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Geo-electrical Resistivity Survey of Bayero University Kano New Campus, Nigeria

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Abstract:

This work is about the evaluation of the subsurface condition of Bayero University, Kano new campus using electrical resistivity method. Apparent resistivity data were acquired from the study area using vertical electrical sounding Schlumberger Array. Forty nine stations were sounded; the stations were spread with the range of about 200m to 500m. The measurement were conducted using Terrameter SAS 1000, collected data were analyzed using IPI2WIN, and surfer version 7.0 software. The area is bounded by latitude 11.9922° N to 11.9615° N and longitude 8.4399° E to 8.1273° E. The interpretation of the acquired data was based on the borehole information obtained from the Department of Water and Technical Services, Kano state ministry of works. The study revealed that the area is underlain by two, three, four and five subsurface layers. The study based on the acquired data identified areas around VES 3, 11, 12, 13, 19, 21, 22, 29, 34, 44, and 46 as the favorable areas for groundwater exploration with the depth to which boreholes to be sink recommended to be 40m to 75m. The research also provides information about the subsurface condition with regards to building construction and safe refuse dumping site.

Keywords: Vertical electrical sounding, subsurface, Bayero university Kano new campus

1. Introduction

Access to clean water is a human right and a basic requirement for economic development. The safest source of water supply is the groundwater. Since groundwater normally has a natural protection against pollution by the covering layers, only minor water treatment is required. Detailed knowledge on the extent, hydraulic properties and vulnerability of groundwater reservoirs is necessary to enable a sustainable resource, (Kirsch, 2009). As groundwater becomes more important and a source of uncontaminated water, methods for locating good aquifers must become more efficient. Partly for this reason, geophysical methods are playing an increasingly important role in groundwater investigations. Of all surface geophysical methods, the electrical resistivity method has been the most widely used in groundwater investigations, (Walter and William, 1981).

Considering the area extent of BUK New Site and the number of boreholes available in the site and even the way water is being distributed daily within the campus by the use of tankers, there is the need to carry out an investigation of this kind in order to strategize drilling of boreholes for optimal supply rather than indiscriminate water exploitation activities.

Another important issue in this study is the determination of the subsurface lithology, which will help in delineating the depth to which the borehole(s) can be sunk to obtain maximum, portable and consumable water, thus determining the depth of each layer and also the need for detailed evaluation of subsurface condition to guide civil engineering activities

The geology of the study area is the same as that of Kano in general. The Bayero University, Kano permanent site is underlain by the basement complex rock of the north-western Nigeria. The rock types in the area are older granites sediments and older basement (www.kanostate.net, 2011) as cited by Oritsejолonsan and Saleh (2011).

1.1. Theory

The purpose of electrical resistivity surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface. From this measurement, the true resistivity of the subsurface can be estimated. The ground resistivity is related to various geological parameters such as the mineral and fluid content, porosity and degree of water saturation in the rock.

The fundamental physical law used in resistivity surveys is Ohm's law that governs the flow of current in the ground. The equation for ohms law in vector form for current flow in a continuous medium is given by (Loke, 2001)

$$J = \sigma E \quad 1$$

where σ is the conductivity of the medium, J is the current density and E is the electric field intensity. In practice, what we measured is the electric field potential which is related to the field intensity as

$$E = -\nabla\Phi \quad 2$$

Combining equations 1 and 2, we get

$$J = -\sigma \nabla\Phi \quad 3$$

We consider a case of homogeneous subsurface and a single point current source on the ground surface. In this case, the current flows radially away from the source, and the potential varies inversely with distance from the current source. The equipotential surface has a hemisphere shape, and the current flow is perpendicular to the equipotential surface. The potential in this case is given by (Loke, 2001)

$$\Phi = \frac{\rho I}{2\pi r} \quad 4$$

where r is the distance of a point in the medium (including the ground surface) from the electrode.

