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Geoelectric Evaluation of Groundwater Potential: A Case Study of Sabongida-Ora and Environs, Southern Nigeria

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ABSTRACT: A d.c resistivity investigation for groundwater was carried out in Sabongida-Ora and its environs of Owan West Local Government of Edo State. A total of seven vertical electrical sounding (VES) was carried out using the Schlumberger configuration with a maximum current electrode spacing ranging from 500- 650m. The data was interpreted using conventional partial curve matching and computer aided iteration techniques. Seven hybrid curve types were deduced viz: KHAHQH, KHKHA, KHAKQQ, QQHKH, HKHAA, QHKHA, and KQHKQ. The results showed seven to eight geoeletrical layers with resistivity values ranging from 127Ωm to 767Ωm, 47Ωm to 672Ωm, 70Ωm to 1380Ωm, 4Ωm to 428Ωm and 21Ωm to 400Ωm for the first to eight layers respectively with lithologies consisting of clay, clayey sand and coarse grained sand as indicating in the computed model parameters and geoeletrical section. From the geoelectric section, the area shows a vertical and lateral lithologic heterogeneity as a result of variation in depositional conditions which made unit correlation between the VES stations difficult. Nevertheless, borehole lithologic logs were also correlated with the geoelectric section and similar lithologies were observed. The section showed the occurrence of confined aquifer at a depth range of 60-100m in some places and variable in other places. Results from both data revealed clay layers to be dominant in the study. It is therefore paramount to carry out a thorough geophysical investigation in any locality prior to sinking a borehole in order to forestall loses and to have productive wells. @JASEM

Keywords: Geoelectric, groundwater potential, Sabongida-ora, lithologic heterogeneity, confined aquifer

Groundwater includes all water found beneath the earth's surface. It is the body of water derived primarily from percolations and contained in location of aquifers by subsurface investigation to provide data interpretable in terms of aquifer depth, thickness, area extent and structure is a preliminary assignment in the water development scheme of any community. The extent to which geophysical methods may be applied to a given problem in groundwater is technically dependent on the geological and hydrological controls that bear upon it and the degree to which the geophysical methods provide information on these controls. Boreholes could be problematic if thorough understanding of the subsurface geology is not known. This could be achieved by geophysical investigation using electrical resistivity method. This method is based on the fact that certain physical properties of the rock change considerably depending on their water content, thereby creating a physical boundary between the host rock and the water bearing strata. The superiority of this technique over others to predict the groundwater potential of an area was confirmed by the work of Selemo, et al., (1995); Olayinka and Mbachi, (1992). The study area, located in the Northern part of Edo state has witnessed an upsurge in both infrastructural development and in human population, hence the need for provision of portable water for human consumption and agricultural needs. The provision of potable water via water supply scheme for the area is grossly inadequate. Its neighboring communities have very few or no boreholes and their only source of water is from streams and hand dug wells which are highly reliable during the dry season.

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This calls for the detailed geological and geophysical investigation of the area with a view of evaluating the groundwater potential of the area. It is hoped that the result of this investigation will be of immense benefit in the future ground water development programs in Sabangida-Ora and its environs in which water problems has existed for a long time.

Location of Study Area: The study area is located within longitude 5^0 55^1E and 6^0 00^1E and longitude 6^052^1N and 7^000^1N (fig 1). Sabongida – Ora and environs comprises Sabongida-Ora, Okpokhumi, Ovbiokhuan, Eme, Ojavun, Oke And Ebule. These communities are within a distance of 3.5km – 10km from Sabongida–Ora town, the headquarter of Owan West Local Government council of Edo state. The study area is accessed by both secondary roads, minor roads linking the various towns. The area is within the Tropical Equatorial climate dominated by two major climatic seasons: the wet season from April to October and the dry season from November to March. The average annual rainfall is about 1500mm (Akintola, 1986), and this serves as the major source of groundwater recharge in the area.

Geology and Hydrogeology: The study area falls within the localities where the lithofacies of the Niger Delta grade into the lithofacies of the Anambra basin. The area is underlain by sediments of cretaceous, tertiary and quartenary ages (Reyment, 1965), Allen 1965, Short and Stauble (1972).

