Full Length Research Article

ASSESSMENT OF THE AQUIFERS IN SOME SELECTED VILLAGES IN CHIKUN LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA.

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ABSTRACT
The Vertical Electrical Sounding (VES) technique was used to investigate the sub-surface layering in some selected villages in Chikun LGA of Kaduna State with the aim of determining the configuration of the aquifer underlying the region. The result of the interpreted VES data suggests that the area is underlain by three to five layers. The geologic sections derived from the analyzed geoelectric section suggest that the alluvial deposits of sand, silt and sandy clay as well as the weathered and fractured basement rocks constitute the aquifer in the areas. The average thickness of the aquifer was found to be 25m. The geoelectric section generated also suggest that the resistively values of the aquifer components range from 100 Ωm to 250 Ωm for the alluvial deposits to an average of 50 Ωm to 350 Ωm for the weathered/fractured basement formations. Results obtained for the pumping tests and transmissivity values of boreholes drilled shows that the area's aquifer are capable of producing at least 0.75l/s i.e. 2.7m³/hr of portable water.

***Keywords**:* Geoelectric, Aquifer, Borehole, Vertical Electrical Soundings (VES).

INTRODUCTION
The Vertical Electric Sounding method, which has been found successful in groundwater investigation and in aquifer delineation (Keller & Frischknecht, 1966; Kas *et al.,* 1997). is used in investigating the subsurface formations in some villages in Chikun LGA located towards the south eastern flank of Kaduna main town. Some of the notable villages include Unguwar Dodo, Kakau, Unguwar Biji, Kudenda, Maichibi, Unguwar Barde, Unguwar Gimbia, Karatudu, Sabon Tasha, Romi and other several settlements of nomadic cattle herdsmen. The problem of water supply in Chikun LGA is a major concern as with most parts of Kaduna State. Most of the water required for domestic and agricultural uses is sourced from seasonal streams and riverlets which exists in the area as well as from shallow hand-dung wells. These sources most often do not provide the needed good quality supply as they are prone to contamination by human beings and animals. Many of the villages and hamlets are situated at great distances and virtually out of reach from these surface water sources. This scarcity of clean water supply has led to the prevalence of water-borne diseases like guinea worm, cholera and typhoid fever. The United Nations International Children Education Fund's Rural Water Sanitation, UNICEF-RUWATSAN Project had reported that more than one million people are yearly affected by allied diseases such as guinea worm (UNICEF, 1988). Provision of sustainable potable water for the inhabitants of the area is therefore of utmost concern. A solution to this anomaly will stem the scourge of identified water-borne diseases presently identified as plaguing the area. This research is aimed at identifying the nature, extent and spatial distribution of the components of the aquifer in the area and invariably provides some preliminary data on the groundwater potentials of the area that can lead to improvement and development of the water resources of the area.

MATERIALS AND METHODS
Geology and Geomorphology: Chikun Local Government Area and the entire adjoining landmass, lies within Basement Complex in the northern part of Nigeria. The rocks of the area are mostly Precambarian in age and have been subjected to several phases of deformation, the latest being the Pan African Orogeny (McCurry, 1975). This thermotectonic event has virtually obliterated the imprints of earlier events but left its own structural earmarks, which include: filing, fracturing, shearing, granitic emplacement and granitisation. The Migmatic-Gneiss Complex which underlies most of the Kaduna-Zaria area and typifies the area of investigation is characterized by spectacular exposure of well defined Migmatite around Kudenda, Kakau, Sabon Tasha, Kabala east and west areas in Kaduna metropolis (Ogezi, 1988). These materials are usually liable to form aquitard and permeable zones to the bedrocks in the country rocks of the area. Associated with the crystalline rocks are the presence of structures like fractures, fissures, veins, joint and such other structural deformations of the basement complex which controls the flow of ground water and also influence the rate of recharge and discharge of the main aquiferous units (Offodile, 1992).

The dominant topographic feature is the alluvial Plain of the small tributaries of river Kaduna which dot the area and stretches across and up to rivers Kudenda and Romi on the northern flank. These alluvial plains gently rise into the consolidated lateritic hills and inselbergs found around the Nassarawa and Kudenda village axes. The Vegetation of the area is of the typical Guinea Savana type which according to Udo (1982) has a characteristic mean annual temperature of 29oC and means annual rainfall of 300mm. The dominant River Kaduna control the course of most of the rivers and streams in this area.

