Geoelectric investigation of the aquifercharacteristics inTopo area of Badagry, Lagos State.

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Abstract: Vertical electrical sounding using schlumberger configurations were conducted in LASU Foundation programme site, Topo Badagry, Lagos state to investigate the aquifer characteristics and ground water status. The ABEM terrameter (SAS 1000) was utilized in data acquisition with current electrode separation (AB) varying from 1 m up to 400 m. The field data was interpreted using the software called WingLink. The result shows that the topsoil had resistivity value ranging from 547.65 to 1162.08Ωm with thickness range of 1.00 to 1.4m. The second geoelectric layer depicted a sand formation with resistivity ranging from 290.75 to 2891.88Ωm and thickness of 2.38 to 10.36m.This aquiferous layer is expected to contain a relative good quality groundwater but due to its closeness to the surface it may be prone to salt water intrusion. The third layer resistivity values ranges from 18.07 to 784.05Ωm with a thickness of 1.05 to 16.69 m. The aquifer contained a relatively good quality groundwater. The forth layer however has resistivity value in the range of 65.8 to 668.33Ωm indicative of saline brackish water resulting from the saline/Brakish nature of the coastal river which serve as a recharge unit for the aquifers in the study area.

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1.0 Introduction

Generally, a number of geophysical techniques are available which enables an insight in obtaining a rapid nature of water bearing layers (Emenike, 2001). Out of the known geophysical prospecting methods, the electrical methods happen to be the most widely used geophysical method in engineering studies, environmental assessment and hydro-geological investigation (Brookes, et al, 1988). However, although, more labour intensive, the electrical resistivity method is more viable for deep sub-surface investigations (Dobrin, 1976).There are approximately one hundred independent geoelectric arrays (Szalai and Szarka, 2008) , but Schlumberger array is found to be more suitable and common in groundwater exploration. It is well known that resistivity methods can be successfully employed for ground water investigations, where good electrical resistivity contrast exists between the water-bearing formation and the underlying rocks (Zohdy *et al*., 1974). This method is regularly used to solve a wide variety of groundwater problems such as determination of depth, thickness and boundary of a aquifer (Bello and Makinde, 2007; Omosuyi *et al*., 2007; Asfahani, 2006; Ismailmohamaden, 2005), determination of the boundary between saline and fresh water zones (El-Waheidi *et al*., 1992; Khalil, 2006), determination of zones with high yield potential in an aquifer (Akaolisa, 2006; Oseji, 2005), delineation groundwater contamination (Park *et al*., 2007), determination of groundwater quality (Arshad *et al*., 2007), delineation seawater intrusion in coastal Aquifer (Sung-Ho *et al*., 2007; Benkabbour *et al*., 2004), exploration of geothermal reservoirs (Cid-Fernández and Araujo, 2007; El-Qady, 2006), estimation of hydraulic conductivity of aquifer (Khalil and Monterio, 2009; Asfahani, 2007; Yadav, 1995), estimation of aquifer transmissivty (Yang and Lee, 2002) and estimation of aquifer specific yield (Onu, 2003).

The Schlumberger method have a greater penetration than the Wenner. In the resistivity method, the Wenner configuration discriminates between resistivities of different geoelectric lateral layers while the Schlumberger configuration is used for the depth sounding (Olowofela *et al*., 2005). However, in general, the depth of infiltration is small in this method and only shallow subsurface layers have been surveyed (Danielsen *et al*., 2007). The resisitivity technique was successfullyused in investigating groundwater potential indifferent geological settings. Emenike (2001) alsoused this method to explore for groundwater in asedimentary environment. The geophysical dataobtained and the analyses were correlated withgroundwater lithological logs from a nearby borehole inthe study area.

2.0 Location and Geology of the study area

Badagry is located at approximately latitude 7°15' and 7'N and longitude 5°W and 7'W. It is located at the coastal plain and rarely is any part above 3m above mean sea level (Fig. 1). The sandy nature of the local government area makes drainage easy and this is what is responsible for its sparse vegetation. More than 75% of the entire local government area is made up of loose sand and the rest are alluvial materials especially along river courses. Given its coastal location, there are many creeks and lagoons. The most important are Coaster river(Badagry creek) which enters into the sea at Apapa. Ologe lagoon is also an important water body in the environment. The entire Badagry is underlain by recently laid sedimentary rocks, in which most of the top layers are unconsolidated sandstone. Towards the ocean front are alluvial soils and towards the eastern end, along the lagoon front, are mangrove forests. There are marshy places in areas close to the lagoon and other places where river pass.