In practically all surveys, the potential difference between two points (normally on the ground surface) is measured. The potential difference is then given by

$$\Delta\Phi = \frac{\rho I}{2\pi} \left\{ \left(\frac{1}{r_1} - \frac{1}{r_2} \right) - \left(\frac{1}{r_3} - \frac{1}{r_4} \right) \right\} \quad 5$$

The above equation gives the potential that would be measured over a homogeneous half space with a 4 electrodes array (Figure 1). Resistivity measuring instruments normally give a resistance value $R = \Delta\Phi/I$, so in practice the apparent resistivity value is calculated by

$$\rho_a = KR \quad 6$$

where $K = \frac{2\pi}{\left\{ \left(\frac{1}{r_1} - \frac{1}{r_2} \right) - \left(\frac{1}{r_3} - \frac{1}{r_4} \right) \right\}}$ is called the geometric factor which depends on the arrangement of the four electrodes.

2. Method

Figure 1: Four Electrodes Array

The measurements were conducted using terrameter SAS 1000 with the electrodes arranged as shown in Figure 1. The data was collected with the electrodes injected into the ground, the current electrodes were spaced at 3.0m and the potential electrodes spaced at 1.0m which are connected with the Terrameter using cables. The current was sent into the ground via the current electrodes which leads to potential difference to be measured at the potential electrodes; this gives the resistance from which the apparent resistivity is calculated using equation 6. The procedure is then repeated with the current electrodes spaced at 4.0m, 9.0m, and 14.0m up to 400m as shown in Table 1. The procedure was repeated in the remaining 48 VES points.

AB/2 (m)	MN/2 (m)	K (m)	ρ (Ω m)
1.50	0.5	1.77	394.99
2.00	0.5	3.14	417.00
3.00	0.5	7.07	334.19
4.50	0.5	15.91	193.09
7.00	0.5	38.49	106.67
8.00	0.5	50.27	88.277
10.00	0.5	78.55	64.253
10.00	2.00	314.20	138.520
12.00	2.00	452.45	104.87
14.00	2.00	615.83	92.015
15.00	2.00	706.93	74.381
17.00	2.00	908.04	89.430
20.00	2.00	1256.80	139.07
25.00	2.00	1963.75	156.36
30.00	2.00	2827.80	121.53
45.00	2.00	6362.55	117.66
45.00	5.00	15906.38	94.891
60.00	5.00	28278.99	299.40
70.00	5.00	38489.50	331.12
80.00	5.00	50272.00	500.78
100.00	5.00	78550.00	802.9
140.00	5.00	153958.00	722.12
140.00	10.00	307916.00	1024
160.00	10.00	402176.00	884.42
180.00	10.00	509004.00	214.30
200.00	10.00	628400.00	972.4

Table 1: Typical Apparent Resistivity Data for Station 1

3. Data Analysis

Geoelectric data acquired are normally processed to remove noise arising from instrumentation and environmental influence. The apparent resistivity data are presented as sounding curves. The curves are obtained by plotting the apparent resistivity values against half of the current electrodes separation (AB/2). The curve type in each VES station depends on the subsurface layers sequence. The main purpose of processing the VES data displayed as curve is to determine the subsurface layers, their resistivity as well as their thicknesses.

The data analysis was performed using IPI2WIN software which gives automated interpretation of the Schlumberger sounding curves to obtain the equivalent n-layer model from apparent resistivity curve of each sounding. Figure 2 shows representative sample of the VES curve and the modeled parameter table obtained using IPI2Win. The interpretation of the resistivity data was done by comparing the resistivity values on the model parameters Table in Fig. 2 to the typical resistivity range of values adopted for this research presented in Table 2. The comprehensive results of the interpreted layer parameters for VES 1 is presented in Table 3. Surfer 7 software was used to map the various layers in the study area.

Figure 2: Sounding Curve and Corresponding Parameter Table for VES 1

Rock Type	Resistivity range (m)
Top soil	0 - 50
Laterite	51 - 200
Weathered basement complex	201 - 500
Fractured basement complex	501 - 800
Fresh basement complex	> 800

Table 2: Typical Resistivity Values Adopted for This Work (Source Telford, 1990)

VES	Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Rock Type
1	1	124	1.236	1.236	Laterite
	2	344	1.224	2.46	Weathered basement
	3	638	1.54	4.00	Fractured basement
	4	2560			Fresh basement

Table 3: Interpreted Layer Parameters for VES 1

3.1. Maps Produced from the Interpreted Data

Contour maps were produced from the interpreted layer parameters for all the VES stations.

3.1.1 Top Soil Thickness Map

The topsoil thickness map (Figure 3) shows that the top soil ranges from 0.23m to 44m in thickness. This indicates that the first geoelectric layer in the area is appreciably thick and the top soil is majorly clay though in some areas the laterite, weathered basement or even fresh basement are encountered at the top which is as result of weathering and/or outcrop.

