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Aquifer Delineation Using Vertical Electrical Sounding *In* Ogale Community, Eleme Local Government Area Of Rivers State Nigeria.

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ABTRACT

Five Vertical Electrical Soundings (VES) were carried out in Ogale Community, Eleme Local Government Area of Rivers State, to delineate aquifers in the area for the drilling of productive boreholes, using ABEM Terrameter SAS 1000. The interpreted geo-electric sections from the VES data and modelling curves revealed four geo-electric layers. The first geo-electric layer has resistivity value of 301ΩM and a thickness of 2.4m. This layer is interpreted as topsoil. The second geo-electric layer which has a resistivity value of 651ΩM with a thickness of 5M is interpreted as unsaturated fine sand. The third geo-electric layer which has a resistivity value of 2053ΩM and a thickness of 16M is interpreted as very coarse sand. The fourth geo-electric layer has a resistivity value of 1269ΩM with a thickness of 40M is interpreted as coarse sand. The third and the fourth layers are aquiferous and considered to be the target for drilling. The fifth geo-electric layer has a resistivity value of 598 ΩM, with both depth and thickness unknown. The geo-electric sections were compared with strata-log of a near-by well and these were correlatable. From this study, a benchmark of 24 meters depth has been recommended to represent subsurface horizons saturated with freshwater in the study area.

Keyword: Resistivity, Aquifer Delineation, River State

INTRODUCTION

Potable water supply problems *a*re very common in many areas in the Niger Delta, *w*here Ogale Community is located. This is due to high iron concentration in the aquifer, the presence of microbes at shallow depths, and saline water intrusion into aquifer horizons in coastal communities. Apart from these, aquifers in the state have not been properly delineated for the drilling of productive boreholes. Thus it has become necessary to use the vertical electrical sounding (VES), to delineate aquifers in the study area. This resistivity method would also give an idea of the water quality of the aquifer delineated. It is believed that the geophysical data generated during this study will be useful in proper groundwater resource management in the area, it will also add up to the scanty groundwater data in this part of Rivers State.

STUDY AREA DESCRIPTION

The study area is located between Latitudes 04^0 79′ 0.913″ and 04^0 47′ 32.772″ N and Longitudes 00 7^0 13′ 2039″.and 007^0 07 50′.083″ E of the Greenwich Meridian. Ogale Community is in Eleme Local Government Area of

Rivers State, which is (Fig.1) located within the Niger Delta Basin. The Niger Delta Basin was formed in the Tertiary period due to interplay of subsidence and deposition of sediments arising from a succession of transgressions and regressions of the Atlantic Ocean (*Short & Stauble, 1967)*. This cyclic event resulted in the deposition of three litho-stratigraphic units in the Basin. These three units are Benin Formation, Agbada Formation and the Akata Formation in order of increasing in age *(Reyment, 1965)*. The Benin Formation is the major aquiferous stratigraphic unit in the study area (*Amajor, 1991)*. It consists majorly of thick *sands inter fingered with clay bands and lenses.* The sands are medium to coarse grained, and are poorly sorted. The sand and clay intercalations give rise to a multi-aquifer system in the area (*Murat, 1970).* The entire electrical resistivity survey that were done in the study area terminated in the Benin Formation.

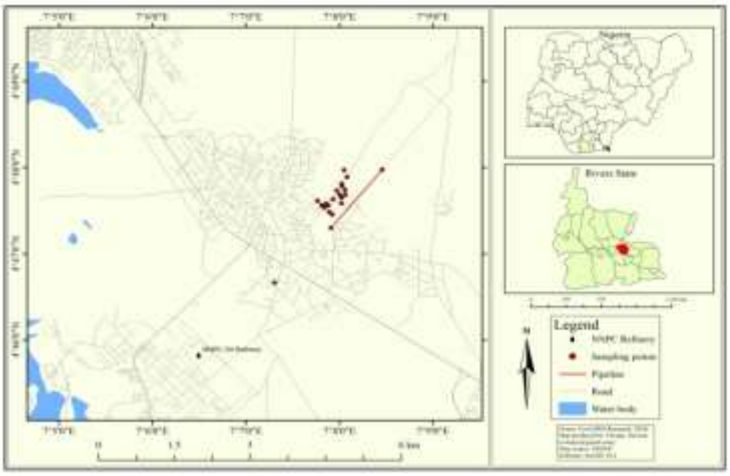

Fig.1: Map of study area showing VES sampling points

METHODOLOGY

Five vertical electrical soundings (VES) were made using the Schlumberger configuration in the study area. The resistivity survey instrument used was the ABEM Terrameter SAS 1000, a digital signal averaging system. The maximum current electrode separation for the VES was 400m. The VES data obtained in the field were processed and analysed using the IPI2WIN software in accordance with Loke and Baker (1996).