VES data Collection and Interpretation: A total of Twenty two (22) Vertical Electrical Soundings (VES) data using Schlumberger array were carried out at various sites located within the Chukun LGA. Borehole logs of some wells located close to the sounding sites were similarly collected for quantitative analyses in order to correlate the two derived information. This is basically aimed at determining the subsurface layering, thickness of the surface layers, thickness of the overburden and thickness of the aquiferous or saturated ground water layer beneath each of the studied VES sites. Quantitative interpretation of the data was carried out using the new iterative method developed by Zohdy (1989). The method, which is an improvement on the curve matching technique, does not require a preliminary guess for the number of layers, their thickness, or their resistivities, and it does not require extrapolation of the last branch of the sounding curve to their respective asymptotes. The number of layers is equal to the number of digitized points, and the layers boundaries are spaced uniformly on a logarithmic depth scale.

RESULTS

The evaluated apparent resistivity values for each sounding point was uploaded and after carrying out a number of iterations, the subsurface layers, their depths, thickness and the resistively values for each of the sounding points were evaluated by the computer using the Zohdy programme. Tables 1 and 2 shows the data for two drilled borehole in Unguwar Dodo area. Interpretation of the curve suggests the area is underlain by five geoelectric layers of various lithologies. The fourth layer has an average low resistivity value of 65.17Ωm and an estimated thickness of 25m. This fourth layer is thus suggested to comprise of the saturated ground water zone at this VES site, and is hence the aquiferous formation. The log result also gives the thickness of this formation as 25.15m. Thus the average value of resistivity of the area's aquifer was found to be 65.17Ωm while the average thickness of the aquifer is 25m.The procedure described above for determining the aquiferous zone was repeated to analyze the nature and characteristics of the aquifer beneath the 22VES data collected for the various VES sites in the study area of this work.

UNGDODO 1

Schlumberger Array

Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	DIFFERENCE	Smooth Model: Synthetic Resistivity	DIFFERENCE
1	1.50	0.500	239.3				
2	2.50	0.500	269.6				
3	4.00	0.500	201.3				
4	6.00	0.500	169.0				
5	6.00	1.00	168.0				
6	8.00	1.00	148.5				
7	10.00	1.00	146.2				
8	15.00	1.00	126.7				
9	20.00	1.00	119.1				
10	25.00	1.00	123.0				
11	25.00	5.00	123.0				
12	30.00	5.00	123.7				
13	40.00	5.00	138.0				
14	50.00	5.00	155.5				
15	65.00	5.00	190.0				

NO DATA ARE MASKED -

Layered Model

L #	RESISTIVITY	THICKNESS (meters)	DEPTH	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
				0.0		
1	255.6	2.41	2.41	-2.41	0.00945	617.8
2	107.7	2.13	4.54	-4.54	0.0197	229.5
3	159.1	3.59	8.14	-8.14	0.0225	572.3
4	81.65	15.32	23.46	-23.46	0.187	1250.9
5	456.7					

TABLE 1. INTERPRETED DATA FOR VES POINT 1, U/DODO

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UNGDODO 2

Schlumberger Array

Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	Layered Model: DIFFERENCE	Smooth Model: Synthetic Resistivity	Smooth Model: DIFFERENCE
1	1.50	0.500	417.6				
2	2.50	0.500	360.0				
3	4.00	0.500	282.3				
4	6.00	0.500	225.0				
5	6.00	1.00	226.0				
6	8.00	1.00	196.0				
7	10.00	1.00	189.7				
8	15.00	1.00	175.0				
9	20.00	1.00	162.8				
10	25.00	1.00	131.6				
11	25.00	5.00	131.6				
12	30.00	5.00	132.0				
13	40.00	5.00	140.0				
14	50.00	5.00	157.0				
15	65.00	5.00	190.0				

NO DATA ARE MASKED

Layered Model

L #	RESISTIVITY	THICKNESS (meters)	DEPTH	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
				0.0		
1	443.3	1.61	1.61	-1.61	0.00363	714.3
2	171.1	3.63	5.25	-5.25	0.0212	622.7
3	268.8	4.42	9.67	-9.67	0.0164	1188.9
4	53.53	11.67	21.35	-21.35	0.218	625.1
5	505.3					

TABLE 2. INTERPRETED DATA FOR VES POINT 2 U/DODO

Fig. 1 (a) – (d) show typical geoelectric sections obtained from the interpreted VES data and the geologic sections derived from the borehole logs collected for some of the investigated VES sites.