2.1 Materials and Methods

Resistivity data of the study area were acquired using the vertical electrical resistivity (VES) technique. Eight vertical electrical soundings (VESes) were measured using the Schlumberger array. The VES data were acquired using ABEM terrameter(SAS1000) with current electrode separation (AB) varying from 1 m up to 400 m in successive steps. The increase of potential electrode spacing MN is often marked by a discontinuity in the field curve. The electrical current (*I*) is applied to A and B electrodes and the potential (*U*) are measured between M and N electrodes. The bulk soil electrical resistivity (*ER*) is calculated with

$$ER = K\frac{\Delta U}{I}$$

where *K* is the geometric factor.

The data were acquired on two traverses AA`,and BB`, all in the NW – SE direction. Two points were sounded on traverse line AA` while five points were sounded on traverses BB`. The average (apparent) resistance value R_a as displayed by the terrameter was multiplied by the geometric factor for Schlumberger array. This gave the (apparent) resistivity ρ_a values which were then recorded against corresponding current and potential electrodes separation. The apparent resisitivity values obtained from the measurement were plotted against half the current electrode spacing using computer iteration software called WinGlink.

3.0 Results and Discussion

The plotted log–log graphs of the results of the apparent resistivity against electrode spacing each representing the two major curve types we have are as shown in (Fig. 2).The various curve type obtained, the true resistivity value, number of layers, thickness, depth and the lithologic units of each VES point for the study area are as shown in (Table.1). VES 1 and 2 has a curve type QH reflecting the presence of four geoelectric layers. VESes 3, 4, 5, 6, 7, and 8 have the curve type KQH indicative of five geoelectric layers. Samples of the curves are shown in Fig. 2. The layers delineated were identified into various possible lithologies aquifers characteristics using the resistivity interpretation procedure as proposed (Zohdy et al, 1993).

3.1 Resistivity cross – section AA`

This geoelectric section was obtained from the result of VES 001 and 002 (Fig. 2a). The topmost layer along the section, with probable composition of unconsolidated sediment and it is expected to be permeable, enhancing groundwater recharge through filtration. It had a resistivity ranging from 840.60 – 979.76 Ωm.

The second layer is composed of sandy clay. It had a resistivity range of 290.75-317.95Ω m. This layer has thickness 3.71 – 4.54m, which may serve as good protective layer for the underlying rock.

The third geoelectric layer is composed

of sand with thickness of 14.12 -15.79m along the section. It had a relatively low resistivity value ranging from 179.31 – 236.25Ωm**.** It represents a confined aquifer and is probable of containing good quality groundwater.

However the fourth geoelectric layer could be said to compose of sandy clay. It had a resistivity range of 668.33 – 2829.11Ωm. However the thickness could not be determined as the current terminated within this layer.

3.2 Resistivity cross – section BB`

This geoelectric section was drawn from the interpreted result of VES 003- 008 (Fig. 2b). The topmost layer had resistivity values of 191.24 – 1162.08 Ωm. It correspond to the topsoil of unconsolidated sediments and have thickness ranging from 0.75 - 1.18m.

The second layer had a resistivity values in range of 1829.61-2891.88Ωm. It is a probable zone of sandy clay. It is an unconfined layer with thickness in the range of 2.03 - 10.36m. Because of its closeness to surface, it is prone to pollution. The third geoelectric layer could be characterised as confined aquifer composing of sand with thickness ranges 1.93 – 13.77 m with resistivity values from 114.02 - 784.03 Ωm. However, the section vindicates the danger in making neighbourhood judgement because of the thickness of the bed under VES2.The forth layer had resistivity that ranges from 66.46-278.07Ωm and is probable of clay formation with thickness between 20.39 – 37.77m.The fifth geoelectric layer with resistivity value between 253.00 –1873.72Ωm is composed of sandy clay. However the thickness of this aquifer could not be ascertained. To determine the thickness of this layer, a longer current electrode is advised.

4.0 Conclusion

The geoelectric investigations showed that there are four to five geoelectric layers and these layers correspond to topsoil, sandy clay, sand and clay. However the layer of interest is the third geoelectric layer of both sections which a sand formation a probable aquiferous zone.