RESULT AND DISCUSSION

This study relies on the fact that the presence of sand and clay as geologic materials produce changes in the electrical conductivity of such materials (Abdel, 2000). It is also proven that pore fluid strongly influences the resistivity of geologic materials. VES technique measures the resistivity of rock and can be used to obtain information on soils and groundwater quality (Nwankwo and Emujakporue, 2012). Boreholes in Ogale Community tap water from the Benin Formation. Thus the VES were done on the Benin Formation. A good understanding of the geology of the Formation was of great importance in the interpretation of the resistivity data obtained in the field. Fig.2 to 6 are the computer model curves for VES 1 to 5,

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while the corresponding tables (Tables 1-5) show the resistivity values of the layers delineated, their depths and thicknesses. Moreover, the interpreted geo-electric sections are given in Fig.7 to 11.

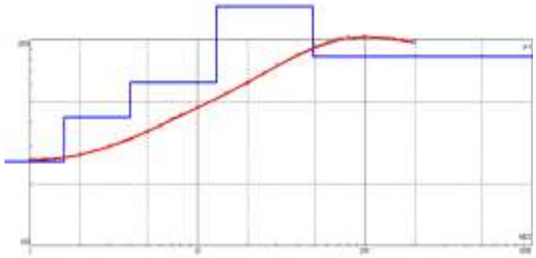

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Fig. 2: Computer Modelling for VES 1.

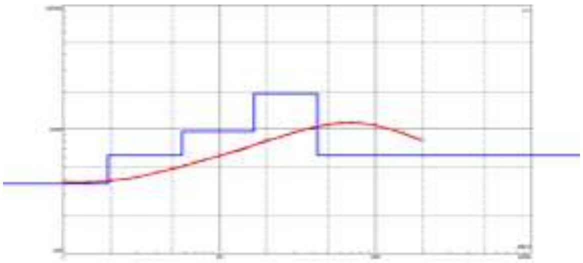

Fig .3: Computer Modelling for 2

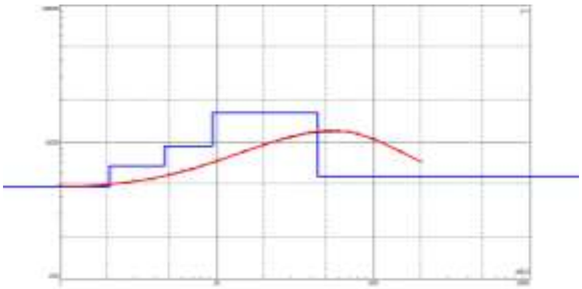

Fig.4: Computer Modelling for VES 3.

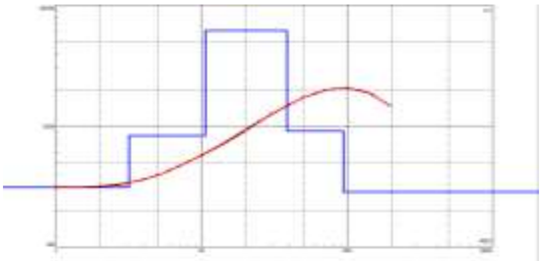

Fig. 5: Computer Modelling for VES 4

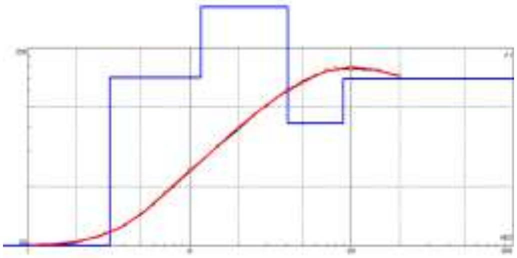

Fig. 6: Computer Modelling for VES 5

Table 1: Resistivity value, depth, thickness and lithological units for VES 1

Resistivity (Ωm)	Depth (m)	Thickness (m)	Interpreted Lithological Units
255	1.6	1.6	Top Soil
420	3.96	2.37	Fine Sand
621	13	9.05	Coarse Sand
1441	49	36	Very Coarse Sand

