IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 4, Issue 5 Ver. II (Sep. - Oct. 2016), PP 39-46
www.iosrjournals.org

Top Soil Resistivity Contrast From the Vicinities of Two Dumpsites, Using Electrical Resisitivity Method In Kutunku, Gwagwalada, Abuja, Nigeria.

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Abstract: *In this study, data obtained with the aid of an ABEM Terameter (SAS 300C), from twenty-five (25) Vertical Electrical Soundings (VES) stations in Kutunku, with maximum half-current electrodes spacing AB/2, of 170m and maximum half-potential electrodes spacing MN/2, of 7.5m for most of the profiles, were analysed with IPI2Win software. The analysis indicated 3 to 5 geo-electric layers where the former was predominant. The lithologic units showed characteristic layer resistivity ranges of 1.95 - 1360Ωm, 0.4 - 1723Ωm, 7.7 - 180000Ωm and 71 - 44878Ωm for the first, second, third and fourth layers respectively. In the same vein, depth of the layers ranged from 0.6 - 4.3m, 1.1 – 47.3m, 3.9 – 56.9m and 31.1m to undetermined depth. The second layer in most of the profiles showed conductive zones with low resistivity values ranging from 0.403Ωm to 151Ωm. In most of the profiles, the third layer manifested as the last layer, predominantly with high resistivity readings of the order of 10^3Ωm to 10^5Ωm with unknown depths suspected to be fresh basement rocks. In the few profiles where four geo-electric layers were detected, with the exception of VES 18, the resistivity values (in Ω.m), obtained for the last layer, were of the order of 10^3 and above, with unknown depth suspected to be fresh basement rocks. Contour maps of overburden thicknesses and layer resistivities were produced and VES 2, VES 5, VES 8, VES 14, VES 21, VES 24 and VES 25 stations were identified as viable locations for groundwater development because of the thicknesses of the layers interpreted as weathered or fractured zones which ranged from 25m to 55m. The topsoil resistivity for VES 7 and VES 17 which were both in the vicinities of dumpsites were extremely low compared to results obtained for other VES stations. Thus, the dumpsite composition has contributed to the relatively low resistivity of the topsoil around the two locations.*

Keywords: *Resistivity,dumpsite, Kutunku, lithologic unit, aquifer.*

I. Introduction

Geophysical techniques involve the use of non-invasive techniques for investigating subsurface elements by conducting surface measurements of physical quantities on the earth (Lateef, 2012). Electrical methods of prospecting are more diversified than many other geophysical methods (Osemeikhian and Asokhia, 1994). Some of them such as spontaneous potential (SP) and telluric currents depend on naturally occurring fields (Osemeikhian and Asokhia, 1994; Sumner, 2012; Kearey *et al.*, 2013). Others like Potential Drop method such as Resistivity and Equipotential Line methods depend on artificial fields (Osemeikhian and Asokhia, 1994; Kearey *et al.,* 2013).

Resistivity method is commonly used for ground water investigation (Oseji and Ujuanbi, 2009; Oseji, 2010; Anomohanram, 2011; Alile *et al.*, 2011; Alile *et al.*, 2012; Adepelumi *et al.*, 2013). The principle of operation of resistivity method depends on the fact that any subsurface variation in conductivity alters the form of current flow within the earth and this in turn affect the distribution of electric potential. Thus, it is possible to have information about the subsurface formations from potential measurements made at the surface.

Thus, electrical resistivity surveys have been used in hydrogeological investigations (Olayinka and Olorunfemi, 1992; Olorunfemi and Fasuyi, 1993; Emenike, 2001; Mallam and Emenike, 2008; Dikedi, 2012; Amadi *et aI.*, 2015), mining (Amigun *et al.*, 2012; Othman *et al.*, 2014) and geotechnical investigations (Brookes and Kearey, 1988; Adegbola *et al.*, 2010; Dangana et al., 2010). It has also been used for environmental surveys (Adeoti *et al.*, 2008; Abdullahi *et al.*, 2011; Adewuyi and Mallam, 2014). Resistivity methods, principally Electrical Resistivity Tomography (ERT), are investigatory means for environmental forensics (Pringle *et al.*, 2012). Other environmental applications of the method include looking for leachate leaking from landfills (Reynolds, 2011) and contaminant plumes from urban sites (Vaudelet *et al.*, 2011). The locations of illicitly concealed solid waste in the ground could be determined by the method (Cardarelli and Di Filippo, 2004; Ruffell and Kulessa, 2009). The method could be deployed for investigating probable aquifer contamination by graveyards (Matias *et al.*, 2004). Ruffell and Kulessa (2009) acknowledged the detection of animal mass graves from the 2001 foot-and-mouth cattle epidemic in Northern Ireland by the integrated use of

ERT and Ground Penetrating Radar (GPR). Resistivity method has also been deployed in agriculture, plant science and ecology to monitor the availability of soil water to plants (Brillante *et al.*, 2015).

