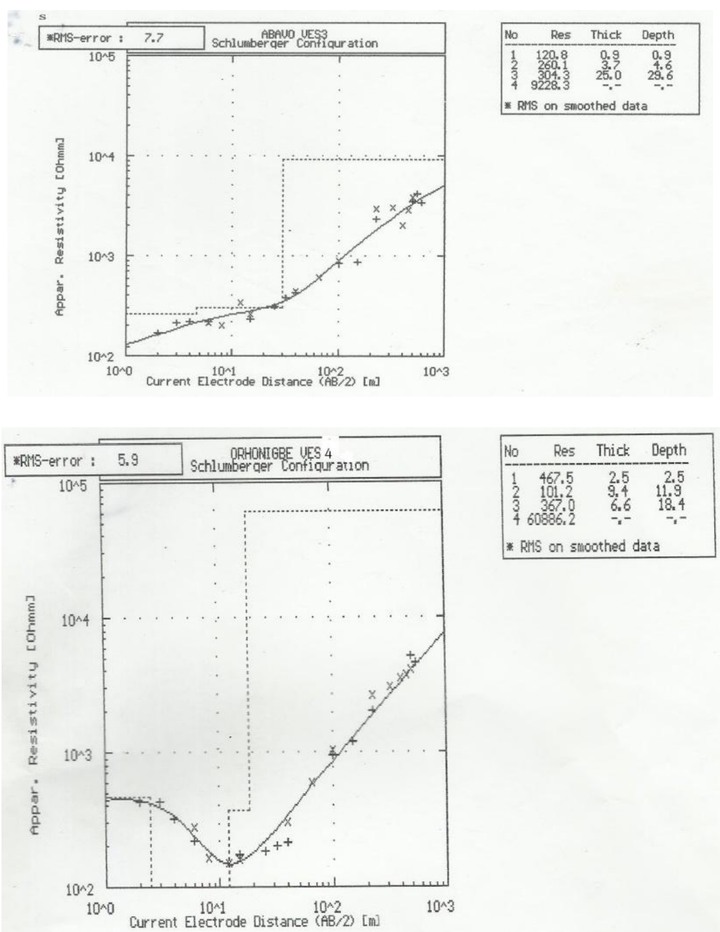


Figure 5. Iterated Field Curve for VES 3 and 4

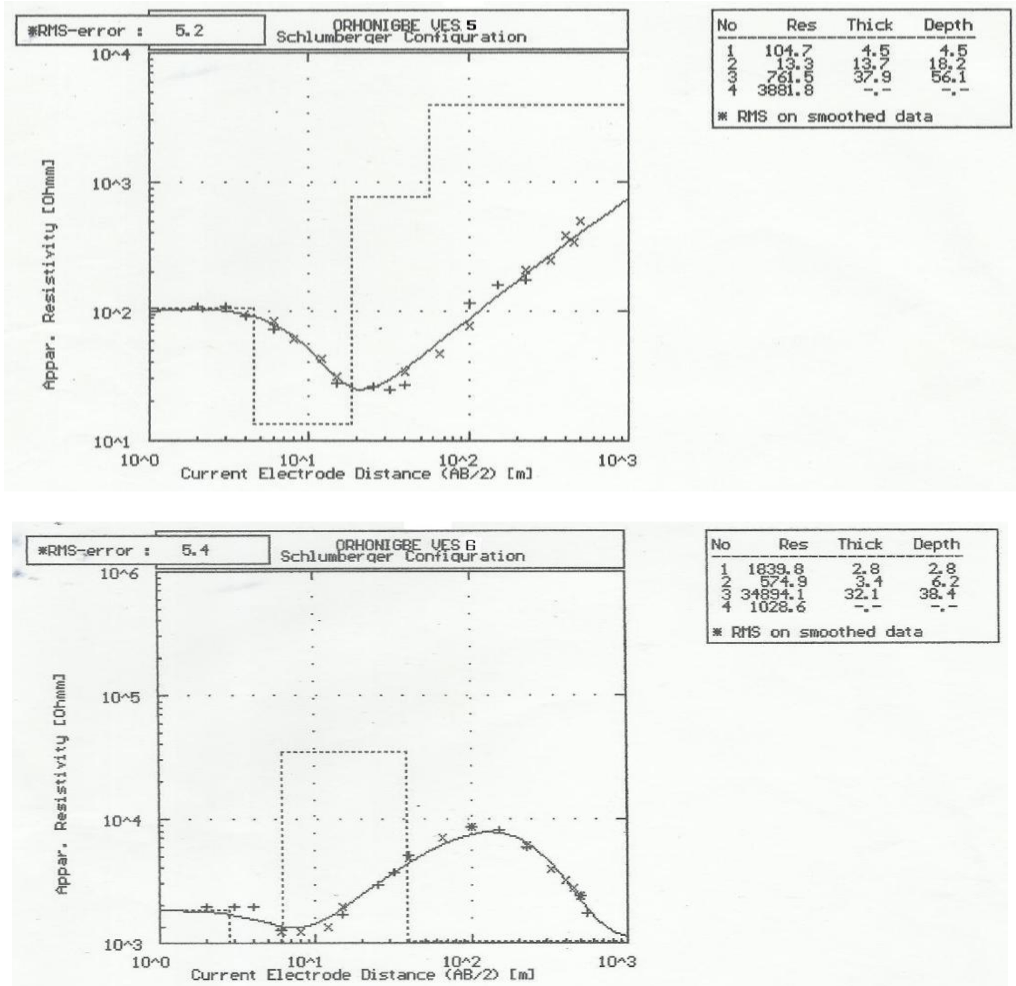


Figure 6. Iterated Field Curve for VES 5 and 6

DISCUSSIONS AND RESULTS

The interpreted field curves of the six (6) VES stations showed that the curves are of types HK, AH and AA. The HK-type indicates decrease in resistivity and then, a progradational increase in sand contents with increasing resistivity and depth. While the AH and AA curves, the resistivity increases with depth but starts falling from certain depth in the case of AH-type. The obtained depths and resistivity values were used to produce geoelectric section in table 1, 2 and 3. The results of the data analysis showed that the areas had four layers. The first layer (top soil) in Abavo area had a resistivity range of (120.8Ωm-493.2Ωm) with a thickness of (0.9m-2.9m). This layer composed of fine grained to medium grained sands with incalation of clay. The second layer had a resistivity range of (260Ωm-1271Ωm) and a corresponding thickness of (3.7m-26.5m) with a depth of ranging from (4.6m-27.4m). This layer composed of pinch-out of fine-grained to medium grained sands. Abavo soil is very loose and it is easily recharged when precipitation is high. This layer could be a vadose zone if the rate of discharge is greater than recharge and well drilled into this region will not be productive. The third layer had a resistivity range of (304.3Ωm-21090Ωm) and a thickness of (25m-149m) with a depth of (29.6m-177m). This layer is not persistent and it composed mainly of gravelly sand and some pinch-out of fine grained sands. However, there's a progradational increase in grain sizes with increasing depth, this is, from fine to gravelly sands. The fourth layer had a resistivity range of (1033Ωm-9228Ωm). This layer can be identified as the major aquifer in the area with the thickness and depth ranging to infinity and its composed of medium-grained to gravelly sands, hence well drilled into this region will have high specific capacity, transmissivity and groundwater yield because of it high porosity and permeability. In the case of Urhonigbe, the first layer had a resistivity range of (104.7Ωm-1839.8Ωm) with thickness of (2.5m-4.5m). This