828	…….	……….	Coarse Sand

Table 2: Resistivity value, depth, thickness and lithological units for VES 2

Resistivity (Ωm)	Depth (m)	Thickness (m)	Interpreted Lithological Units
364	1.92	1.92	Top Soil
616	5.76	3.83	Carse Sand
958	16.6	10.8	Coarse Sand
1940	42.4	25.8	Coarse Sand
617	…….	……….	Coarse Sand

Table 3: Resistivity value, depth, thickness and lithological units for VES 3

Resistivity (Ωm)	Depth (m)	Thickness (m)	Interpreted Lithological Units
473	2.08	2.08	Top Soil
671	4.65	2.58	Coarse Sand
934	9.42	4.77	Coarse Sand
1637	44.2	34.8	Very Coarse Sand
559	…….	……….	Fine Sand

Table.4: Resistivity value, depth, thickness and the lithological units for VES 4

Resistivity (Ωm)	Depth (m)	Thickness (m)	Interpreted Lithological Units
311	3.18	3.18	Top Soil
840	10.6	7.44	Coarse Sand
6145	38.6	28	Very Coarse Sand
914	94.2	55.6	Coarse Sand
286	…….	……….	Fine Sand

Table 5: Resistivity value, depth, thickness and lithological units for VES 5

Resistivity (Ωm)	Depth (m)	Thickness (m)	Interpreted Lithological Units
101	3.2	3.2	Top Soil
706	11.8	8.55	Coarse Sand
1609	40.6	28.9	Very Coarse Sand
415	89.5	48.9	Fine Sand
700	…….	……….	Coarse Sand

