Subsurface Characterization and its Environmental Implications using the Electrical Resistivity Survey: Case with LASU Foundation Programme Campus Badagry, Lagos State, Nigeria

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Abstract. Measurements of eight vertical electrical soundings (VES) were carried out in the premises of Lagos State University (LASU) Foundation Programme Campus site located at Badagry. The resistivity method was carried out with a view to characterize different subsurface geological units and to provide the engineering/environmental geophysical characterization of the study area. One-dimensional numerical inversion of individual DC resistivity was used to enhance the processing of the results for better achievement of the aim of the study. Models obtained from the 1D inversion of each VES, together with borehole information, were used for construction of two geoelectrical sections which exhibit the main geoelectrical characteristics of the geological units present in the area.
The interpretation results showed that the geoelectrical succession consists of four to five layer namely, topsoil, sand, sandy clay and clay. The investigation revealed the third layer (sand), to be the most competent for founding small to medium engineering structures with thickness values that range between (6.55m – 13.77m) and resistivity values that vary from (114.02 - 784.03 ohms-meter). This layer beneath VES 5 and VES 8 can as well be considered to be highly promising water-bearing layer for well/borehole drilling. [Nature and Science 2010;8(8):146-151]. (ISSN: 1545-0740).

Keywords: Geoelectrical Inversion, Electrical Resistivity, LASU

1.0 Introduction

Lagos State University (LASU) Foundation Programme Campus in badagry area is a new site that is intended to be developed for both administrative and academic activities. Though there are existing structures on the site, however, there is need for the development of new structures to meet the population challenges. For this reason, a pre-construction investigation was carried out for evaluation of site condition as an aid to geotechnical engineers.

Geophysical methods, particularly geoelectrical resistivity techniques, have been extensively used for a wide variety of engineering and environmental problems (Zohdy, 1975; Barker, 1980; Boyce and Kaseoglu, 1996; Mousa, 2003, OIorunfemi, et al., 2004; Hosny et al., 2005; Alotaibi and Al-Amri, 2007; Nigm, et al., 2008; Oyedele, et al., 2009). This is due to the fact that, the electrical resistivity survey is one of the simplest and less costly geophysical surveys employed. The use of electrical resistivity measurements has been a favorite tool of geophysicists because of the wide range of resistivity values found in nature which represents a greater dynamic range for this technique than most other commonly used methods. Electrical resistivity survey is relatively easy to perform and can be used to identify geological structures (Al-Sayed and El-Qady 2007).

Several studies reported in the literature have applied electrical resistivity techniques to environmental and engineering investigations. By imaging the distribution of underground resistivity, the electrical resistivity method can provide information on the spatial distribution of contaminants, the location of contamination sources, and the impact of leachate on groundwater, etc. (Ross et al., 1990; Adeoti, et al., 2008). For an environmental contamination survey, the electrical resistivity method can be used to rapidly investigate a broad area and monitor the spread of contamination (Aristodemou and Thomas-Betts 2000). Resistivity surveys are often used to search for ground water in both porous and fissured media. These methods provide detailed information about the geometry, source and amount of contamination in the groundwater (Kelly, 1976). Engineering applications includes investigation of bridge, dam and building structure foundations using electrical resistivity survey (Omoyoloye, et al., 2008; Adeoti, et al., 2009; Mahmoud; et al., 2009).

2.0 Site Description and Geological settings

The area of investigation is located in Badagry, Badagry Local Government Area (Fig 1a) of Lagos State, Nigeria. The area is traversed by Badagry creek, emptying into the Lagos lagoon. Badagry is situated on the coastal margin of Lagos State, approximately at latitude 7^{o}15’ and 7’N and longitude 5^{o}W and 7’W. It is located at the coastal plain and rarely is any part above 3m above mean sea level. The sandy nature of the local government makes drainage easy and this is what is responsible for its sparse vegetation. More than 75% of the local government 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 Badagry creek which enters into the sea at Apapa. Ologe lagoon is an important water body in the local government (Yinka Balogun 1991). The entire Badagry is underlain by recently laid sedimentary rocks. Most of the top layers are unconsolidated sandstone. Towards the ocean front are alluvial soils. 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 (Tayo Odumosu 1993).

