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Electrical resistivity survey of a waste dumpsite at Uyo, Akwa Ibom State, Nigeria

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ABSTRACT

Electrical resistivity measurements was conducted at an old waste dumpsite in Uyo Local Government Area to determine leachate contamination to soils, and it's possible contamination to subsurface groundwater. Twenty vertical electric sounding (VES) lines were measured in a grid format spaced at about 50m intervals. The equipment used was the Abem Terrameter "SAS 1000", the data was analysed using computer processed methods with the following softwares Zoody software, surface 9.0, and 3D field pro programmes. The analysis indicate that there was leachate contaminant at the dumpsite with a very low resistivity of 4.5ohms-9.5ohms which infiltrated to depths of 3.5m-5.1m within the top layer. The result indicate that the leachate was localized at about 50m from the dumpsite and is spreading in the direction of the groundwater flow.

Keywords: leachate, Terrameter, Groundwater, Zoody software, Contamination.

INTRODUCTION

Electrical resistivity methods are well known in delineating the subsurface resistivities both vertically and laterally. Waste dumpsite over time are expected to release leachate to the surrounding environments, these leachates originate due to the disposal of domestic and industrial solid waste, they are highly conductive materials and are major source to acquifer contamination [5],[12]. Since resistivity is the inverse of conductivity, electrical resistivity method is a popular tool for ground water exploration [11], its also used in determining groundwater quality, i.e whether the water is saline, fresh or contaminated [4],[7],[8],[10],[13].

In studying the leachate effects, it's expected that areas of high concentrations of leachate, there will be a corresponding very high value of conductivity and a very low value of resistivity [1],[12], [14]. The above concept guides the use of this method in studying this waste dumpsite new Uyo local government headquarters in Akwa Ibom State, Nigeria. The waste dumpsite is located within latitude 5^0 02' 36" N and longitude 7^0 56'00" E, however the survey covered other locations within Uyo Municipality from latitude 5.02 – 5.04 N and longitude 7^0.50-7^0.59E. The study area was accessed through major and minor road and tracts created by field guides. The GPS was used in collecting the mean sea level elevation in all the VES data points. The coordinate positions of the survey area and the elevations obtained from the GPS is contoured as the topographic elevation map of the study area (fig1). The dumpsite indicate a moderately low elevation of about 50m. The elevation increases towards Uniuyo and so indicating the surface wash out direction towards the dumpsite.