Subsurface resistivity could be influenced by the degree of saturation, temperature, clay content, salinity (Brillante *et al.*, 2015) and rock porosity as well as composition. The proliferation of open dumpsites and indiscriminate disposal of waste without adequate treatment or pre-treatment especially in some developing countries is increasing apprehension amongst environmentalists because of the potential impacts on the environment and possible risks to human health (Li et al., 2011). Apart from contribution to Greenhouse Gas emissions, open dumpsite matter could alter the physical and chemical composition of soil strata and aquifer in such vicinity. Potentially toxic elements could be transmitted to aquifers, plants and thereby pose high risk across the food web to animals and humans. In this paper, the earth strata in the study area of Kutunku is investigated using geo-electrical method and interpretation result of processed Vertical Electrical Sounding (VES) resistivity data is presented with the perceived environmental implication.

Physical Features, Weather Condition And Geology Of The Study Area

The study area is Kutunku. It is located in Gwagwalada Area Council, Federal Capital Territory (FCT), Nigeria. It lies within latitudes 8^{o}55′00″N and 8^{o}56′30″N, and between longitudes 7^{o}03′30″E and 7^{o}05′00″E. Gwagwalada is a suburb of the Federal Capital Territory, situated along Abuja-Lokoja road, about 55km S-W of Abuja City centre, between latitude 8^{o}49' and 9^{o}04' North and longitudes 6^{o}50' and 7^{o}06' East (Abuja Guide, 2002). According to a publication of the Nigerian Geological Survey Agency (2006), FCT lies within latitudes 8^{o}22'N and 9^{o}26'N and longitudes 6^{o}42'E and 7^{o}43'E.The study area is within the tropical savannah vegetation zone with complete soil and vegetation cover. River Usuma and its tributaries drain the area. Figure 1 shows the topographic variation in elevation, VES stations and other physical features in the study area.

The project area is influenced by rainy and dry season usually between April & October and November & March respectively (Dikedi, 2012). The area is at times characterised by dense cloud cover and lower temperatures during the rainy season when compared with dry season. Precipitation ranges from 1100mm to 1600mm annually (Dikedi, 2012) while Relative Humidity ranges from 27% to 89% (Olugbenga and Osiewundo, 2015). Mean monthly temperature ranges from about 27^{o}C to 30^{o}C (Eduvie *et al.*, 2003). The wind pattern of the area is mainly south-west during the wet season and north-east during the dry season.