layer composed of sandy clay to coarse grained sand. The second layer had a resistivity ranging from (13.3Ωm-470Ωm) and a thickness ranging from (3.4m-9.4m) at a depth range of (6.2m-18.2m). This layer composed of clay and find grained sands. The low resistivity could be as a result of geologic noise such as buried conductive materials and pinch-out of clay that may be conductive in many ways. The third layer had a resistivity of (367Ωm-3484Ωm) with a thickness range of (6.6m-37.9m) and a depth of (18.4m-56m). There is a lateral variation in grain sizes from VES 4 to VES 6. The layer composed of fine-medium to gravelly sands. The fourth layer had a resistivity range of (1028.6Ωm-60886.2Ωm) with thickness and depth ranging to infinity. The composed of mainly gravelly sands, hence the major aquifer in the area. From the interpretation, it is probable that layer 3 and 4 were the aquiferous units in Abavo while layer 4 was the only aquiferous unit in Urhonigbe. The soil units exposed by boreholes litho-log in the study areas corresponded with these interpretations. The static water table range from (35m-50m) in Abavo, and (30m-40m) in Urhonigbe respectively. Difference in the water table was due to the relief of the areas.

CONCLUSION

Electrical Resistivity Method, using Vertical Electrical Soundings (VES) was used to delineate the subsurface geology, aquifer thickness, groundwater potentials as well as the depth of water table in the areas. The results of the research showed that layer 3 and 4 have the best aquifer thickness and depth. Layer 3 is 25m-77m thick with a depth of 29.6m-177m and layer 4 extended to infinity in Abavo. While in Urhonigbe, the best aquifer unit was in layer 4 location. From the geoelectric interpretation, Abavo could have it well drilled to 100m, and 70m to 85m in Urhonigbe area. In addition, suitable location for boreholes drilling should be around VES2 and VES 4 &5 because of it characteristic such as porosity, permeability and large spaces between their grains. Urhonigbe had a confining bed that can protect the aquifer from contaminations while Abavo soil is very loose, no confining beds hence prone to groundwater pollution.

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