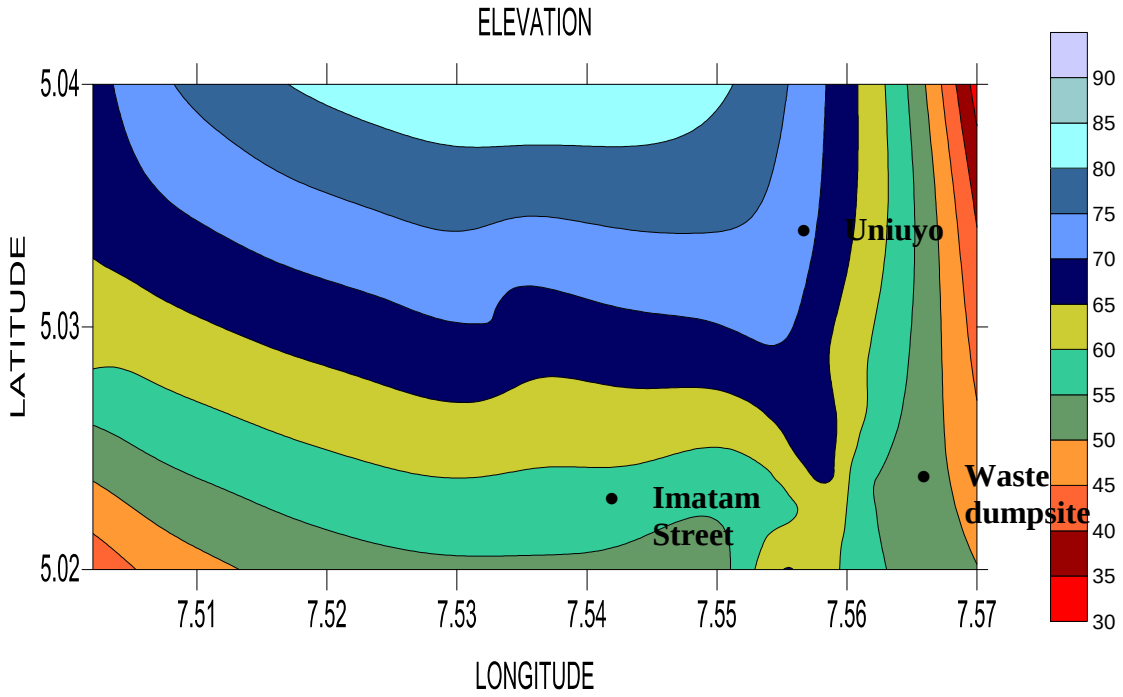

Fig. 1 Elevation Map of the study area

Geologically, the Uyo area of Akwa Ibom State belongs to the Niger Delta region of Nigeria. The area lies within the tertiary to Quatenery period and comprise of Eocene to Pleistocene coastal plan sandstones of clays and shales which grade to the Itara formations of the lower Benue trough (Fig.2).

MATERIALS AND METHODS

The following materials were used in this study:

(i) The Abem Terrameter (SAS 1000) is the main instrument used in collecting VES data.
(ii) Zoody software is the major data processing and interpretation package.

GPS is the global positioning system used in obtaining longitude and latitude positions of VES data points for contouring the 2D subsurface maps

(iii) Surface 9.0 is the golden software package used in contouring 2-D maps
(iv) 3-D field pro is the software for projection in 3D maps

The method of study involves field data acquisition. It took two weeks for the collection of twenty (20) VES data in a grid format (fig 3.0). The field measurements were done using the schlumberger array where AB/2 current separation was between 250 -300m and MN/2 the potential separation was between 30-40m. The mathematical expressions for the schlumberger array is illustration in [9].