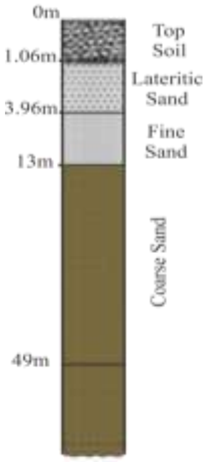

Fig 7, VES 1

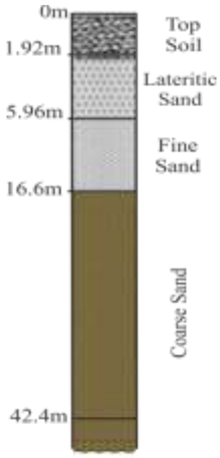

Fig 8, VES 2

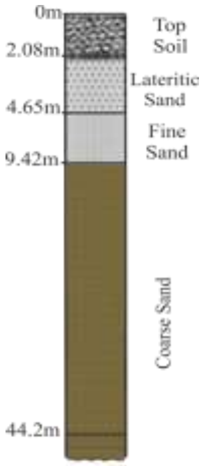

Fig 9, VES 3

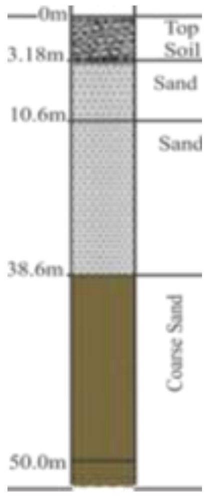

Fig 10, VES 4

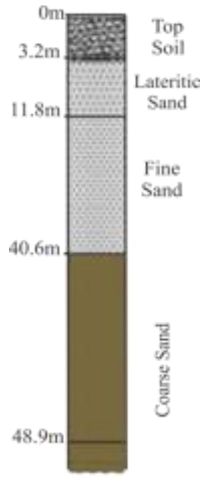

Fig 11, VES 5

Geo-electric section for VES 1 –5

VES 1

VES 1 (Fig.2) is located at Latitude 4.792994^0 N and Longitude. 7.13096 E. It has four (4) interpretative geo-electric layers; with resistivity values, thicknesses and depth as shown in (Table 1). The geo-electric section (Fig. 7) shows the type of soil in each of the layers below the surface. The first layer has a resistivity value of 255Ωm with a thickness of 1.6m, has been interpreted as top soil. Underlying the first layer is the second layer, which has a resistivity value of 420Ωm with a depth of 3.96m, and a thickness of 2.37m, has been interpreted as fine sand. The third layer has a resistivity value of 621Ωm, with a depth of 13m, and a thickness of 9.05m, and has been interpreted as medium coarse sand. There is a fourth layer with resistivity value of 1441Ωm, a depth of 49m, and thickness of 36m. This layer is interpreted as coarse sand. The next layer with resistivity value of 828Ωm and an unknown thickness was interpreted as coarse sand.

VES 2

VES 2 (Fig.3) is located at Latitude 4.792638^0 N and Longitude 7.131337^0 E. It has four (4) interpretative geo-electric layers; resistivity values, thicknesses and depth are shown in (Tab. 2). The geo-electric section (Fig.8) shows the type of soil in each of the layers and depth below the surface. The first layer has a resistivity value of 364Ωm with a thickness of 1.92m has been interpreted as top soil. Underlying the first layer is the second layer which has a resistivity value of 616Ωm, with a depth of 5.766m, and a thickness of 3.83m, has been interpreted as medium coarse sand. The third layer has a resistivity value of 958 Ω m, with depth of 16.6m, and thickness of 10.8m, and has been interpreted as coarse sand. There is a fourth layer with resistivity value of 1940Ωm, depth of 42.4m and thickness of 25.8m was interpreted as very coarse sand. The next layer which has a resistivity value of 617Ωm, and an unknown thickness was interpreted as coarse sand.

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VES 3

VES 3 (Fig.4) is located at Latitude 4.793375^0 N and Longitude 7.132205^0 E. It has four (4) interpretative geo-electric layers; resistivity values, thicknesses and depths, are shown in (Table 3). The geo-electric section (Fig.9) shows the type of soil in each of the layers and depth below the surface. The first layer which has a resistivity value of 473Ωm with a thickness of 2.08m has been interpreted as the top soil. Underlying the first layer is the second layer which has a resistivity value of 671Ωm, with a depth of 4.65m, and thickness of 2.58m, has been interpreted as fine sand. The third layer has a resistivity value of 934Ωm, a depth of 9.42m, and a thickness of 4.77m, has been interpreted as coarse sand. There is a fourth layer with resistivity value of 1637Ωm, a depth of 44.2m, and a thickness of 34.8m is interpreted as very coarse sand. The next layer with resistivity value of 559Ωm and an unknown thickness was interpreted as fine sand.

VES 4

VES 4 (Fig.5) is located at Latitude 4.793058^0 N and Longitude 7.133656^0 E. It has four (4) interpretative geo-electric layers; resistivity values, thicknesses and depths are shown in (Table 4). The geo-electric section (Fig.10) shows the type of soil in each of the layers and depth below the surface. The first layer has a resistivity value of 311Ωm, with a thickness of 3.18m, and a depth of 3.18m, has been interpreted as the top soil. Underlying the first layer is the second layer which has a resistivity value of 840Ωm, with a depth of 10.6m and thickness of 7.44m, is interpreted as coarse sand. The third layer has a resistivity value of 6145Ωm with a depth of 38.6m, and thickness of 28m, and has been interpreted as fine sand. There is a fourth layer with resistivity value of 914Ωm, a depth of 50.2m, and a thickness of 55.6m, is interpreted as very coarse sand. The next layer with resistivity value of 286Ωm and an unknown thickness was interpreted as gravel.

VES 10

VES 10 (Fig.6) is located at Latitude 4.794112^0 N and Longitude 7.133675^0 E. It has four (4) interpretative geo-electric layers; the resistivity values, depths and thicknesses are presented in (Table 5). The geo-electric section (Fig.11) shows the type of soil in each of the layers and depth below the surface. The first layer has a resistivity value of 101Ωm with a thickness of 3.2m, has been interpreted as the top soil. Underlying the first layer is the second layer, this layer has a resistivity value of 706Ωm, with a depth of 11.8m and thickness of 8.55m has been interpreted as coarse sand. The third layer with resistivity value of 1609Ωm, with a depth of 40.6m, and thickness of 28.9m, and has been interpreted as very coarse sand. There is a fourth layer with resistivity value of 415Ωm, with a depth of 89.5m, and a thickness of 48.9m has been interpreted as fine sand. The next layer with resistivity value of 700Ωm, and an unknown thickness was interpreted as coarse sand.

