Critical Study Of Ground Water Potential Of Part Of Obubra Local Government Area, Cross River State, Nigeria

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ABSTRACT: The vertical electrical sounding (VES) technique employing the Schlumberger electrode array was used to survey some villages in Obubra Local Government Area of Cross River State with a view to determine the groundwater potntial of the area. The study area is located between longitude 8^0 12' and 8^0 16' E and latitudes 5^0 45' and 6^0 15' N. a total of seventeen (17) electrical soundings were undertaken using the ABEM TERRAMETER model SAS 300, maximum current electrode spread of 500m was attained. The data were interpreted using resist computer software programme to obtain the final model for each VES location. These models were combined to produce a profile showing the geoelectric sections of the subsurface. Correlation of the inferred geoelectrical models showed that the first layer is composed of the sand mixed with clay and its resistivity is between 157 and 497Ωm. The second layer inferred as clay has a resistivity range between 17 and 67Ωm. the third layer suspected to be sandstone had resistivity range of 541-7603Ωm. The fourth layer suspected to be shale had a resistivity range of 97-574Ωm, while the last layer is sandstone with resistivity range of 309-4412Ωm. The sandstone layers (3^{rd} and 5^{th}) are considered to be the potential aquifer units in the area.

Keywords: Ground Water Potential, Vertical Electrical Sounding, Abem Terrameter Model SAS 300

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INTRODUCTION

The area of study lies between longitudes 8^0 12' and 8^0 16'E and latitude 5^0 45' and 6^0 15'N of the equator (Fig. 1) The parts of Obubra being studied have suffered severe lack of good surface water especially during the dry season when nearly all the surface streams in the area usually dry up, were the steams manage to survive the dry season, they are not fit for drinking because of the attendant scramble for the water by farmers, cattle rearers and the entire inhabitants of the area. This water problem have been an age long problem to the extent that most of the communities like Adun Beach and Ofodua Waterside have to migrate from Oderegha and Ofodua respectively to their present locations because of water. Some effort have been made by both individuals and the communities to develop surface water by digging of ponds and wells but hardly do these efforts yield the required dividends as these wells and ponds have the problems of bad quality, contamination and drying up. In the face of this insurmountable challenge that confronts these communities, and considering the fact that they have exhausted all their indigenous techniques and technology to solving the problem, it became necessary to employ geophysical technique to undertake a study to investigate the presence of groundwater in the subsurface of these communities. The study is aimed at determining the overall water levels in the area using the vertical electrical sounding method, the aquifer layer(s), the depth of the aquifer layers, thickness of the aquifer, and other geoelectric parameters are determined.

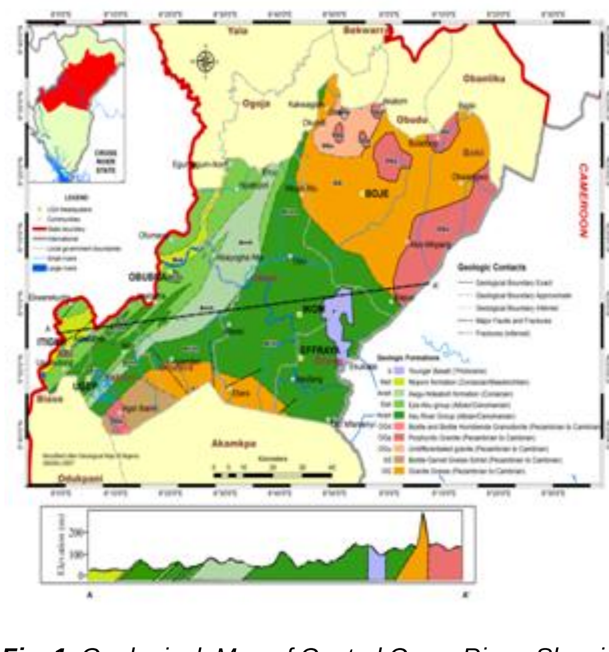

Fig. 1. *Geological Map of Central Cross River Showing Obubra the Study Area*

LOCATION AND GEOLOGY OF THE STUDY AREA

Geologically, the study area is situated in the Ikom- Mamfe embayment. The Precambrian basement rocks in the area are covered by four major lithostratigraphic units comprising the Asu River Group (ARG), Eze-Aku Group (EAG), post-santonian Nkporo-Afikpo shales formation (NASF) and the Benin formation (Odigi,2010) shown in fig.1. Eze-Aku group is