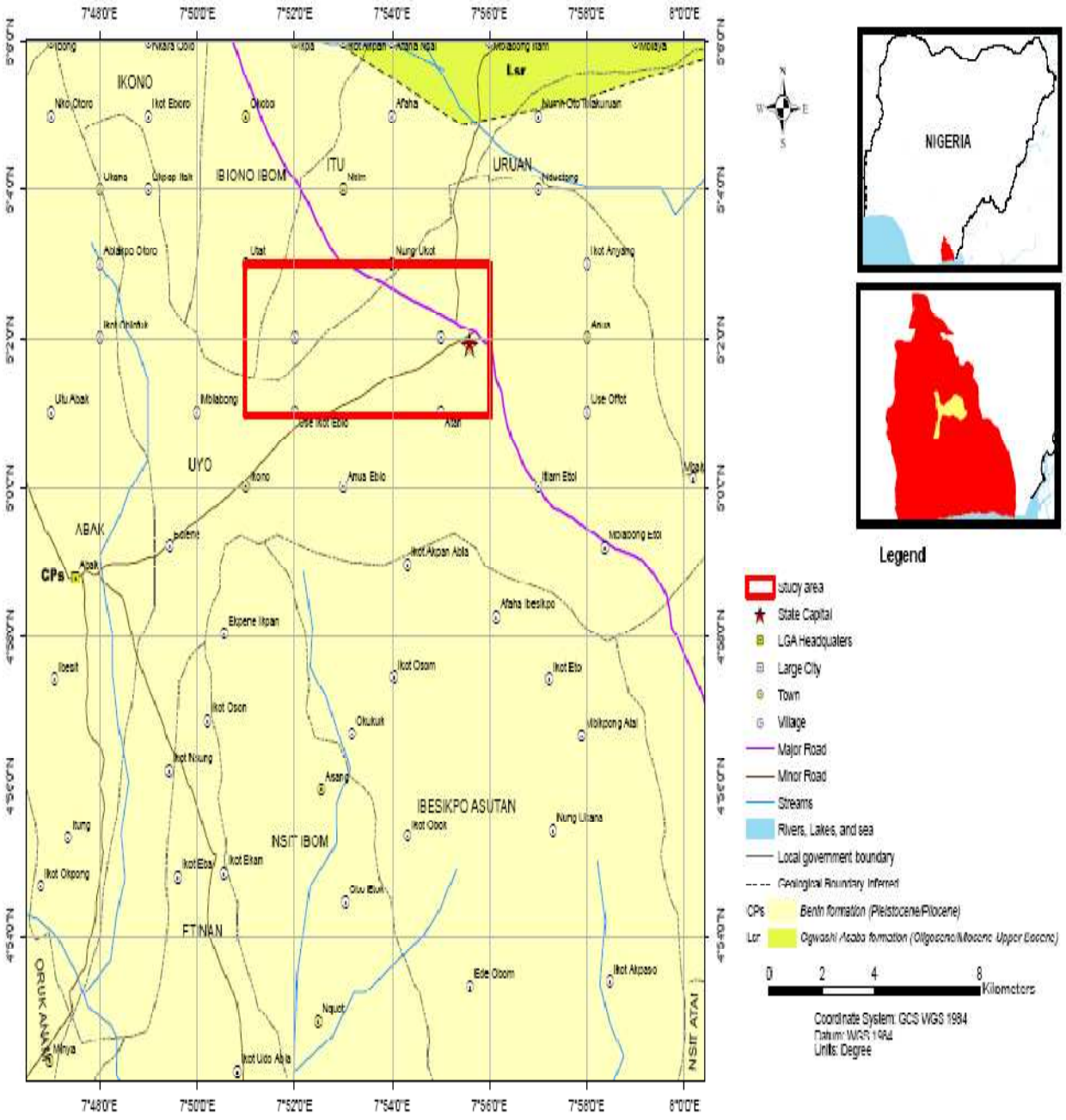

Fig. 2 Geologic Map of the study area

A total of twenty (20) vertical electric sounding (VES) measurements were made in the survey area. The VES measurement around the dumpsite had several challenges where steep valley prevented the current electrodes in attaining the maximum current separation, such lines were.