Considering the thickness,depth value and relatively low resistivity values, the best location for quality groundwater in this area, is suggested to be in VES 5 and 8 at depth from 16m.

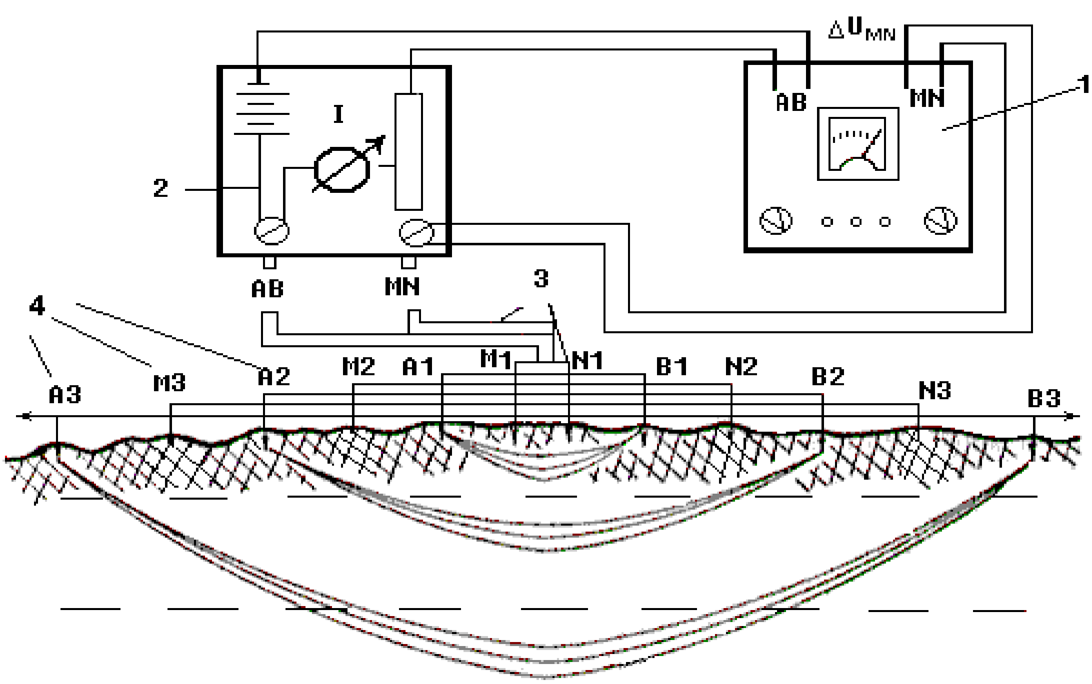

Fig. 1. Scheme of the vertical electrical sounding (VES) device: (1) auto-canceller, (2) commutator for electrodes AB and MN, (3) netted wires for different distances among electrodes AB and MN, and (4) electrodes.

Table. 1: The curve types obtained, the true resistivity value, number of layers, thickness, depth and the lithologic units of each VES point

Number of Sounding	Number of Layers	Resistivity(m)	Thickness (m)	Depth (m)	LithologicalUnits	Curve Type
VES 1	1	979.76	1.00	1.00	Topsoil	QH
	2	317.95	4.54	5.54	Sandy clay	
	3	179.31	14.12	19.66	Sand	
	4	668.33	-	-	Sandy clay	
VES 2	1	840.60	1.09	1.09	Topsoil	QH
	2	290.75	3.71	4.08	Sandy clay	
	3	236.25	15.79	20.59	Sand	
	4	2829.11	-	-	Sandy clay	
VES 3	1	942.31	1.18	1.18	Topsoil	KQH
	2	1884.17	2.89	4.07	sandy clay	
	3	311.01	6.55	10.62	sand	
	4	68.73	27.10	37.72	Clay	
	5	253.00	-	-	sand	
VES 4	1	547.65	1.04	1.04	Topsoil	KQH
	2	1829.61	2.38	3.42	Sandy clay	
	3	281.95	16.69	20.11	sand	
	4	66.46	26.08	46.19	Clay	
	5	1873.72	-	-	Sandy clay	
VES 5	1	1162.08	1.41	1.41	Topsoil	KQH
	2	2358.69	10.36	11.77	Sandy clay	
	3	114.02	1.93	13.70	sand	