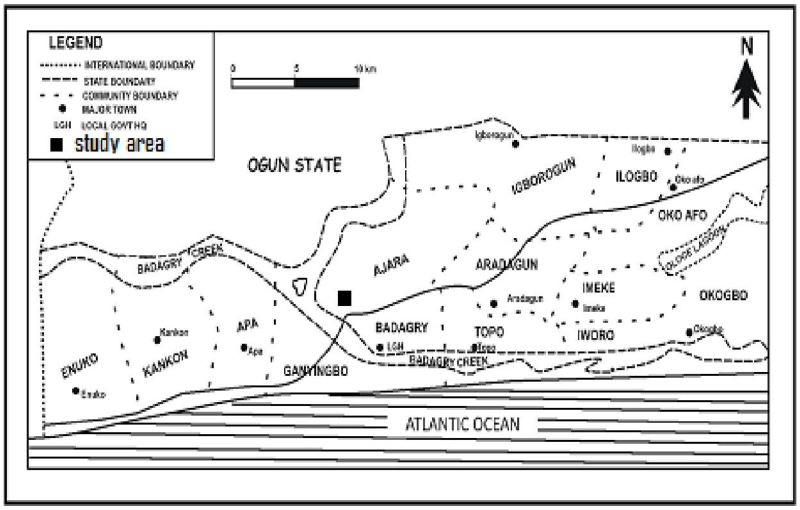


Fig 1a: Map of Badagry Local Government Area showing the study area

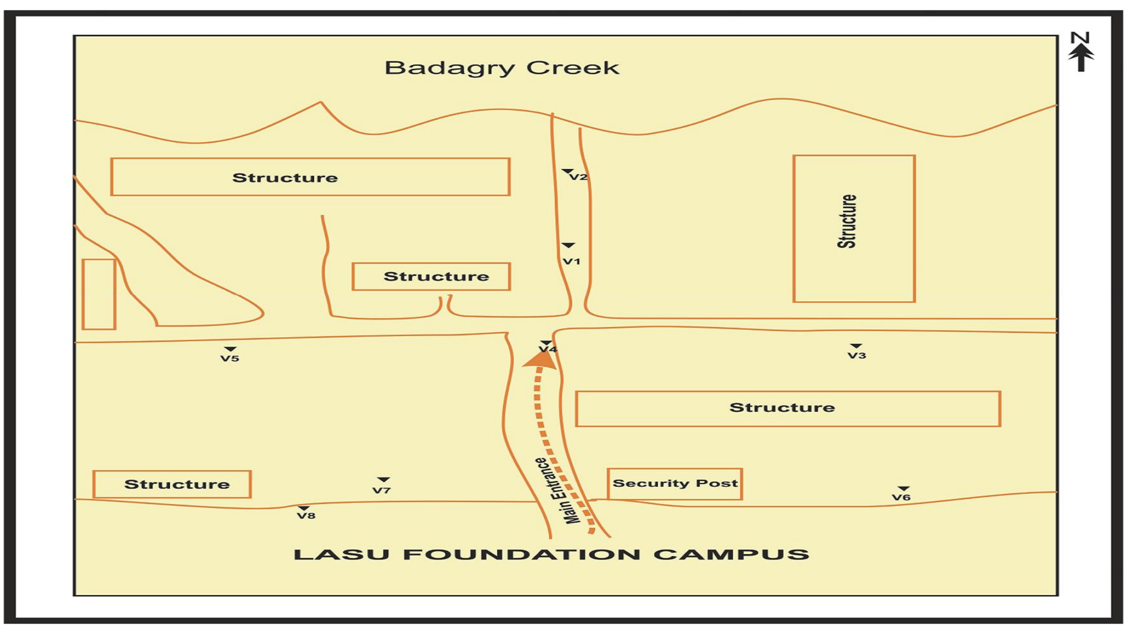


Fig 1b: Location map of Study Area.

3.0 Materials and Methods

The resistivity soundings conducted in this work concerns with a DC resistivity survey utilizing the well-known Schlumberger array (Fig 2a). The geoelectrical resistivity measurements were performed using ABEM SAS 1000 Terrameter. Eight vertical electrical soundings (VES) were obtained from the location with half current electrode separation (AB/2) starting from 1 m up to 240 m in successive steps for the current electrode and 0.25 to 7.0m for the potential electrodes. The increase of potential electrode spacing is often marked by a discontinuity in the field curve. The location and distribution of the VES stations were based on the available space and accessibility within the study area. The sounding number 1 and 2 are located to the extreme northern part of the investigated area. The sounding numbers 3, 4 and 5 run mainly from east to the west direction of the investigated area. The sounding numbers 6, 7 and 8 are parallel but in the same direction to sounding numbers 3, 4 and 5 (Fig 1b).