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composed of shale intercalated with sand and gravel, the Asu River Group (sand, sandstone and gravel). Nkporo-Afikpo shales formation is made up of sands, sandstone, intercalated with shale, clay and the Benin formation (Coarse-grained sands with intercalation of clay) at the top. Benin formation, shales and gravel are sufficiently exposed in the study area. The drainage is generally toward Northeast. There are network of access roads linked up to the Calabar- Ikom highway. The Area is bounded in the North by, Yala and Ikom Local Government Areas, in the south by Yakurr, the East by Akamkpa Local Government Area in the West by Ebonyi State. The major occupations of people in this area is farming, fishing and trading. The area is influenced by two major climatic conditions; the rainy season starts in April and ends in mid October while the dry season begins in mid October to April. Rainfall ranges from 120 to 220mm annually. The obvious characteristic of rainfall is double maximum with breaks in July and September. There is usually a brief spell of dry period in August often termed the August break. The area generally has a land surface of very little or no significant relief over many kilometers. Surface water found in the area is mainly seasonal ponds and few streams. The study represents one of the major attempts at detailing the geophysical and hydro geological conditions for the development of a suitable water project for exploitation of groundwater resources in the area, a few manually operated boreholes are found in the area some of which have very low yield while others produce only during the raining season

Materials and methods

Necessary geologic, topographic and political maps were acquired to provide information on the surface and subsurface structures and the peculiarities of the area. This information was necessary to guide the choice and location of the traverse on the site for investigation. It was usual for site to be located in advance of field measurement. The work was carried out using ABEM Terrammeter Model SAS 300. The instrument can service resistivity measurement both on-surface and borehole studies. Lithology log of some boreholes in the study area were used to compare the results obtained from electrical soundings (indirect method) for effective interpretation of the geophysical results. The ABEM Terrameter model SAS 300 is a signal average system powered by a 12-volt rechargeable nickel-cadmium clip on battery. In the absence of internal power source, the system can be connected to an external DC power source (a 12-volt battery). The source voltage can be checked by turning the switch on the rage selector knob and depressing the BATT button, the range voltage (V) or resistivity mode (Ω). By turning the selector knob to the appropriate range of 0.2-20mA to the ground but with aid of a booster this range can be extended to a maximum of 500mA. The system has measuring and self-check devices comprising microprocessor monitors and controls that enable it to display (LCD) with an accompanying beeper signal. The interpretation of error codes is done with the help of the instrument manual (ABEM, 1980). Measurement of Earths' resistance are done by selecting the required measurement cycle(s) (in the cycle range of 1, 4, 6 and 64) with pairs current and potential electrodes respectively connected to the current electrode terminals (C_1 and C_2) and the potential electrode terminals (P_1 and P_2).

FIELDWORK

Conventional Schlumberger VES (Telford et al., (1990) were carried out at 17 sites with a maximum electrode spacing of (AB/2) of 250m on five straight roads. To this end, a wider coverage was given to the entire area. Field measurement started with choice of the centre of the electrode spread at points that would enable electrode to be deployed along an approximately straight road. At each centre, spreading two calibrated rolls of twine along two opposite directions established the traverse. This usually gave a total traverse length of 250m (that is 125m either way). An extension of the line beyond this 250m was made possible by the use of another roll of calibrated twine to obtained a traverse length longer than 250m were necessary. Measurement of the earth's resistance, R commenced with the two potential electrodes (P_1 and P_2) planted at 0.25m respectively from the sounding centre giving an initial separation 'a' of 0.5m between them. The two current electrodes (C_1 and C_2) were similarly given an initial separation 'b', of 2m, with each of them being situated a distance, equal to 1m from the centre. These electrodes were connected to their respective terminals of the ABEM digital terrameter. At some measurement points where the immediate earth surface was hard and dry, ground at such point were watered. After selecting four measurement cycles, the earth's resistance was automatically measured by depressing the measure button on the instrument panel while in the "ON" mode. The maximum permissible current level was normally used. Low apparent resistivity values were observed in some sounding points. These may be due to underlying layer being highly conductive. To avoid too low apparent resistivity values which were experienced in some sounding points, high current values were used as recommended by Okon-Umoren (1983). It was impossible to increase the current values beyond 5A because the booster (SAS 2000) used for boosting up current was not available for use. Subsequent measurements involved a systematic expansion of the current electrodes. The potential electrodes occasionally were also expanded. At very large current electrode spread (i.e. for b greater than 150m), it was necessary to use cell phones to establish communication link with crew members at their various locations so that the extent of spread at any given measurement could be properly ascertained and relevant messages conveyed in the process. Some soundings were carried out near the sites of existing boreholes for comparative purpose.