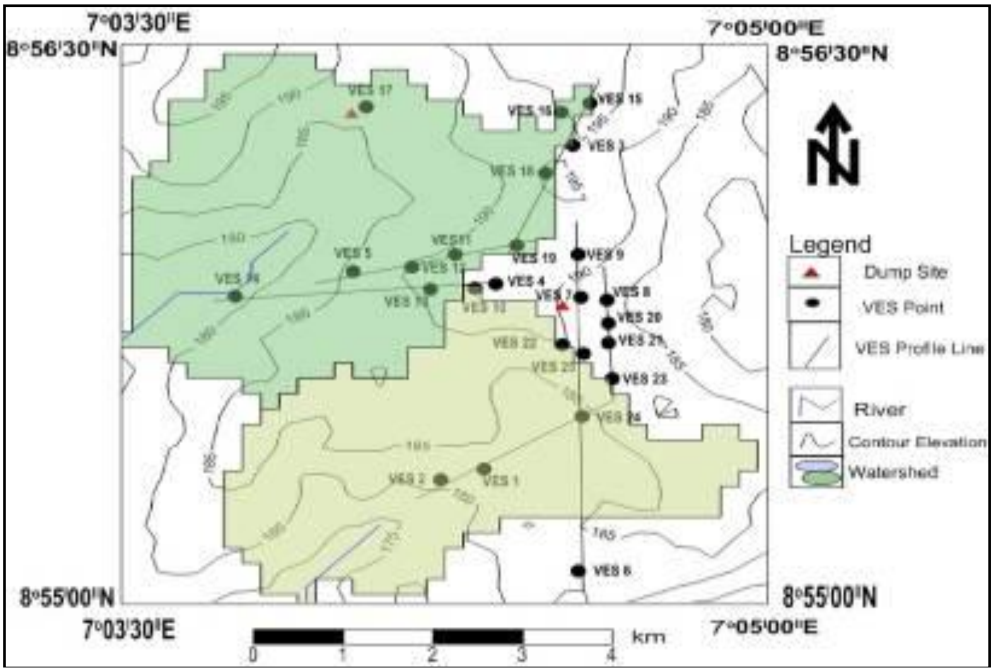

Figure 1: Location map of the study area.

FCT is predominantly underlain by the Nigerian Basement Complex rock of the Precambrian age (Mamman and Oyebanji, 2000). Figure 2 shows the geologic map of FCT indicating the basic geologic formations. The rocks include different textures of granites, gneiss, migmatites, diorites, metasediments and pegmatites (Eduvie et al., 2003; Dikedi, 2012). Dikedi (2012) documented that the geology of the FCT is same as that of Gwagwalada. Groundwater is found mainly in the variable weathered/transition zone and in fractures, joints and cracks of the crystalline basement while sparse amount of water can be obtained in the freshly unweathered bedrock below the weathered layers (Eduvie et al., 2003)

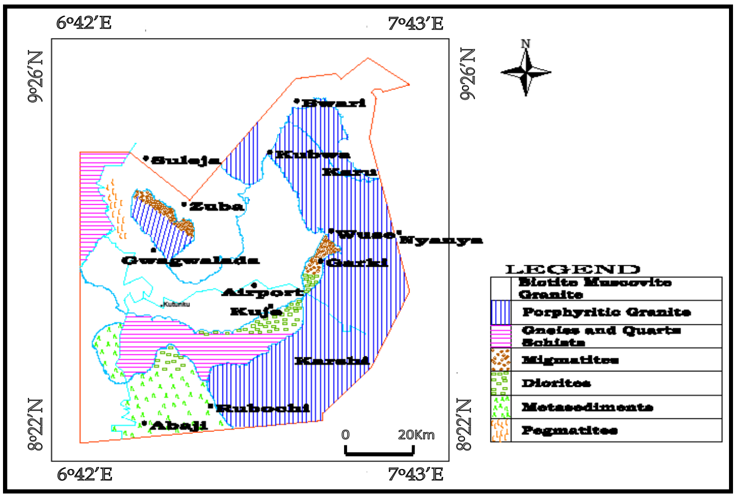

Figure 2: Geologic map of FCT (Adapted from: Dikedi, 2012).

II. Materials And Methods

An Abem Terrameter SAS 300c, batteries, two pairs of electrodes, insulated multi-strand copper cables, non-conducting measuring tape, Megellan Triton 300 GPS (WP001) device, hammer and four crocodile clips were deployed to the field to aid in data acquisition. The microscopic form of ohm's law is the fundamental formula used in resistivity measurements. That is,

$E = J\rho$ ....(1)

The Vertical Electrical Soundings (VES) were carried out using the Schlumberger electrode configuration described by Zohdy *et al.*, (1974). The arrangement of electrodes is illustrated in figure 3. L is half the distance between the current electrodes and l is half the spacing between the potential electrodes. The potential electrodes indicated by P_1 and P_2 are kept fixed and the current electrode separation is varied to obtain the changes in subsurface resistivity at greater depth. The field procedure was implemented by taking soundings with successive increase in the distance between current electrodes (AB) along the profile while the distance between potential electrodes (MN), was kept fixed. At the point when the measuring capability of the Terrameter tended to overwhelmed as a result of a decreasing potential difference across MN, a new value for MN larger than the preceding value was taken and the survey was continued.