Figure 3: Top Soil Thickness Map Contour at 1m Interval

3.1.2. The Overburden Thickness Map

Figure 4 shows the overburden thickness map. All surface layers above the fresh basement are considered to constitute the overburden. This includes the topsoil, laterite the weathered/fractured basement. This is produced by calculating the depth to fresh basement in each VES station. The overburden thickness ranges from 0.55m to 78m.

Figure 4: Overburden Thickness Map Contour at 5m Interval

3.1.3. Aquifer Thickness Map

This map as shown in Figure 4 is produced using the thickness of the weathered and the fractured basement complex layers which are believed to constitute the aquifer unit in the basement complex (Bala and Ike, 2001). The aquifer has thickness ranging from 0.19m to 75m which is thick enough to retain a large amount of groundwater. Area around VES 3, 11, 12, 13, 19, 21, 22, 29, 34, 44, and 46 have aquifer thickness within the range above which corresponds to basement depression. These areas are good enough for ground water exploration in the study area.

Figure 5: Aquifer Thickness Map Contoured at 5m Interval

4. Deductions

The interpretation of the data shows that two, three, four and five subsurface layers exist in the study area. From the maps produced, the thickness of the overburden can be observed to be varying from VES point to another across the study area. This means that the fresh basement complex rock topology of the area is undulating.

The determination of the regions within the study area with greatest groundwater potential is led by the interpretation of the VES points. The interpreted result and the maps produced were examined carefully, and also the aquifer thickness led to the conclusion that VES 3, 11, 12, 13, 19, 21, 22, 29, 34, 44, and 46 constitute good aquifer for groundwater exploitation in the area.

Dumping refuse everywhere may lead to groundwater contamination and there for describing suitable areas for refuse dumping is very important for healthy and hygienic reasons. The result of the study shows that area around VES 27 will be the best place for refuse dumping as the area is dominated by clay up to a depth of 44m and because of the absence of aquifer in the area.

It is necessary that detail investigation about the characteristics of the subsurface lithology and ground conditions be carried out prior to the commencement of construction works in an area. Olorunfemi and Fatoba (2004) established that citing a giant engineering structure in an area that is dominated by clay may result in the failure or collapse of the structure. The result of this geophysical investigation carried out showed that the study area is strong enough to accommodate low to high engineering structures. But area around VES 27 can only accommodate low engineering structure because of clay materials that predominates, however, in areas around VES 6, 11, 13, 14, 15, 16, 17, 19, 21, 29, 31, 32, 43, 45, there is the need of clearing away the topsoil for a depth of about 1 to 5m before the commencement of engineering structure.

5. Conclusion

This survey is carried out to investigate the subsurface condition of BUK new site. Vertical electrical sounding using Schlumberger array has been used. Forty nine stations were sounded. The following conclusions are drawn:

- The survey reveals that the study area is underlain by two, three, four and five subsurface layers of different lithology, which are the topsoil, laterite, highly weathered Basement, partially fractured Basement and fresh Basement complex rock
- The aquifer in the study area varies from 0.19m to 75m in thickness and the overburden thickness varies from 0.55 to 78m.
- The depth to which borehole should be sink should be from 40m to 78m.

6. References

- Bala, A. E and Ike E. C. (2001).The Aquifer of the Crystalline Basement of Rocks in Gusau Area, Northwestern Nigeria. *Journal of mining and geology*. 37(2), 177-184.
- Keary, P., Brooks, M. and Hill, I. (2002): *An introduction to Geophysical Exploration*. USA: Blackwell Publishing.
- Kirsch, R. (2009). *Groundwater geophysics* 2nd Edition, Springer-Verlag Berlin Heidelberg.
- LokeM H. (2001). 2-D and 3-D Electrical Imaging Surveys, Lecture Note
- Nigerian Industrial Standard (2007). Nigerian Standard for Drinking Water Quality.
- Olorunfemi, M. O. and Fatoba, J.O (2004). Geoelectric and Hydrogeological Characterization of Lagos State. *Nigeria Journal of Mining and Geology*, 28(2), 210-219.
- Oritsejolonesan, O.U. and Saleh M. (2011): *Geoelectric Investigation of Subsurface structure of academic area of the old Campus of Bayero University Kano* for Optimized citing of bohereholes. *Bayero journal of pure and applied sciences*, 4(2) 192-198.
- Sharma, P. V. (2002). *Engineering and Environmental Geophysics*. Cambridge: Cambridge University Press.
- Telford, W.M., Geldart, L.P., and Sheriff, R.E. (1990): *Applied Geophysics*, 2nd edition. London: Cambridge University Press.
- Water K, K and William, E K: Geoelectricsoundings for predicting aquifer properties. *Groundwater* 19(2), 163-171
- www.kanostate.net (2011): Geology of Kano.