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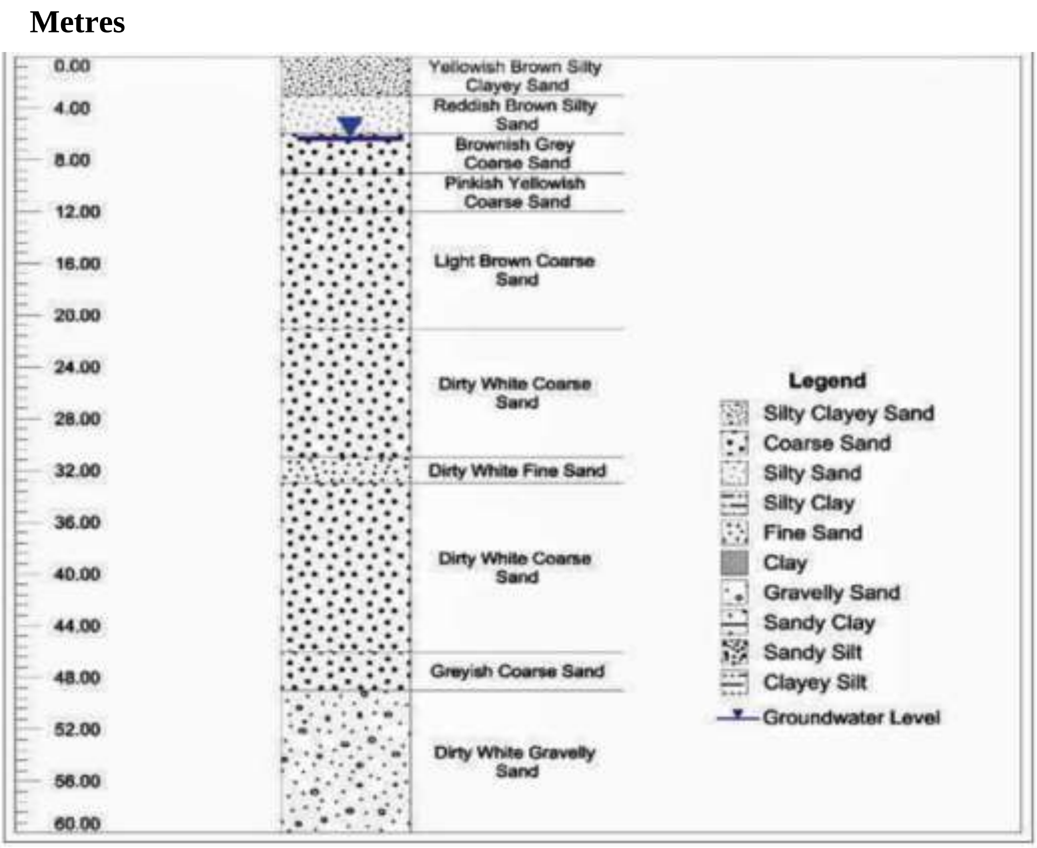

Figure 12: Borehole Lithology from Ogale (UNEP, 2011)

1.14 Lithological Profile of Borehole from Ogale

Strata log of a 60m borehole drilled in Ogale Community located at Longitude 7.129233° E and Latitude 4.786521° N shows that the aquifer is predominantly sandy with minor silty clayey sands, occurring at the surface to 3m depth. Beyond this depth, the sands are fine to coarse grained, poor to fairly sorted (Fig.12). The lithological profile is correlatable with the interpreted geo-electric sections result obtained in Ogale Community.

CONCLUSION AND RECCOMMENDATION

The VES investigation reveals four (4) delineable geo-electric layers, with layers three and four being aquiferous, a depth of about 24 meters should always be targeted in the area so that productive wells can be drilled.

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