	4	278.07	37.71	51.41	sand	
	5	1134.99	-	-	Sandy clay	
VES 6	1	191.24	1.02	1.02	Topsoil	KQH
	2	1334.14	2.68	3.70	Sandy clay	
	3	666.36	3.85	7.55	Sand	
	4	109.98	28.06	35.61	sand	
	5	306.27	-	-	Sandy clay	
VES 7	1	567.67	0.93	0.93	Topsoil	KQH
	2	2110.43	2.03	2.96	Sandy clay	
	3	305.54	13.41	14.37	sand	
	4	96.63	20.39	34.76	Clay	
	5	519.17	-	-	Sandy clay	
VES 8	1	1102.11	0.75	0.75	Topsoil	KQH
	2	2891.88	3.55	4.30	Sandy clay	
	3	784.03	13.77	15.07	sand	
	4	258.78	37.77	52.84	Sand	
	5	1260.13	-	-	Sandy clay	

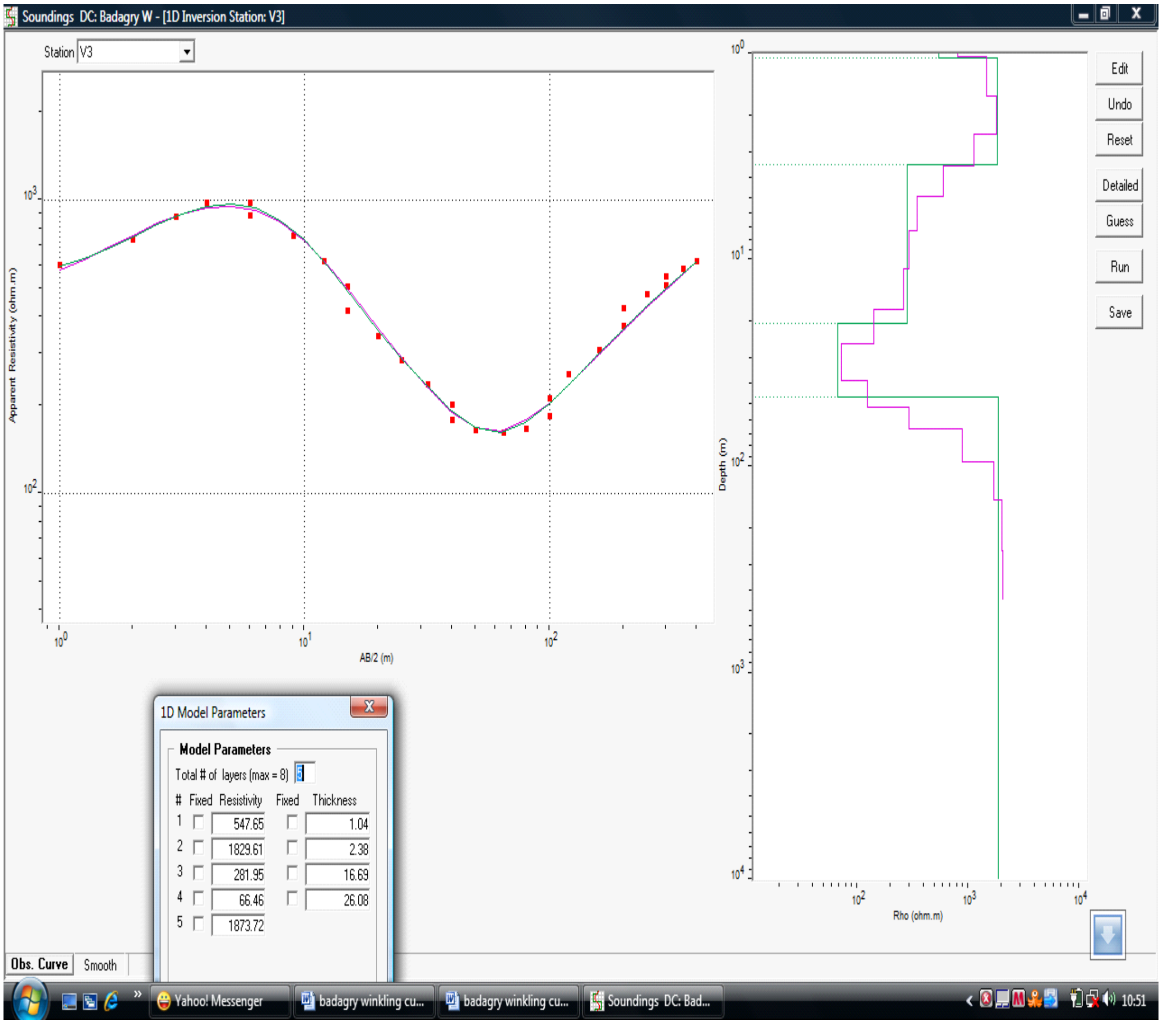

Fig. 2a: Geoelectric section AA`

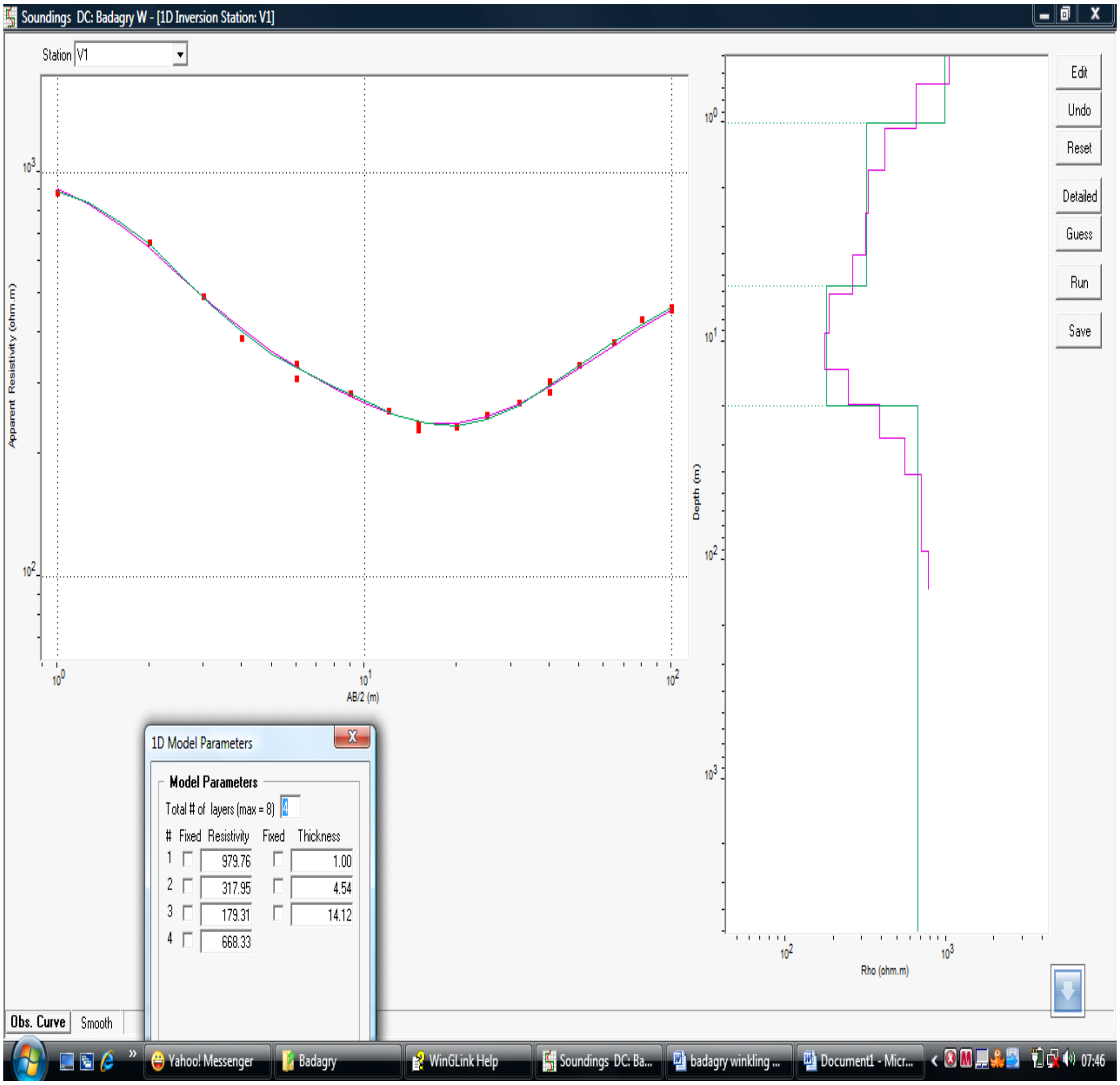

Fig. 2b: Geoelectric section BB`

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