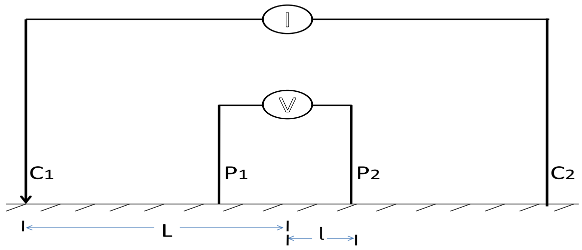

Figure 3: Diagram of Schlumberger array

The apparent resistivity equation for the Schlumberger array is given by

$$\rho_a = \pi \left(\frac{L^2}{2l} - \frac{2l}{4}\right) R \quad ....(2)$$

where, the geometric factor,

$$G = \pi \left(\frac{L^2}{2l} - \frac{2l}{4}\right) ....(3)$$

Vertical Electrical Soundings (with AB/2, ranging between 2m and 500m, and MN/2, ranging between 0.5m and 45.5m) were carried out at twenty-five VES stations and resistivity data were obtained. The coordinate locations and elevations above sea level were obtained with GPS device. Borehole lithology logs for two locations near the study area were obtained to aid in result interpretation.

III. Results And Discussion

The resistivity data processed with IPI2Win software revealed three to five geo-electric layers with predominance of the former. The layer curve characteristics identified include H, HKH, HA, KH and HK-type. Typical curve types are shown in figures 4a to 4e. The summary of the VES interpretation result is shown in table 1.

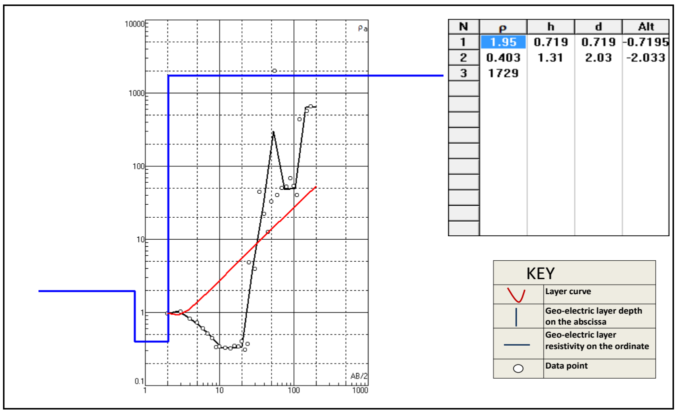

Figure 4a: Layer curve and interpretation for VES 7.

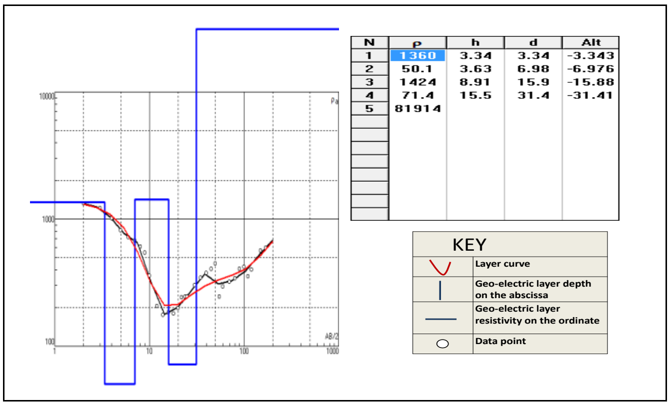

Figure 4b: Layer curve and interpretation for VES 8.

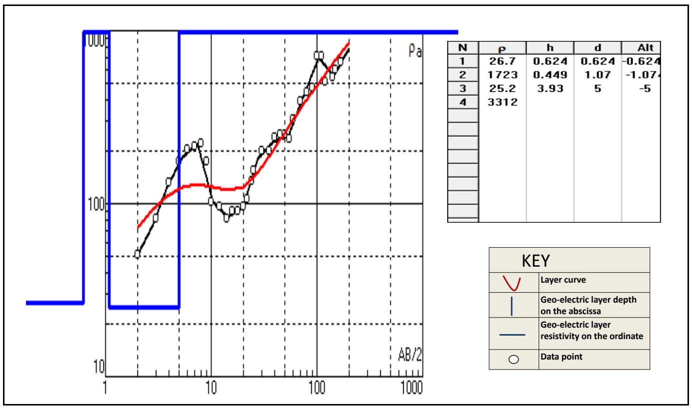

Figure 4c: Layer curve and interpretation for VES 17.