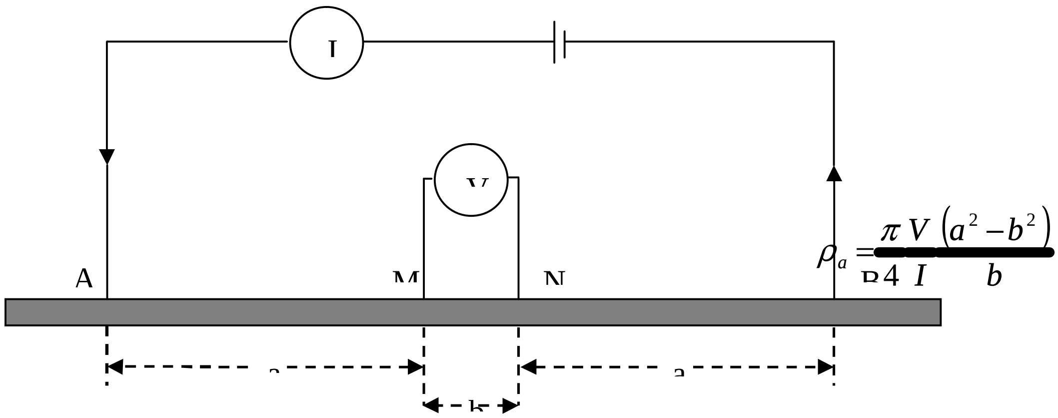


Fig. 2: Electrode arrangement for the Schlumberger array electrode configuration

4.0 Results and Discussion

The result of the geoelectric survey was processed and quantitatively interpreted using available geological information and presented as geoelectrical sections along the various traverse. The interpretation of the apparent electrical resistivity data were achieved using computer iteration software called WinGLink. The results are presented as sounding curves as shown in figure 3a and 3b. From the inspection of the interpreted resistivity curves, it is apparent that the curves are two QH curves and six KQH curves. The interpretation results are presented in Table 1. The careful examination of the constructed geoelectrical sections beneath the VES are shown in geoelectric section AA' (Fig. 4a) and geoelectric section BB' (Fig. 4b).