Water level measurements were also made with an electric sounder to determine the average specific yield capacity value for the area's aquifer. To this effect, a Grundfos SQ 3-80 submersible stainless steel pump was installed at an average depth of 23m in each of the sampled wells. A semi constant discharge method was adopted for the operation. The initial average discharge in the wells was 1.0l/s though it dropped slightly to 0.75l/s and was maintained through the pumping period, which lasted for 5hrs. The average value of the initial static water level, measured from top of well head, was maintained at 7m. After 5hrs of pumping, the water level in these sampled wells stabilized at 16.9m. The recovery level of water in the boreholes was also measured with same equipment when pumping stopped. The calculated average transmissivity value was 2.7m^2/day.

A resistivity map of the aquifer (Fig. 2) was produced to give a regional picture of the nature of the area's aquifer. This was produced by contouring the average values of the resistivity of the aquifer in the various villages and also from the information obtained from the borehole logs collected from the wells drilled in the areas.

DISCUSSION

As shown earlier the interpreted VES data and information obtained from the borehole logs have been used to produce the geoelectric and geologic sections associated with each of the VES sites investigated.

Geoelectric and Geologic Sections: The model geoelectric and geologic sections beneath each section were derived in order to determine the geological parameter of lithology and thickness and the resistivity characterizing each aquifer. In deriving the geological sections corresponding to the geoelectric sections, the results of the borehole logs of the wells situated close to each sounding area were used in addition to the information on the geology of the area. These borehole logs serve as control on the interpretation of the corresponding VES data for each site. Additional information used was obtained from similar reports of Aboh & Osazuwa (2000), Ajayi & Hassan,(1990), Shemang (1993). The analyses of the sections obtained for this work suggest that the storage elements for