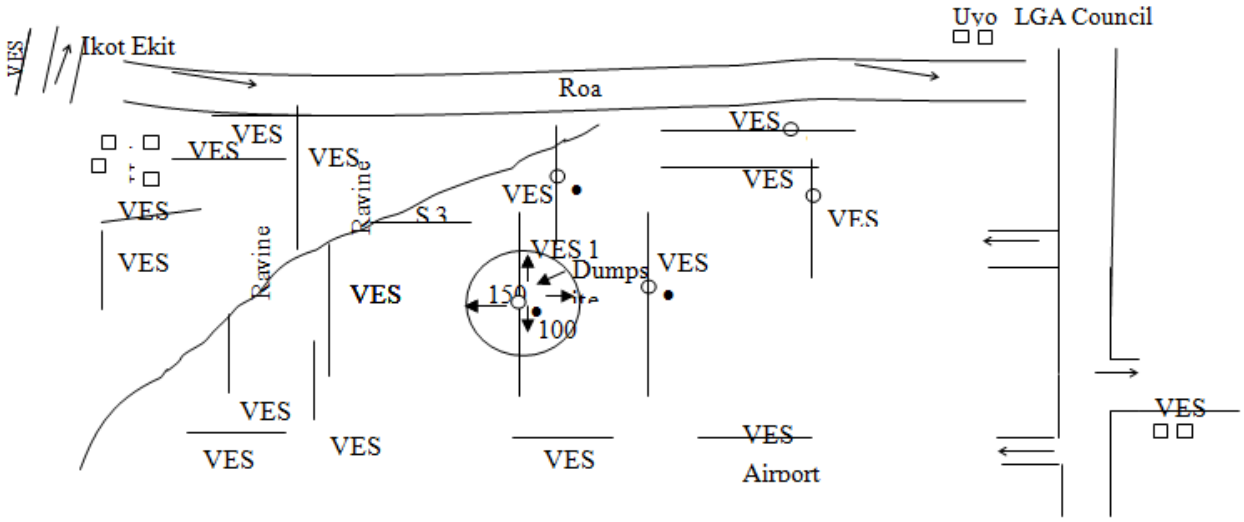

Fig. 3 Sketch VES Locations of the study area

RESULTS AND DISCUSSION

All the data sets collected from the VES surveys were processed electronically using different software programmes as stated in materials used. The Zoody software programme is the major data processing programme, when made active it pops for AB/2, MN/2 and ρ_9 data, it utilizes various iterations equations to produce model plots showing calculated and observed plots. [2],[3],[10]

Also created at each programme run is a layer plot file indicating depth and resistivities values, a combination of these layer files and the model plots are used in creating the Geomodels for each VES location. The Geomodel is a representative section showing vertical depth in meters with their corresponding no of subsurface layers and their corresponding earth resistivities.

Though twenty (20) VES locations were studied only four (4) model plots and four (4) Geomodel from VES 1,2,6,4 will be presented for illustration purpose. The result of VES 1 was displayed as (Fig 4) model plot of Uyo 01 and the geomodel (fig 5) as geomodel VES 01. This VES line is directly on the dumpsite, the top layer has a very low resistivity value of 4.50hms and is about 5.1m deep. The very low resistivity top layer indicate the possible presence of leachate contamination. VES 02 is displayed as (fig 6) and the geomodel plot as geomodel plot of Uyo (Fig 7). This VES is about 150m away from the dumpsite. It's top layer has a very high resistivity value of about 2797 ohms which indicate no effect of the leachate contamination. VES 06 results is displayed as model plot of Uyo 06 (fig.8) and the geomodel plot as geomodel plot of Uyo 06 (fig.9), this VES is about 500m away from the dumpsite it has a high resistivity value of about 1128 ohms for the top layer. This model indicate no influence of the leachate contamination.

Also VES 04 result is displayed as model plot of Uyo 04 (Fig. 10) and the geomodel plot as gomodel plot of Uyo 04 (Fig.11). This VES is about 50m away from the dumpsite. The top layer has a very low resisitivity of 9.5 ohms which penetrated to depths of 3.5m. Its top layer has possible influence of leachate contamination.

VES 05–VES 020 were analysed in a similar manner as described above and the results of their top layer (overburden) resisitivities map is displayed (fig.12) [15]. Also the water level layer resistivities were estimated from both the model and geomodel plots of the twenty (20) VES and the results displayed as the 2D ground water flow direction map of the study area (fig.13).

Similarly, the 3D model of the dumpsite and its environs was plotted using field pro with inputs as overburden thickness resistivities of the top layers, and elevation above level were modeled to obtain the 3D view of the waste dumpsite. The Dumpsite has a low resistivity < ohms and had only a localized spread within areas of low elevation of 50-60m.

The waste dumpsite has a moderately low elevation of 50m which increases towards Uniuyo, so the surface wash out direction is towards the dumpsite. In estimating the spread of the suppose leachate contamination from the dumpsite and the possible infiltration of the leachate to the subsurface groundwater, the resisitivity map of the top layer (fig.12) and the groundwater flow direction map (fig.13) were utilized. The resistivity map of the top layer was

contoured at 20 ohms intervals with the dumpsite having even lower resistivities values as shown in model plot and gemodel plots of VES 01 and VES 4. The geomodel and model plots indicate abnormally low resistivity values (4.5.9.5ohms) which indicate leachate contamination of the top layer. Also the dumpsite (fig.12) of the 2-D resistivity model map of the top layer indicates resistivity values of <20 ohms within the dumpsite.