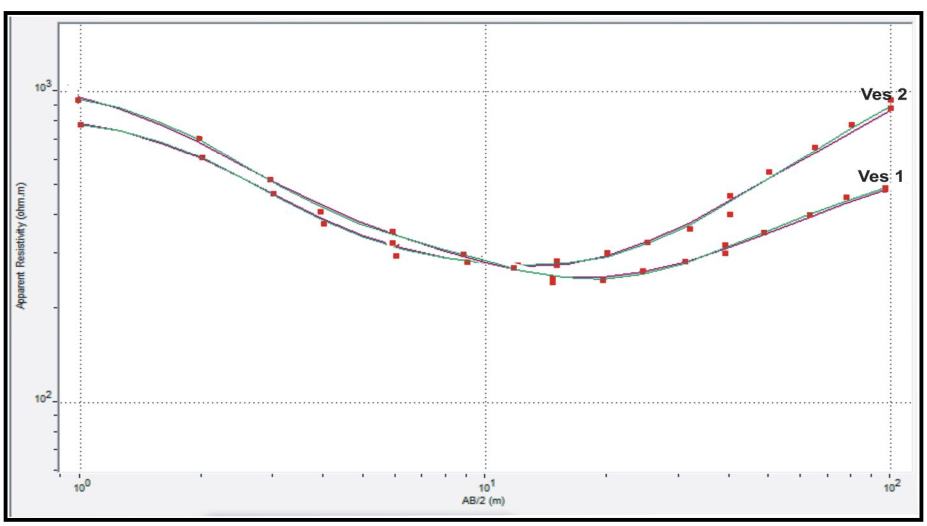


Fig 3a: Samples of Vertical Electrical Sounding Curves

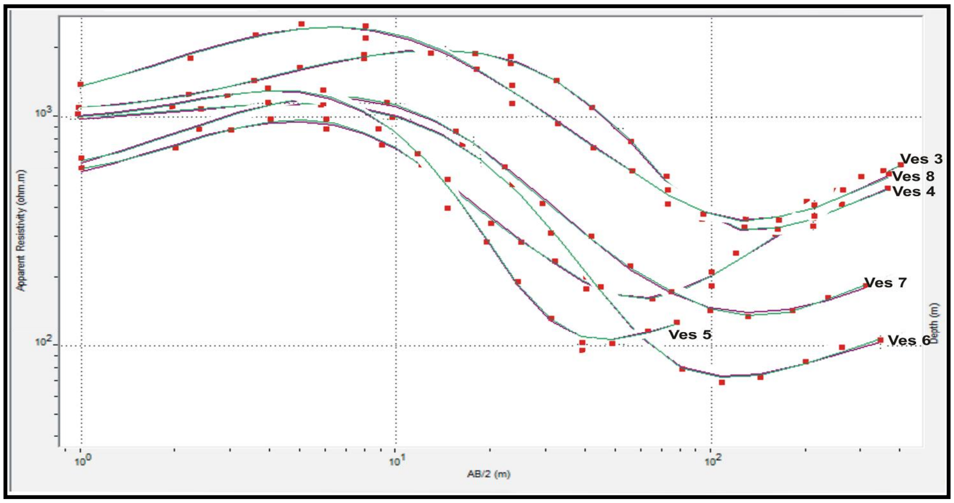
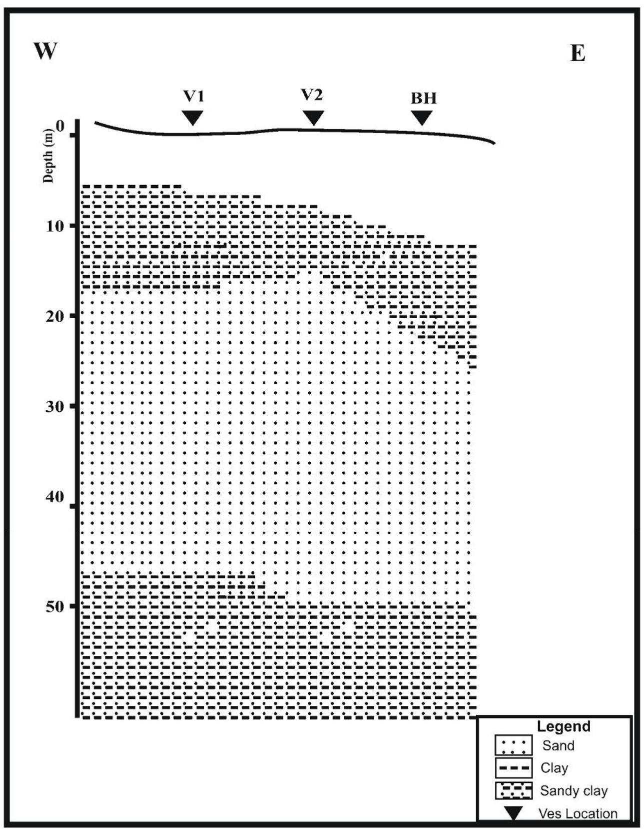