RESULTS AND INTERPRETATION

Computation of apparent resistivity

First and foremost the apparent resistivity were calculated using the formula

$$\rho_{as} = \pi \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \frac{\Delta V}{I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where AB = is the current electrode separation,
MN = is the potential electrode separation, and
$\frac{\Delta V}{I}$ = gives the resistance R.

The earths' resistance taken in four cycles (representing the statistical average for each set of values for a given electrode separation and potential spread). All these measurable physical properties are expressed in appropriate S.I. units. The Schlumberger apparent resistivity values were calculated and recorded in units of Ohm-meter. The calculated data were afterwards cross-checked. The calculated Schlumberger apparent resistivity ρ_{as} of each sounding station was plotted against half of the current electrode spacing (AB/2) on a log-log graph paper. In all cases, the field results were not used directly as input for VES interpretation because the resulting curves usually have different segments that were not smooth. All the sounding curves with noisy segments were first and foremost manually corrected (smoothed). Each of the corrected sounding curves were then used as the input data for computer modeling (Habbergam, 1976; Zohdy *et al*., 1980). Computer aided interpretation of the data was done in two related stages. In the first stage, all the manually smoothed sounding curves were subjected to forward modelling techniques run by Schlumberger sounding data processing and interpretation programme version 1.82 (Zohdy & Bisdorf, 1989). This yielded initial estimates of the resistivities and thicknesses of various geo-electric layers in assumed layered earth models. These parameters were then used in the second stage of interpretation as starting models for the computer iterative least-square inversion. A VES modelling programme for Schlumberger automatic analysis, version 0.92 (SAA-V 0.92) developed by Hemkler (1985) was then used to obtain the final model curves. The Hemkler programme calculates resistivity and depth values at each measurement point. The calculated resistivities and depth values are recorded in Table 1.

TABLE 1

Summary of results of geoelectric survey from computer modeling

VES Station Number	***Location***	***Elevation above sea level (m)***	***Numbers of Layers***	***Geo-electric layers resistivities (Ωm)***		***Geo-electric layers thickness (m)***	***Depth to bottom of Geo-electric layers (m)***											
				ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	d_1	d_2	d_3	d_4	d_5	h_1	h_2	h_3	h_4	h_5
1.	Ofudua Market	72	5	195	31	606	211	470	5.2	8.9	25.6	12.0	-	5.2	14.1	39.1	51.7	-
2.	Ofat 2	94	5	392	67	793	264	825	3.2	7.0	27.8	20.9	-	3.2	10.2	38.0	58.9	-
3.	Ofodua 2	66	3	237	29	62491	-	-	3.1	36.3	-	-	-	3.1	39.4	-	-	-
4.	Ofat 3	75	5	165	188	1649	245	853	1.5	3.5	18.4	33.0	-	1.5	3.0	21.4	54.4	-
5.	Ofodua 1	61	5	740	75	1620	847	19682	6.5	23.7	41.0	29.7	-	6.5	30.2	71.2	100.9	-
6.	Ofodua 3	72	5	491	55	844	259	311	3.7	8.2	13.3	9.7	-	3.7	11.9	25.2	34.9	-
7.	Ababene 1	79	5	176	17.3	981	97	839	64	13.2	37.9	22.1	-	6.4	19.6	57.4	79.5	-
8.	Ababene 2	84	5	165	24	5776	574	4412	4.6	12.8	29.4	19.9	-	4.6	17.4	46.8	66.7	-
9.	Ababene 3	69	5	491	55	844	259	311	7.8	33.0	26.8	25.8	-	7.8	40.8	67.6	93.4	-
10.	Ababene 4	90	5	1538	38	7603	210	2221	8.0	22.7	29.0	19.3	-	8.0	30.7	59.7	77.0	-
11.	Adun 1	71	5	1538	340	1239	499	828	2.8	8.8	19.2	24.9	-	2.8	11.5	30.7	50.6	-
12.	Adun 2	69	5	1834	431	846	479	3155	6.1	45.5	20.1	20.6	-	6.1	51.6	71.7	92.3	-
13.	Adun 3	70	5	1971	429	1007	788	2812	4.3	18.1	13.5	12.9	-	4.3	22.5	36.0	48.9	-
14.	Adun 4	55	5	1299	245	1679	634	4942	3.9	13.6	23.0	14.6	-	3.9	17.6	40.5	55.1	-
15.	Adun beach 5	63	5	1044	206	1252	789	3201	7.3	8.6	23.5	21.2	-	7.3	16.0	39.5	60.7	-
16.	Ofat 5	88	5	490	49	541	2235	309	3.7	6.8	2.3	7.5	-	0.5	5.1	38.3	43.9	-
17.	Ofat 1	91	5	316	50	2738	572	2697	0.5	4.7	33.1	5.7	-	0.5	5.1	38.3	43.9	-