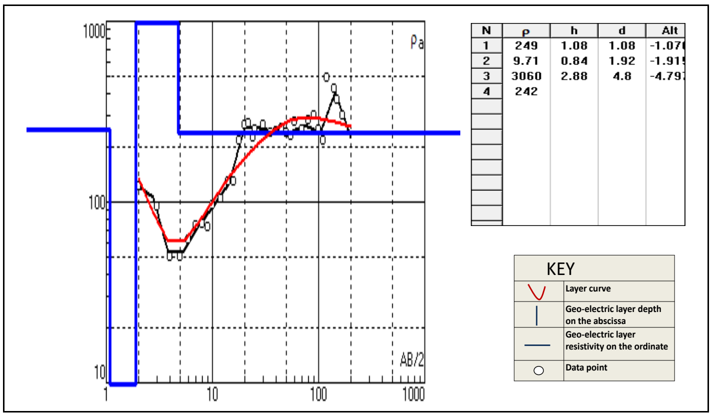

Figure 4d: Layer curve and interpretation for VES 18.

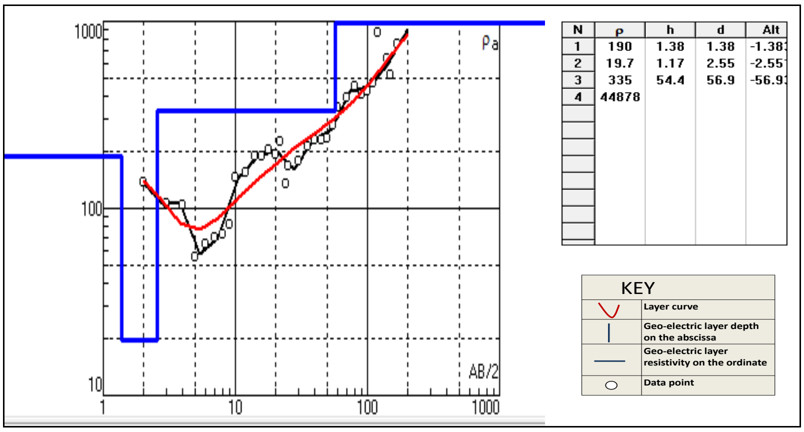

Figure 4e: Layer curve and interpretation for VES 24.

Table 1: Summary of the VES interpretation result

VES No.	Curve Type	Layer resistivity (Ωm)					Layer thickness (m)			
		ℓ_1	ℓ_2	ℓ_3	ℓ_4	ℓ_5	h_1	h_2	h_3	h_4
1	H	72.8	24.0	91750.0			2.6	5.4		
2	H	553.9	77.9	97325.0			0.6	30.5		
3	H	202.8	37.6	58133.0			0.7	18.9		
4	H	475.9	33.4	47501.0			3.0	9.2		
5	H	396.3	56.9	5692.0			2.2	45.1		
6	H	288.0	10.3	17927.0			1.4	4.1		
7	H	1.9	0.4	1729.0			0.7	1.3		
8	HKH	1360.0	50.1	1424.0	71.4	81914.0	3.3	3.6	8.9	15.5
9	H	477.0	6.7	15125.0			1.0	1.6		
10	H	244.0	72.4	110000.0			2.6	15.4		
11	H	456.0	81.3	180000.0			4.3	5.6		
12	H	72.4	2.5	12167.0			1.4	1.3		
13	H	452.0	53.3	36023.0			2.3	10.1		
14	H	246.0	62.3	65752.0			1.3	25.6		
15	H	473.0	92.7	120000.0			1.5	18.5		
16	H	243.0	22.6	806.0			1.9	2.0		
17	KH	26.7	1723.0	25.2	3312.0		0.6	0.5	3.9	
18	HK	249.0	9.71	3060.0	242.0		1.1	0.8	2.9	
19	H	194.0	29.2	668.0			4.1	3.9		
20	H	291.0	53.2	1574.0			2.3	14.0		
21	HA	528.0	11.5	130.0	28052.0		1.6	1.6	23.9	
22	H	173.0	16.4	1296.0			3.4	2.9		
23	KH	116.0	1024.0	7.7	1834.0		0.6	1.5	1.8	
24	HA	190.0	19.7	335.0	44878.0		1.4	1.2	54.4	
25	H	241.0	151.0	79606.0			1.9	34.8		