Fig 3b: Samples of Vertical Electrical Sounding Curves



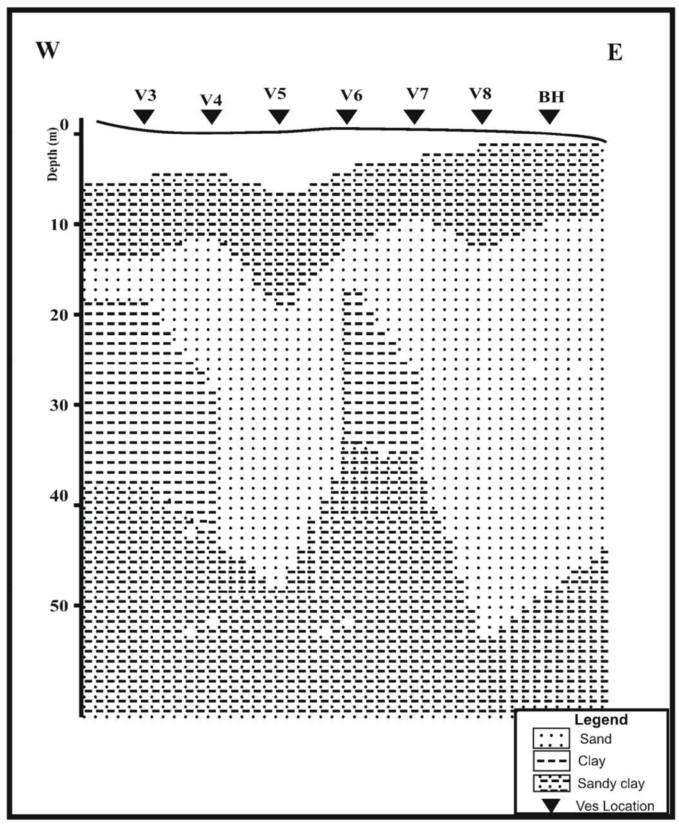


Fig 4a: Geoelectric Section AA'

Fig 4b: Geoelectric Section BB'

Table 1. True Resistivity and Horizon Depths

VES No	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	D_1	D_2	D_3	D_4
1	979.76	317.95	179.31	668.3	-	1.00	5.54	19.66	-
2	840.60	290.75	236.25	2829.11	-	1.09	4.80	20.59	-
3	942.31	1884.17	311.01	68.73	253.00	1.18	4.07	10.62	37.72
4	547.65	1829.61	281.95	66.46	1873.72	1.04	3.42	20.11	46.19
5	1162.08	2358.69	114.02	278.07	1134.99	1.41	11.77	13.70	51.41
6	191.24	1334.14	666.36	109.98	306.27	1.02	3.70	7.55	35.61
7	567.67	2110.43	305.54	96.63	519.17	0.93	2.96	16.37	36.76
8	1102.11	2891.88	784.03	258.78	1260.13	0.75	4.30	18.07	55.84

ρ = True resistivity, D = Depth

Geoelectrical Sections

The geoelectric section AA' lies at the extremely northern part of the area under investigation and very close to the creek. It is covered by two vertical electrical soundings namely Ves1 and Ves2. The results of the borehole information and electrical interpretation assumed that the first two geoelectrical layers are characterized by relatively high electrical resistivity values and thin thicknesses (1.00 - 4.54 m). These layers are considered to be incompetent due to their thin thicknesses; however, their wide ranges of the electrical resistivity values are due to dry nature and percentage of sand. The third layer can be said to be sand formation. It is characterized by relatively moderate electrical resistivity values and at maximum depth of 21m. This layer is considered as the main groundwater aquifer but may be saturated by creek water perpendicular to the shore line as shown in Figure 3b. It was observed that the maximum thickness of such aquifer layer is reached at 15.79m. This layer can as well be considered to be competent for small to medium engineering structures due to its thickness and moderate resistivity. The fourth geoelectrical layer is considered as sandy clay. It is characterized by relatively very high electrical resistivity values.

The geoelectric section BB' lies at the eastern to western part of the area under investigation. It is covered by six vertical electrical soundings namely Ves3, Ves4, Ves5, Ves6, Ves7 and Ves8. The results of the borehole information and electrical interpretation assumed that the first two geoelectrical layer mainly covered the ground surface of the area under investigation is characterized by relatively high electrical resistivity values and thicknesses (0.93 - 10.36 m). The wide ranges of the electrical resistivity values are due to the percentage of sand. The third geoelectrical resistivity layer is a probable sand formation. This layer is considered as the interested zone. It is characterized by relatively moderate electrical resistivity values and thicknesses (0.93 – 10.36 m). The fourth geoelectrical layer is considered as (clay and sand). It is characterized by relatively low to moderate electrical resistivity values with layer thickness value range of (26.08 – 37.72 m). The fifth geoelectrical layer can be countered at the maximum depth of 56m with relatively high electrical resistivity values.

5.0 Conclusion

A key to success in the development of a site is the understanding of the subsurface formation during the planning stages. Measurement of electrical resistivity is one of the most widely used geophysical survey methods in this respect. Vertical electrical sounding can afford a relative means of determining inherent environmental and engineering effects of the subsurface variations.

The investigation of the study area has revealed the third layer to be the most competent for founding small to medium engineering structures due to the presence of sand thickness that varies from (6.55m – 13.77m) and resistivity values that range between (114.02 - 784.03). This layer in VES 5 and VES 8 can as well be considered to be highly promising water-bearing layer for well/borehole drilling based on its resistivity value.

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