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A Study of Superficial Sediments and Aquifers in Parts of Uyo Local Government Area, Akwa Ibom State, Southern Nigeria, Using Electrical Sounding Method

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Abstract: Resistivity sounding method using Schlumberger electrodes configuration was employed to investigate the goe-eletrical properties of the subsurface in parts of Uyo Local Government Area of Akwa Ibom State, Nigeria. Within the maximum electrode spread, the area studied show sandy beds with five layers of various thicknesses. The subsurface sediment harbours a thick aquifer buried in 20.0 m from the surface of the earth and it is exposed to earth surface at VES 13 and 14. The resistivity range for the aquifer layer is between 1,050 - 9,300 Ωm and thickness is above 80.0 m.

Keywords: Uyo, Aquifer, Sediments, Aquifers, Electrical sounding method.

Introduction

Water is one of the most essential gifts of life. It differs from others because its usage is unlimited. The indices of developmental impulses in any society depend largely on water. Besides drinking, water is traditionally used for agriculture, domestic purposes, spiritual purposes, religion and entertainment/recreation[1]. It is not undoubtful that any economy can rightfully survive without a reliable source of water. Before the industrial revolutions, the sources of supply of quality water included rainfall, rivers, stream, dews and ponds. However, all these sources are degraded due to the high level of contamination. The degree of contamination of surface sources of water and the increasing population heightens the demand for quality sources of water. According to Mayer[1], the demand for water at homes, churches, mosques, industries, farms, recreations, transportations, hospital and schools is increasing day by the day. It is not unlikely that the trend will continue as far as there have not been any alternative to water. The alternative source of quality water that complements the degraded surface water supply is the groundwater. Today, one can witness the increasing number of boreholes drilled by the governments, non-governmental organizations and individuals. It is not astonishing that a number of boreholes failed due to insufficient information on the subsurface geology of the site. While acknowledging the drilling of the subsurface to have information on the subsurface geology in a particular location, it is cost effective to get such information in an analog form over the entire area surveyed using geophysical techniques which do not involve actual drilling. Geophysical survey involves taking measurements of the subsurface at or near the earth's surfaces that are influenced by the internal distributions of physical properties of interest. Resistivity is one of such physical properties. The resistivity of rocks varies because of the inhomogeneuos nature of the subsurface. Sounding methods have been proved to be useful in delineating water bearing rocks[2-5]. Analysis of resistivity sounding data reveals how the resistivity of the subsurface varies with depth. The information derived from the analysis can be used to produce a resolved picture of the subsurface geology. For instance, the resisitivity picture at Ukanaufun Local Government Area, Akwa Ibom State, Nigeria, shows a wider range (385-6860 Ωm) in the top soil which indicates change in facies of the layer[6]. Particularly, resistivity sounding method was used to investigate the electrical properties of sediments in parts of Uyo Local government Area, Akwa Ibom State, Nigeria, in an attempt to identity the aquifer for the area. The study area lies between latitude 5^0.00'N and 5^0.05'N and longitude 7^0.50'E and 7^0.75'E in Akwa Ibom State, Nigeria.

The study area is located in the equatorial rain forest belt, which is characterized by wet and dry seasons. The wet season usually starts in March and ends in October, while the dry season begins in November and ends in February. The difference in the two seasons is noticed by a drop in the amount of rainfall from 380 mm to 68 mm. The drop in the amount of rain fall may result in the failure of shallow wells. The study area is a gentle undulating low land, whose height varies between 50 m to 73 m above the sea level.

The geographic positioning system (G.P.S) shows that the study area lies within the deltaic depositional environment of the Southern Nigeria. The upper most unit of this environment is the Coastal Plain sand which is known as Benin Formation. The Benin Formation is about 6000 ft thick and comprises sand of different grain sizes with intercalations of shale[7-10]. Benin Formation is the youngest deposit in the deltaic environment and it harbours prolific aquifers[11,12].

Experimental

Using resistivity sounding method with Schlumberger electrodes configuration, geophysical investigation of the subsurface was conducted in the study area. Fourteen soundings were carried out along a profile of about 11,000 m in length. The maximum current electrode separation for each sounding ranged between 600-800 m. This separation

This separation determined the extent to which the injected current penetrates the subsurface. The resistance of the subsurface was measured on the surface of the earth using SAS 300 model ABEM Terrameter. The measured resistances were recorded against the corresponding half current electrode separation ($^{AB}/2$) and the potential electrode separation (MN) shown in Figure 1.

The measured resistances were multiplied by the geometrical factor for Schlumberger electrodes array to obtain the resistivity values. The resistivity values were plotted on a bilogorithimic graph against half the current electrode separation. The plot helps to determine whether or not the field data can be interpreted. The data from the bilogorithimic graph were modeled electronically in two relative types of computer programme - forward and iterative least square modelings. The result obtained from the later modeling yielded resistivity values for each sounding (VES station). The thickness of the layers were determined from the depth to bottom of the layers (Table 1). The lithologies of drilled boreholes were used to classify the geoeletrical layers into sediments of different grain sizes (Table 2). The resistivity picture of the study was produced using the geophysical survey data and the lithology log of the drilled borehole.