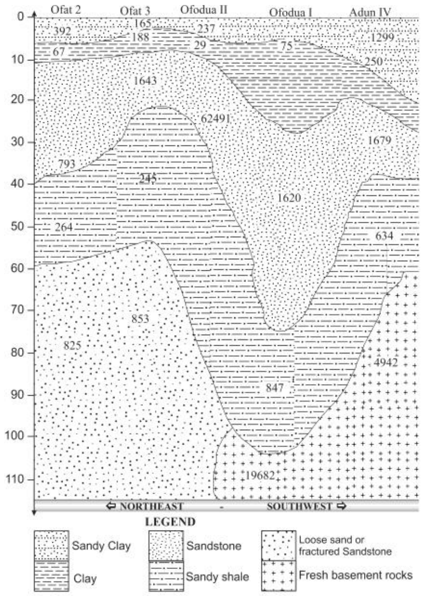

Fig. 2: Northeast - Southwest Geoelectric section in the study area

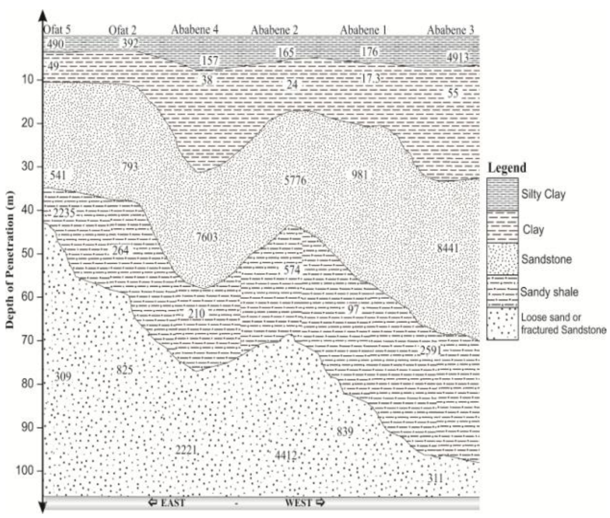

FIG. 3 *East-West geoelectric section in the study area*

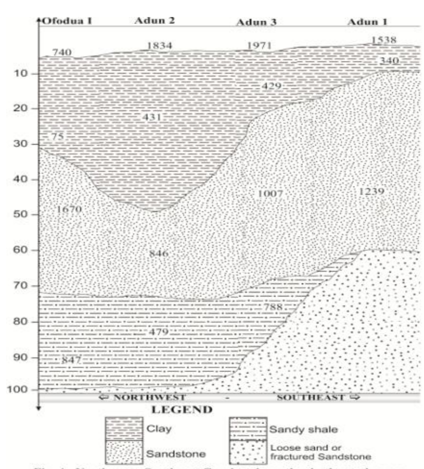

Fig. 4: Northwest - Southeast Geoelectric section in the study area.

Geoelectric sections were drawn for the Northeast – Southwest, East – West, Northwest – Southeast and North – South profile lines of the study area in Fig. 2, 3 and 4 respectively. The resulting soundings curves are of two main groups but mainly dominated by the HKH curve type. In General, 3 to 5 geo-electric layers were identified.