Iso-Resistivity Map Of The Layers

Contour maps of the layer resistivities were modelled using Surfer8 software. Figure 5a shows contour resistivity map of the topsoil. The resistivity spectrum is approximately from 1.9Ωm to $1.3x10^3$Ωm. The contour map reveals that the study area is almost entirely characterised by topsoil resistivity values of the order of 10^2Ωm to 10^3Ωm. The zones characterised with the lower band of resistivity spectrum typified by the brownish and reddish coloration in the contour map is sparse. These zones coincide with the vicinities of two indiscriminate dumpsites in the study area as highlighted in figure 1. Figure 5b shows contour map of weathered/fractured basement resistivities. The resistivity spectrum is approximately from 22Ωm to 800Ωm. The contour map reveals that the higher band of resistivity values for the layer trends visibly in the North-East axis of the map. Figure 5c shows contour map of the fresh basement resistivities. The resistivity spectrum is trends from the order of 10^3Ωm to10^5Ωm. The contour map reveals that the study area is largely characterised by basement resistivity values of the order of 10^5Ωm. The lower band of basement resistivity values is sparse and typified by the dark brown coloration in the contour map.

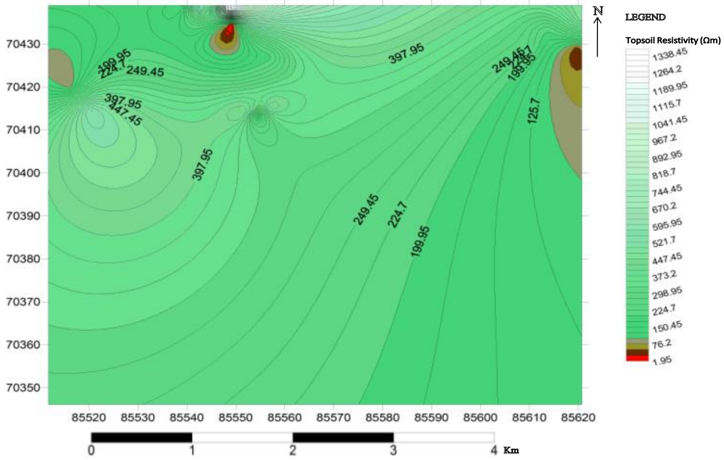

Figure 5a: Contour map of topsoil resistivity

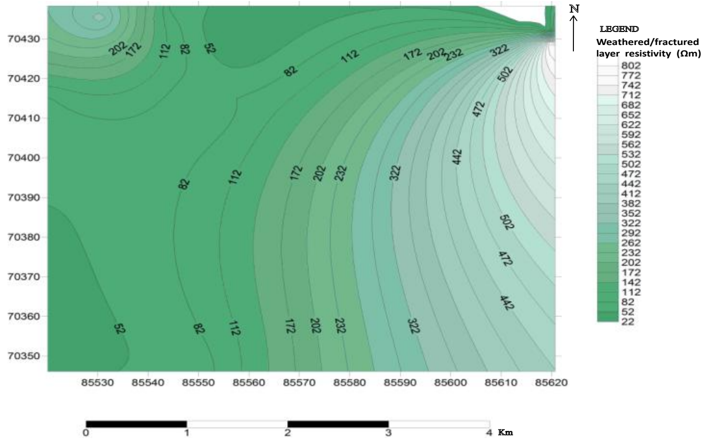

Figure 5b: Contour map of weathered/fractured basement resistivity.

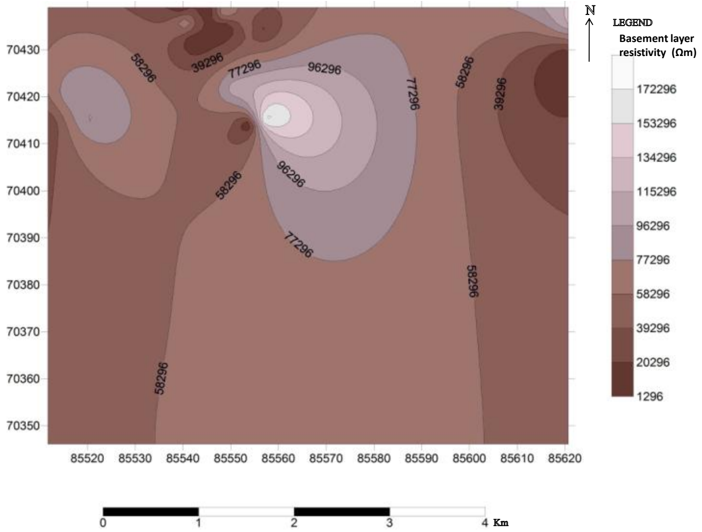

Figure 5c: Contour map of basement resistivity

Isopach Map Of Overburden

Contour maps of the layer thicknesses/overburden were modelled using Surfer8 software. Figure 6a shows the contour map of the topsoil thickness established over the surveyed area. The map shows a variable thickness from 0.6m to 4.2m. A larger percentage of the area has thickness varying between 1.0m and 2.2m. Figure 6b shows the contour map of the weathered/fractured layer overburden thickness established over the surveyed area. The map shows a variable thickness from 4m to 56m. Large thickness zones are around the North-East and North-West axis of the map.