The Cretaceous sediments occur in the area as lenses and boulders of brown to reddish brown ferruginized gritty highly indurated sandstone, mudstone, claystones, probably of the lower coal measures. These ferruginized sandstones, shales, claystones and mudstones belong to the Mamu Formation in literature. Fresh exposures are found in Sabongida-ora and Eme at the Southern part of the study area (fig 1). The Northern part of the study area is underlain by the Nkporo group, consisting of the dark grey, often friable shales/clays and mudstones with occasional thin beds of sandy shale and sandstone.

Three main rivers drain the study area; the River Owan, Onuan and Ule and the drainage pattern is generally dendritic. Hydrological data obtained from Edo State urban water board indicates that the "Static water levels" (SWL) of the first and second aquifers lie averagely between 53.1m – 93.8m and 100m – 118.8m respectively in Oke and about 63m – 103m and 106 – 123m respectively in Sabongida-Ora town. Nevertheless, there is a high degree of variability of static water levels from one locality to another.

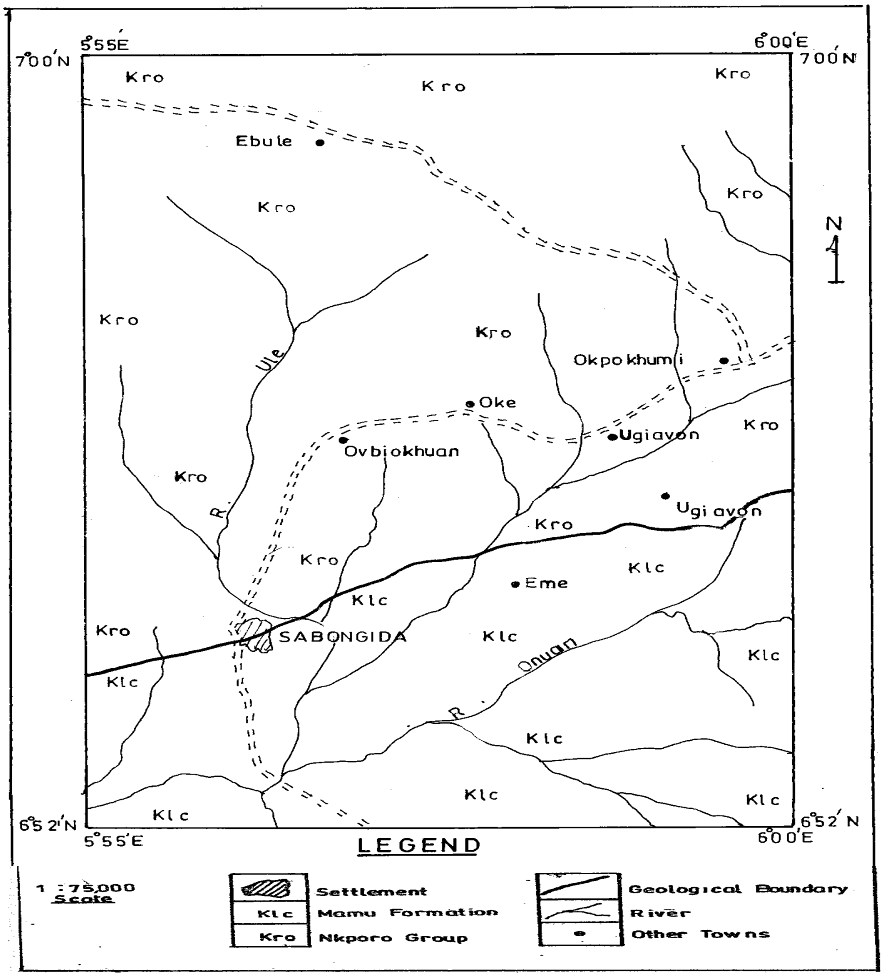

Fig. 1: Geological map of the study area

MATERIALS AND METHODS

The Vertical Electrical Sounding (VES) technique adopting the Schlumberger electrode configuration was used in the data acquisition that was carried out at preferred points in the study area (Fig 1). The choice of locating VES stations was guided by observed relief in the area and the need to have a good geographical spread. A total of seven VES stations were occupied with a maximum current electrode separation ranging from 500-650m depending on accessibility. The ABEM SAS 300 Model Terrameter was used for the data acquisition. The apparent resistivity values obtained from the field measurements were plotted against half current electrodes spacing (AB/2) on a bi-logarithm graph paper to produce corresponding field curves. The field curves were interpreted quantitatively by partial curve matching using two layer standard curves and by computer iteration using Schlumberger O' Neil interpretation software. The geoelectric parameters deduced and inference made therein were compared with lithologic logs obtained from drilled boreholes in the area.

RESULTS AND DISCUSSION