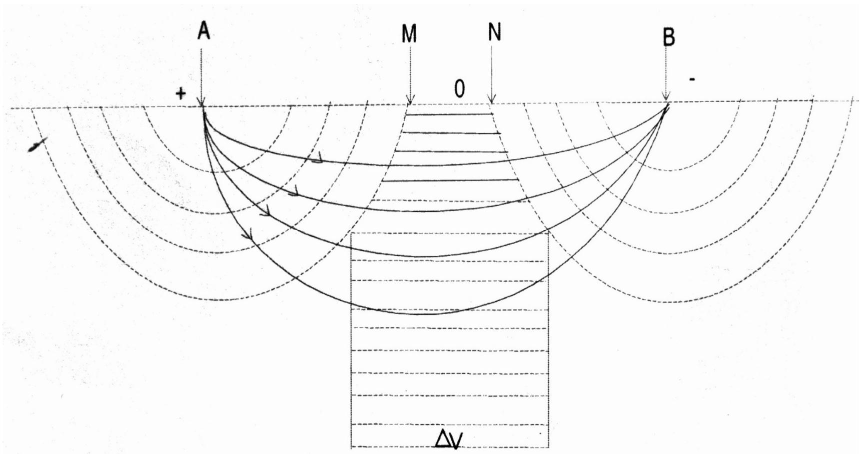

Figure 1. Schlumberger array with current (bold) and equipotential (dotted) lines.

Results and Discussion

The geophysical survey identifies five goe-electrical layers. The first layer is a Loamy top soil with resistivity range 120-334 Ωm; the second layer is medium grained sand with resistivity range 707-8,208 Ωm. The third layer is a sandy clay layer with resistivity range of 105-920 Ωm. The fourth layer is medium- coarse grained sand having resistivity range between 1, 050-9,300 Ωm and the fifth layer is sandstone with resistivity range 10,400 - 92,000 Ωm. The inversion in resistivity of the third layer is explained by the intercalations of clay formed in the layer. The result shows that the study area is a sandy formation of different grain sizes. This result conforms with the literature value[7-10] of a typical coastal plain sand. The aquifer identified for the area is buried 20.0 m depth and intercepted the surface of the earth at Obio Offot (VES 13 and VES 14). This zone is susceptible to surface contamination. The aquifer is a layer of medium-coarse grained sandy with resistivity range of 1,050 -9,300 Ωm and the thickness is above 80.0 m.

Table 1. Summary of vertical electrical sounding results from computer modeling.

			Resistivities of layers in ohm metre						Thickness of layers in metre					Depth to bottom of layers in metre				
Location		Number of layers	P_1	P_2	P_3	P_4	P_5	P_6	T_1	T_2	T_3	T_4	T_5	D_1	D_2	D_3	D_4	D_5
1	Atan Offot	5	254	1220	490	2300	5480	-	0.56	4.54	6.30	91.60	-	0.56	5.1	11.4	103.0	-
2	Atan Offot	5	160	3980	106	3810	4000	-	0.80	2.40	7.60	87.30	-	0.80	3.2	10.8	98.1	-
3	Atan Offot	6	192	708	190	5820	7050	65000	0.45	0.85	1.06	36.30	62.80	0.45	1.3	2.9	39.2	102.0
4	Atan Offot	6	341	2540	175	1660	1130	82000	0.44	3.46	1.70	36.00	56.40	0.44	3.9	5.6	41.6	98.0
5	Obio Etioi	6	124	3200	920	1700	1610	26500	0.87	1.23	3.20	42.20	54.50	0.87	2.1	5.3	47.5	102.0
6	Obio Etioi	6	344	5300	437	7380	5310	76100	0.3	1.20	2.40	33.36	61.50	0.30	1.5	3.9	37.5	99.5
7	Obio Etioi	6	215	3400	532	737	1270	28300	0.46	1.14	2.10	32.80	63.00	0.46	1.6	3.7	36.5	99.5
8	Obio Etioi	5	120	2190	303	4480	15600	-	0.52	8.38	5.70	83.90	-	0.52	8.9	14.6	98.5	-
9	Obio Etioi	6	329	6850	745	8400	5260	34500	1.1	2.30	3.10	28.70	64.90	1.10	3.4	6.5	35.2	100.1
10	Obio Etioi	6	187	4680	403	6350	1500	10400	0.76	1.84	1.80	15.90	67.10	0.76	2.6	4.4	29.9	99.3
11	Obio Etioi	6	169	2610	105	5080	6410	10400	0.75	1.84	1.80	15.90	67.10	0.76	2.6	4.4	29.9	97.0
12	Obio Etioi	5	2380	459	8200	1920	97000	-	0.48	2.72	12.60	79.30	-	0.48	3.2	16.8	96.1	-
13	Obio Etioi	5	188	1160	9300	8200	59800	-	0.38	9.52	15.20	90.00	-	0.38	9.9	25.1	95.1	-
14	Obio Etioi	6	212	2960	5410	2370	1140	57200	0.29	0.91	2.30	29.4	58.40	0.29	1.2	3.2	32.6	91.0

Table 2. Ranges for resistivity of rocks in the soil

Rock Type	Resistivity, Ωm
Loamy topsoil	120-334
Medium grained Sands	708-8,200
Sandy Clay	105-920
Medium-Coarse Grained Sands	1,050-9,300
Sandstones	10,400 -97,000

Conclusion

From the above results, vertical electrical sounding employing Schlumberger electrode configuration thrives in showing that parts of Uyo Local Government Area surveyed, extensively have sandy units of various grain sizes. The area has thick and prolific aquifer which cannot influence by seasonal climatic changes. The boreholes drilled in the area should cut across reasonable section of the aquifer in order to have a prolific well that will reduce the rate of dependency of settlers on polluted or contaminated surface water. Since wells located near VES 13 and 14 are prone surface contaminations, borehole drilled here should be regularly checked for water quality. .

Recommendation

Based on the results of the study, the following recommendations are made, such that their implementations will minimize the problem of water supply in Uyo Local Government Area.

1. Borehole should be drilled to a minimum depth of 40.0 m for private and commercial uses in the study area for reliable supply of water.
2. Borehole drillers should avoid drilling at VES 13 and VES 14 or water quality test should be periodically conducted for wells within the stipulated locations in order to guard against contamination.

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