DISCUSSION AND CONCLUSION

The vertical electrical sounding technique according to the results is a powerful tool employed to delineate the subsurface into its different lithologic units. The rock units identified from top to bottom of investigation are sandy clay, sandstone, shale and very coarse grained sandstone. The identification of these lithological units has been aided by the use of vertical sounding curves which shows resistivity with depth. Correlations of the inferred geoelectric section with the lithologs of some boreholes in the study area shown in Fig. 5.

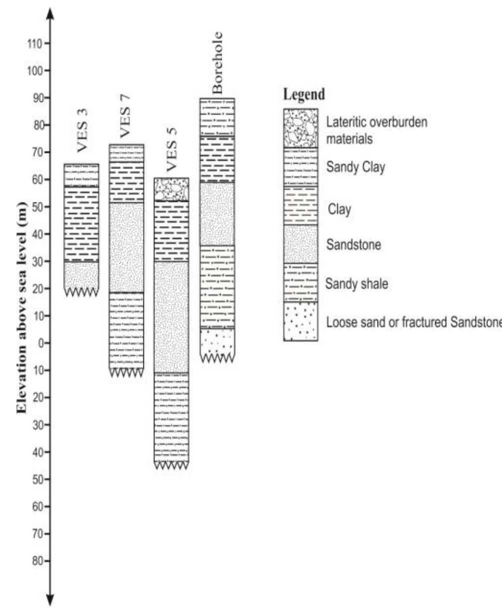

Fig. 5 *Correlation of Borehole Log (BH) with nearby* VES stations.

The sandstone layer and the loose sand or fractured and stone are the two major aquifer units in these parts of Obubra. Of these two aquifers regime the ones at the 3rd layer are unconfined while the ones at the fourth or fifth layers are confined because they are sandwiched within conductive clay sands and shale units respectively. The sedimentary formations which contains aquifers in the area are the Eze Aku group and Azu river group. The two sediments are considered to have lithoogical similarities and groundwater regime is considered to be continuous between them (Kogbe, 1989). The two formations outcrop over a reasonable portion of the study area. The maximum thickness of the Eze Aku group may be up to 302m while estimate of Asu River Group is 250m (short & Stauble, 1967), however, the aquiferous zones are usually thin and there may be more than one in a locality. In some parts of the area hand dug wells penetrates shallow depths and tap waters from suspended water tables. The water levels in this well fluctuates greatly and some of them dry up completely during the dry season because the actual saturated zone is still far beneath. The recharge of these suspended water tables is direct from precipitation on the surface, in the years when prolonged drought is experienced, these well get completely dried up and those who depend on it suffer greatly, this is what is applicable in Ababene 1, 2, 3 and

4. The main aquifers are located at depths of 47m and 90m, the aquifer varies in thickness from 26m to 37m and are usually enmeshed between 10 to 981Ωm. the static water levels of boreholes used for correlation are within 14.0m to 40.0m. Conclusively, the productive zones for groundwater schemes within the study area have been identified.At the Adun 1, 2, 3 and 4 locations, the aquifers occurred at the respective fourth layers with resistivity lying between 479 and 788Ωm at depths of 48.9 to 92.3m. The aquifers around Ofodua 1, Ababene 3, Adun 2, Ababene 1 and Ababene 4 have depths of 100.9m, 93.4m, 92.3m, 79.5m and 77.0m respectively, these implies that those who intends to sink boreholes around the aforementioned locations should not expect to see water at depth shallower than the respective depths for each location. Along the East – West profile, six study locations were captured, five geoelectric layers were imaged, the first layer had a range of resistivity between 157 to 491Ωm the at depth between 3.2 to 8.0m the lighologic material of the layer was inferred to be sandy clay, the second layer had resistivity between 17.3 to 67Ωm and a depth range of 10.2 to 93.4m the layer inferred to be composed of clay material. The third layer had resistivity between 541 to 7603Ωm and depth of 35.8 to 67.6m, the lithologic materials of the third layer are in agreement with the requirement for good aquifer. The fourth layer had resistivity between 97.0 50 2235Ωm at depth of 43.3 to 93.4m and is inferred to be made up of shale while the fifth layer was inferred to be loose sand or fractured sandstone and has resistivity range of 309 to 2221Ωm. All the inferences made are with respect to lithologic log from a nearby borehole in the survey area where a VES was made close to

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