Appendix

Ves	GPS COORDINATE			Description
	Latitude	Longitude	Elevation	
1	11.971	8.4292	490	Front of Convocation Arena
2	11.9671	8.4292	481	Inside the Stadium beside the 1st goal post
3	11.9646	8.429	451	Behind the spectators' pavilion
4	11.9699	8.4399	449	On the football pitch of Staff Secondary School
5	11.9717	8.4393	422	Close to Rimingata gate in the Staff Quarters
6	11.9731	8.4385	472	Along the road adjacent Staff Secondary School
7	11.9742	8.4388	474	In front of house No 612, Rugu road
8	11.9917	8.4387	471	Close to mini gate along Rimingata
9	11.9754	8.438	477	Behind house No 618 in the Staff quarters
10	11.9922	8.4372	466	Close to the hand pump borehole at the football far beside house No 618
11	11.9734	8.4371	473	Beside the tree behind house No 620
12	11.9767	8.4356	469	Behind house No 622
13	11.9771	8.4342	458	Close to the main borehole site
14	11.9781	8.4321	472	Behind Old Faculty of Agric
15	11.9792	8.431	476	Far behind the main borehole site
16	11.9696	8.4297	468	Far beside the main borehole site
17	11.6708	8.4305	479	Front of Security office opposite center of excellence
18	11.9703	8.4325	479	In front of proposed faculty for the study of Nigeria Language

Ves	GPS COORDINATE			Description
	Latitude	Longitude	Elevation	
19	11.9723	8.4311	471	Adjacent Mahmud Tukur junction
20	11.9738	8.4311	463	In front of the new faculty of education
21	11.9717	8.4301	474	Behind new faculty of education
22	11.9692	8.4278	460	Along the foot path adjacent IIIBF temporary site
23	11.9685	8.4246	463	Front of Zainab vision store
24	11.9675	8.4227	468	At the new School business studies
25	11.4222	8.4222	461	Behind Dangote Student hostel
26	11.4243	8.4243	464	At the center of professor quarters
27	11.965	8.4284	473	On the open farmland adjacent professors' quarters
28	11.9694	8.4276	449	Behind PHE department
29	11.9701	8.4175	460	Opposite PHE department
30	11.9719	8.4231	463	Behind SUG secretariat
31	11.9729	8.4277	461	Beside Ummah mosque in the student hostel
32	11.9709	8.4317	478	Behind the Coke Village
33	11.9707	8.4316	475	Adjacent center for Quranic Studies
34	11.9701	8.4341	475	Behind house No 571 at area C
35	11.9707	8.4343	453	Along the road behind house No 538, Dala road
36	11.9694	8.433	471	Opposite entrance of VC's house
37	11.9673	8.4297	471	Beside Jummat Mosque, behind Islamiyya
38	11.9663	8.4305	464	Front of house 573, MuhdAlhaji avenue
39	11.9661	8.1777	463	At children recreational Park
40	11.9666	8.4305	462	Along the road close the main gate
41	11.9671	8.3243	472	Adjacent to the fence of the stadium
42	11.9615	8.1615	453	Behind the recreational Park
43	11.9683	8.431	459	Beside house No 550
44	11.9645	8.4284	432	At the football field opposite house No 562
45	11.9644	8.4282	464	Opposite Gymnasium
46	11.9643	8.4275	466	Behind the Stadium close to the school fence
47	11.9647	8.1273	477	Along Dr Mansur Mukhtar road
48	11.967	8.4288	466	Along the road close to the Bank junction
49	11.9698	8.4295	470	Beside the center of excellence opposite Security Office

Table 4: Location of the Ves Point within the Study Area