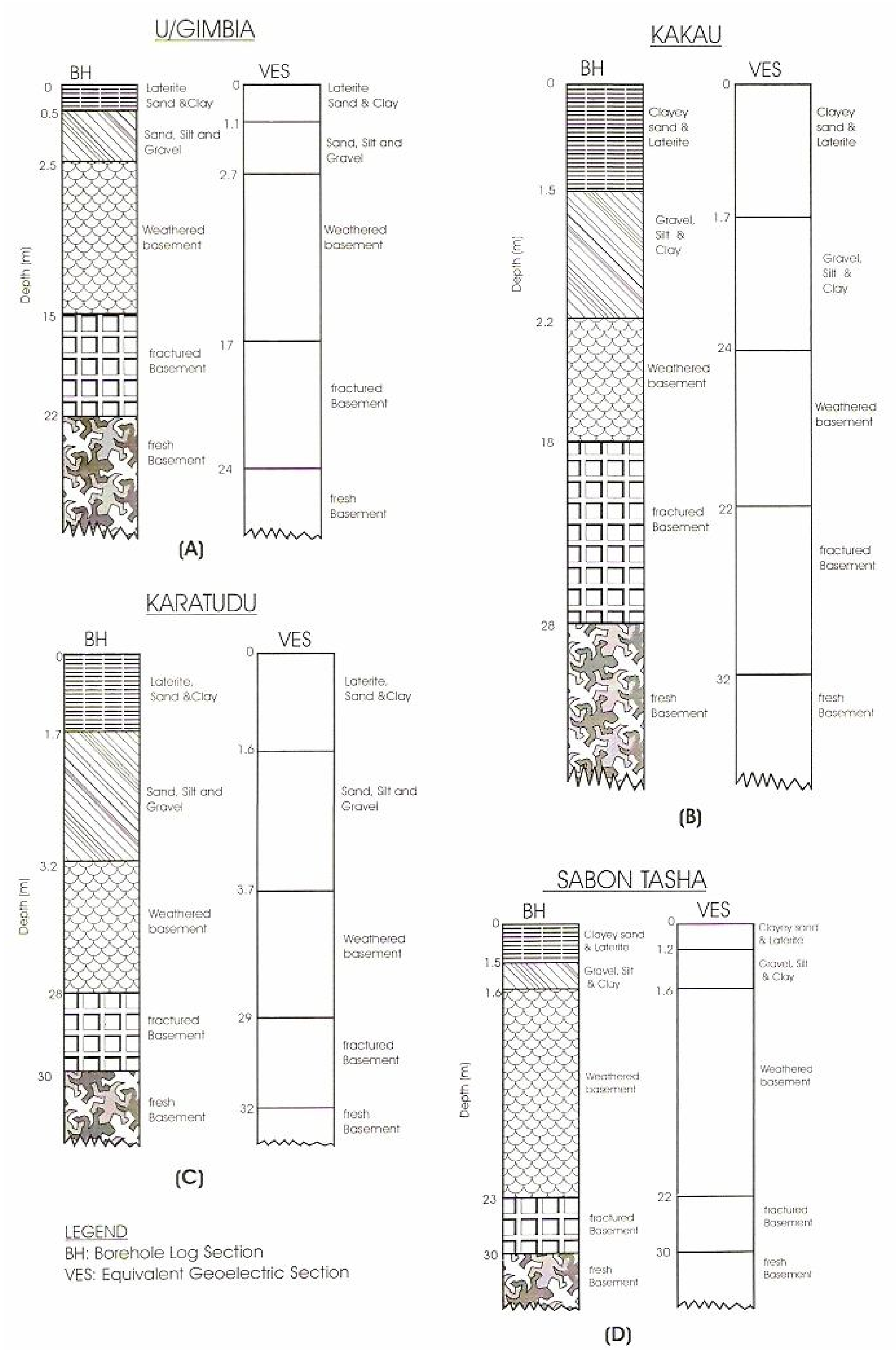

FIG. 1. GEOLOGICAL SECTIONS AND EQUIVALENT GEOELECTRIC SECTIONS DELIVERED

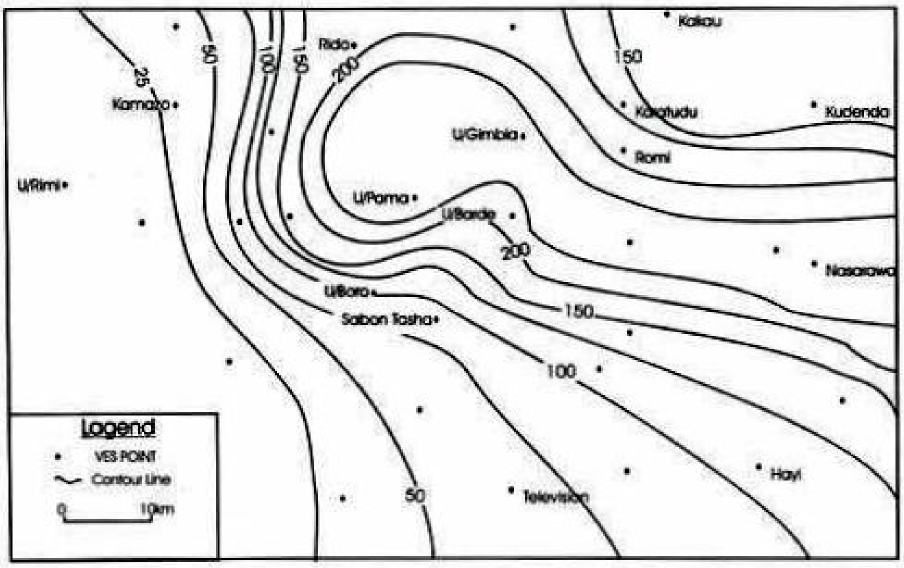

FIG. 2. CONTOUR MAP OF AQUIFER RESISTIVITY FOR THE STUDY AREA

ground water in these selected villages in Chikun LGA consists of mainly the weathered basement and fractured basement rocks of the Precambrian Basement Complex. It was found that the weathered basement aquifers are characterized by resistivity values in the range of 81.65 to 55.53Ωm while resistivity values of 53.53Ωm to 456.0Ωm are associated with the aquifers of the fractured basement rocks. From the results of the well development and pumping tests carried out in the sampled wells, it is obvious that the boreholes within these selected villages all have reasonable yield consistent with the weathered/fractured basement type of aquifer as corroborated in the earlier by Olaniyan & Olabode, (1998). Based on the results obtained for the pumping tests and the calculated transmissivity values, boreholes drilled in the area's aquifer are capable of producing at least 0.75l/s (2.7m^3/hr) of portable water.