The results of the investigation are presented as tables, sounding curves and geoelectric section. Table 1 shows geoelectric layers parameter deduced from the computed integration and modeling of the field curves study area. Seven hybrid field curves type of KHAHQH, KHKHA, KHAKQQ, QQHKH, HKHAA, QHKHA and KQHKQ were obtained. Quantitative evaluation of the VES model curve types and the computed geoelectric layer parameters indicate seven to eight geoelectric layers as shown in table 1. The first layer has resistivity values ranging from 1270Ωm (VES 7) to 7670Ωm (VES 4) and those values are inferred to be clayey sand, medium sand and silty sand.

The second layer has resistivity values that range from 47.10Ωm (VES 6) to 6720Ωm (VES 1) and spanning a depth range of between 1.4m and 6.0m, with thickness ranging from 0.8m to 5.1m. the deduced lithologies includes fine sand, clayey sand clay and silty sand. The third layer resistivity value ranges from 7.90Ωm (VES) to 6220Ωm (VES 5) within a dept range of 5.7m to 33.2m and thickness of between 4.3m to 27.2m. the inferred lithologies includes clay, clayey sand and fine sand.

The fourth layer has resistivity values ranging from 4.10Ωm (VES 6) to 3340Ωm (VES 3). The inferred lithologies include clayey sand, clay and silty sand, spanning a depth range of 15.5m to 51.3m with a thickness ranging from 5.5m (VES 1) to 22.1m (VES 4). The fifth layer has resistivity values ranging from 4.60Ω (VES 6) to 11000Ωm (VES 3). The inferred lithologies includes medium sand, clay, clayey sand and silty sand with a maximum depth of 27.6m (VVES 5) and maximum of 89.3m (VES 4) and thickness ranging from 10.3m (VES 6) to 56.7m (VES 4). The sixth layer resistivity values ranges from 18.10Ωm (VES 5) within a depth range of 47.80Ωm (VES 1) to 1350Ωm (VES 4) and thickness of 13.6m to 45.7m. the inferred lithologies include clayey sand, clay, silty sand and medium sand. The seventh layer has resistivity values ranging from 15.70Ωm (VES 1) to 48200Ωm (VES 5). The inferred lithologies includes clay, medium sand, clayey sand and coarse grained sand with depth and thickness present for only VES 1 and VES 3. That is, depth range 142m (VES 3) to 202m (VES 2) and thickness of 28m (VES 3) and 154.2m (VES 1). It's lithology is mainly clay.From the above VES data and inferred lithologies, it can be deduced that the fifth layer (VES 3 and VES 1), sixth layer (VES 5) and seventh layer (VES 5, VES 2 and VES 6) can be inferred as potential aquifer units. Thus, borehole drilled to a depth range of 52m-120m at these VES locations will have a good water yield.