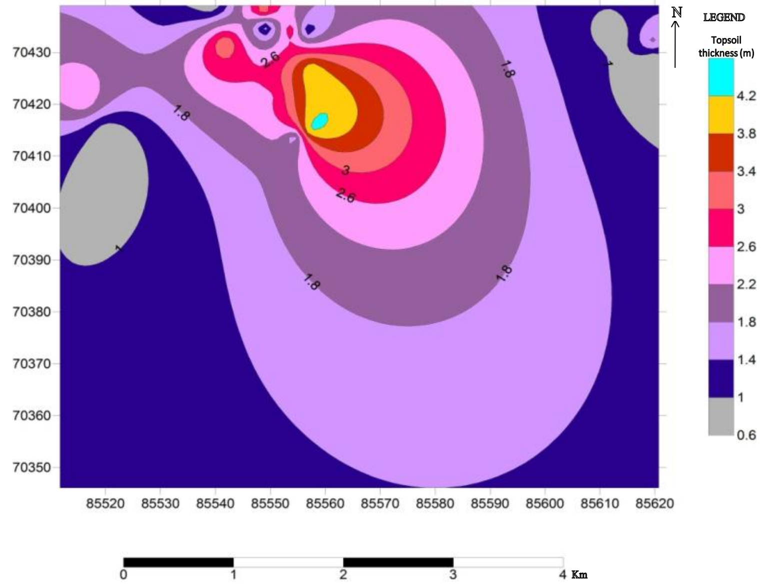

Figure 6a: Contour map of the topsoil thickness

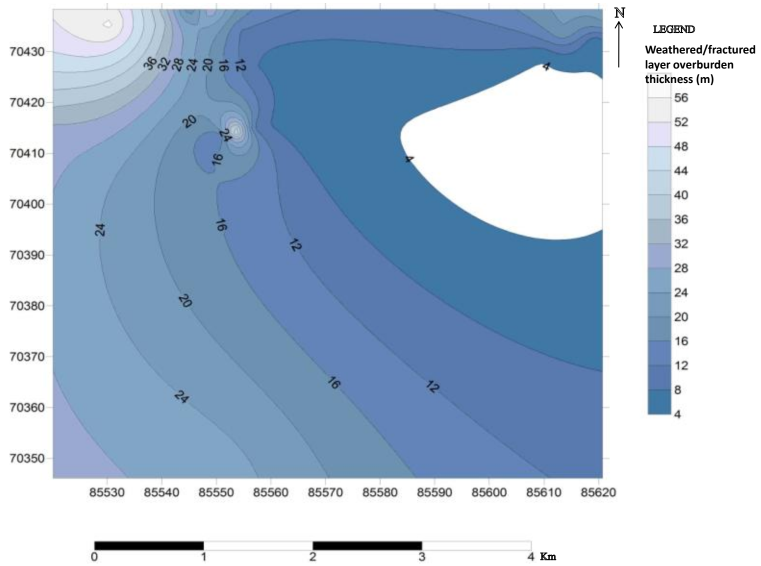

Figure 6b: Contour map of the weathered/fractured layer overburden thickness

IV. Conclusion And Recommendation

The study has help in the identification of the geo-electric layers in the area. Based on the obtained thicknesses of the overburden and layer resistivities VES 2, VES 5, VES 8, VES 14, VES 21, VES 24 and VES 25 stations were identified as potential locations for borehole development. Also, the knowledge of thickness of the first layer (sandy soil) and depth to the second or third layer in the study area will be a useful guide to civil engineers and builders that may carry out subsequent construction works around the area.Migration of matter from the dumpsites as well as its composition and biochemical processes are believed to have contributed to the very low resistivity of the topsoil at VES 7 and VES 17 stations. Although further studies of the strata and aquifers properties around the dumpsite vicinities are required, there is need for development of infrastructure for appropriate solid waste management in the country and active control systems to prohibit indiscriminate disposal of waste at unapproved locations so that environmental sustainability will be guaranteed.

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