From the resistivity map of the aquifer (Fig. 2), the sections where the aquifer are thickest and has an averagely low resistivity value are the best areas for the exploitation of underground water. The northwest areas consisting of the landmass of Kamazou, Unguwar Dodo and Sabon Tasha villages which extend to part of Unguwar Rimi villages are sections where the resistivity values of the aquifer are comparatively low and have high aquifer thickness. Similar features can be found towards Kakau and Kudenda villages on the northeastern flank of the study area. The landmass here is suggested to be underlain by materials most favorable for siting boreholes within the study area. The feature observed here correlate with basement depressions found in that area as discovered from earlier works (Aboh & Osazuwa, 2000). Similarly, this observed phenomenon seem to suggest that the geometry of the underlying weathered basement are most likely serving as a form of structural control on the flow of rivers and streams within the area. In some other situations basement depressions serve as ground water dams.

The areas where the resistivity values of the aquifer are relatively high are found towards the central region of the study area i.e. around Rido, Unguwar Barde, and Unguwar Gimbia, Kudenda, Unguwar Pama, Hayi and Nasarawa Villages. The thicknesses of this area's aquifer are noted to also be small. Few basement outcrops are noticeable in these places as well. These basement outcrops could serve as recharge points for the aquifer. These comparatively shallow aquifer areas could serve as water sheds, especially those close to the river Kaduna and the other existing streambeds. The zone may therefore have low potentiality for underground water.

This work has therefore produced some preliminary data on the ground water potentials for the area as a contribution towards the improvement and development of the groundwater resources in that part of Kaduna State. Studies on the inter connectivity of the fracture system, porosity of the formations could be carried out to further confirm the deductions made of the potentially of the aquifer system of the area.

REFERENCES

Aboh, H. O. & Osazuwa, I. B. (2000). Lithological Deductions from Regional Geoelectric Investigation in Kaduna Area, Kaduna State, Nigeria. *Nigerian Journal of Physics*, 12 (1):1-7

Ajayi, C. O. & Hassan, M. (1990): The delineation of the Aquifer Overlying the Basement Complex of Western part of the Kubani Basin of Zaria (Nigeria). *Journal of Mining and Geology,* 26(1):117-124.

Kas, M., Ibeh, K. M. & Onu, N. M. (1997): Geophysical Investigation for Water in Idah, Kogi State, Nigeria. *Nigerian Journal of Technical Education*, 14(2):68-72.

Keller, G. V. & Frischknecht, F. C. (1966): *Electircal Methods in Geophysical Prospecting.* Pergarmon Press, New York

McCurry, P. (1975). *The geology of the PreCambrian to Lower Palaeozoic Rocks of Northern Nigeria.* Geology of Nigeria, Edited by CA Kogbe.

Offodile, M. E. (1992). *Ground Water Resources of Nigeria*. Medico Limited, Jos, Nigeria.

Ogezi, A. E. (1988). Geochemistry and Geochronology of Basement Rocks from North Western Nigeria. Unpublished Ph.D Thesis, University of Leeds.

Olaniyan, I.O. & Olabode, T.O. (1998). Assessment of the Groundwater Potentials of a Typical Fadama Area, Kaduna State, Nigeria. *Journal of Engineering* 1(2):86-92

Shemang, E. N. (1993). Groundwater Potentials of Kubanni River Basin, Zaria, Nigeria from D.C. Resistivity Study, Water Resources *The Hydrogeologists* 4(1 & 2): 36 – 42.

Udo, P. O. (1982): *Physical Geography of Nigeria*. Heinemann Education Publishers, Ibadan.

UNICEF– RUWATSAN Project, (1988) Borehole logs and VES data of Boreholes Drilled in Edu LGA, Kwara State, Nigeria; unpublished Report.

Zohdy, A. A. R. (1989). A new Method for Automatic Interpretation of Schlumberger and Wenner Sounding Curves. *Geophysics* 54 (2): 245-253.