The geoelectric section (fig 5) also indicate that the study area has lateral lithologic discontinuity as a result of gradational lithologic contacts. This makes unit correlation between VES stations somehow difficult over a wide area. *Conclusion:* The field curve types and the geoelectric parameters derived from computer iteration modeling revealed seven model hybrid curve types viz: KHAKQH, KHKHA, KHAKQQ, QQHKH, HKHAA, QHKHA and KQHKQ. These curves are indicative of a more complex lithologic sequence of alternating high and low resistivity layers inferring high lateral and vertical lithologiic heterogeneity. This is as a result of rapidly changing depositional conditions that ranges from fluvial, deltaic, lacustrine and near shore environments that often characterized the proximal part of a sedimentary basin. According to Agumanu, (1976) these depositional settings often result in complex lithofacies stacking system. The lithologies constituting the aquifer units in the study area are mainly coarse grained sand and the aquifer types are confined. VES 2 and VES 5 are adjudged suitable sites for sinking boreholes within a depth range of 60-100m but would yield an unreliable long term water supply. There is also a viable aquifer at VES 3 at a depth of 85m with thickness of 33m. Though a generalized depth to water table cannot be deduced

for the entire area due to the varying thicknesses and depths of the aquifers, but from borehole lithologic log of Oke that was observed, it can be recommended that boreholes drilled to greater depths of about 200-250m will have good water yields
.

Table 1: Geoelectric layer parameters deduced from computer iteration and modeling of the VES field curves in the study area

VES station	Layer no	Resistivity (Ωm)	Thickness (m)	Depth (m)	Curve type	Inferred lithology
VES 1	1	471.0	1.0	1.0		Silty sand, Fine-
General	2	672.0	2.6	3.6		medium
Hospital	3	54.8	6.4	10.0		Sand
Sabongida-	4	294.0	5.5	15.5	KHAKQH	Clay
Ora	5	930.0	16.3	31.8		Clayey sand
	6	133.0	16	47.8		Medium sand
	7	15.7	154.2	202.0		Clayey sand
	8	40.8				Clay
						Clay
VES 2	1	141.0	1.0	1.0		Clayey sand
By Oba's	2	222.0	1.8	2.8		Clayey sand
Palace	3	9.1	5.6	8.4		Clay
Ovbiokhuan	4	63.1	14	22.4	KHKHA	Clay
	5	4.6	31.3	53.7		Clay
	6	18.1	16.8	70.5		Clay
	7	778.0				Medium sand
VES 3	1	197.0	0.9	0.9		Clayey sand
	2	531.0	5.1	6.0		Fine sand
	3	183.0	27.2	33.2		Clayey sand
	4	334.0	18.1	51.2	KHAKQQ	Silty sand
	5	1100.0	33.8	85.1		Medium sand
	6	308.0	28.9	114.0		Silty sand
	7	155.0	28	142.0		Clayey sand
	8	21.8				Clay
VES 4	1	767.0	0.7	0.7		Medium sand
Ecoh,	2	165.0	1.6	2.3		Clayey sand
Primary	3	28.2	8.2	10.5		Clay
School	4	15.6	22.1	32.6	QQHKH	Clay
Ojavan	5	158.0	56.7	89.3		Clayey sand
	6	102.0	45.7	135.0		Clayey sand
	7	125.0				Clayey sand
VES 5	1	188.0	0.6	0.6		Clayey sand
Okpokhumi	2	75.6	0.8	1.4		Clay
Primary	3	622.0	4.3	5.7	HKHAA	Fine sand
School	4	86.0	10.6	16.3		Clay
	5	355.0	11.3	27.6		Silty sand
	6	1380.0	26	53.6		Medium sand
	7	4820.0				Coarse sand
VES	1	147.0	0.9	0.9		Clayey sand
Eme	2	47.1	1.7	2.6		Clay
	3	7.9	11.9	14.5		Clay
	4	4.1	15.9	30.4	QQHAA	Clay
	5	29.5	10.3	40.7		Clay
	6	74.6	13.6	54.3		Clay
	7	1430.0				Medium sand
VES 7	1	127.0	1.2	1.2		Clayey sand
Commercial	2	428.0	2.1	3.3		Silty sand
Road,	3	102.0	7.5	10.8		Clayey sand
Sabongida-	4	9.3	18	28.8	KKQHKQ	Clay
Ora	5	153.0	36.7	65.5		Clayey sand
	6	89.0	36.5	102.0		Clay
	7	44.9				Clay

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