The groundwater flow direction was contoured with resistivities of subsurface layers between 100 ohm and 150 ohms using geomodel plots with values within subsurface layer between 50 ohms and 400 ohms (fig.13). The study reveals the groundwater occurred in areas with resistivities between 100-150 ohms and is towards the ravine from the waste dump in the N-S direction. Also from Uniuyo it flow towards the ravine in the S-N direction.

However, 3D model of the dumpsite (fig.14) reveals that the dumpsite has a moderately low elevation with the thickness of the invaded leachate < 10m the spread of the leachate is localized with resistivities values < 100 ohm (4.5 – 9.5) and lies within the top layer of the dumpsite area.

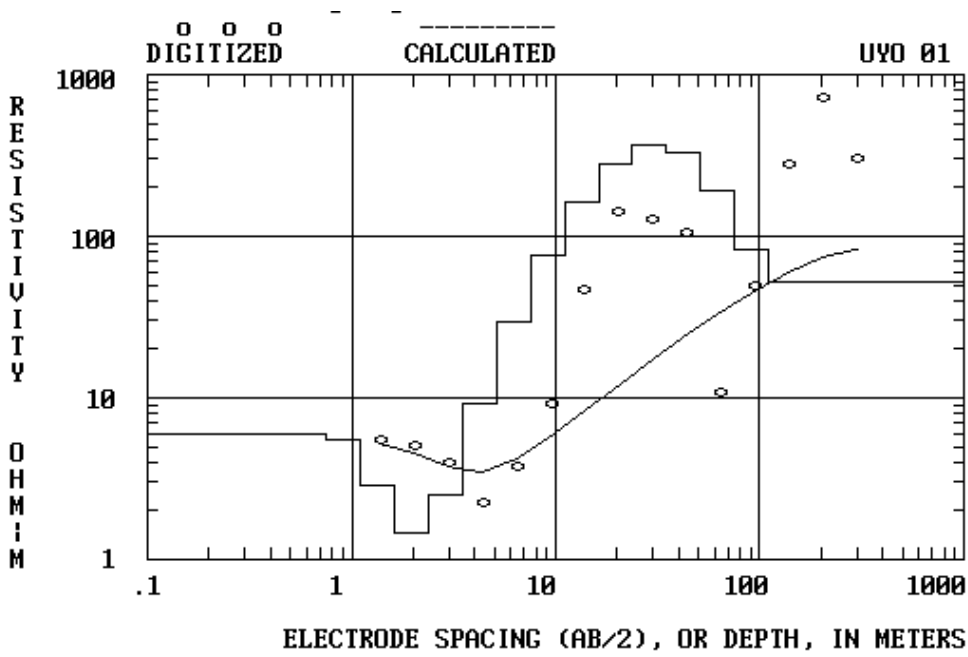

Fig. 4 Modeled VES of Location 1

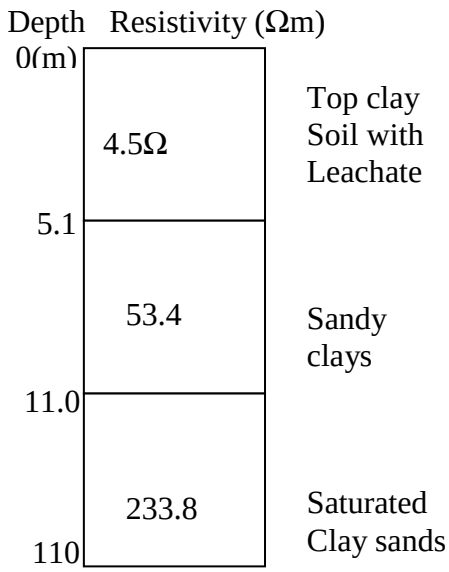

Fig 5 Geoeletric Model of VES 1

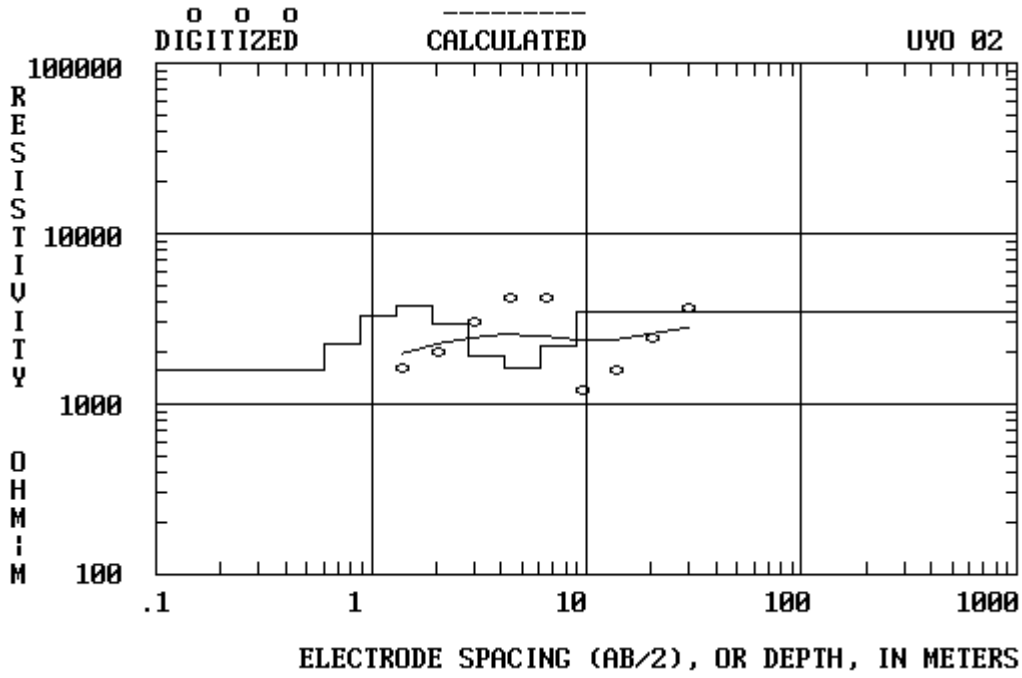

Fig. 6 Modeled Plot of VES 2

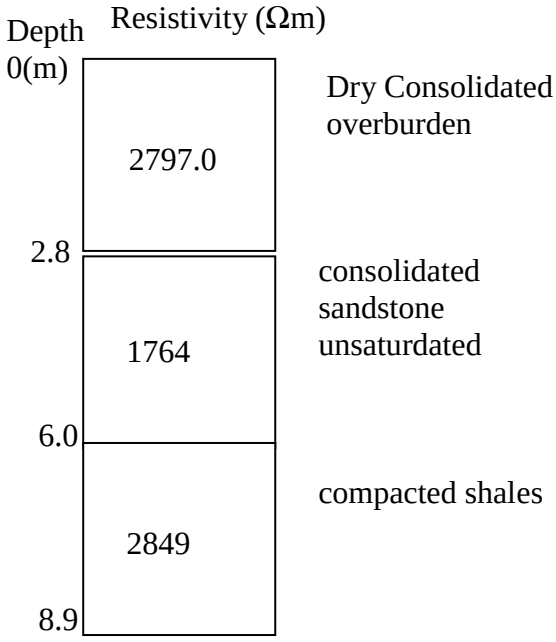

Fig. 7 Geoeletric Model Section of VES 2

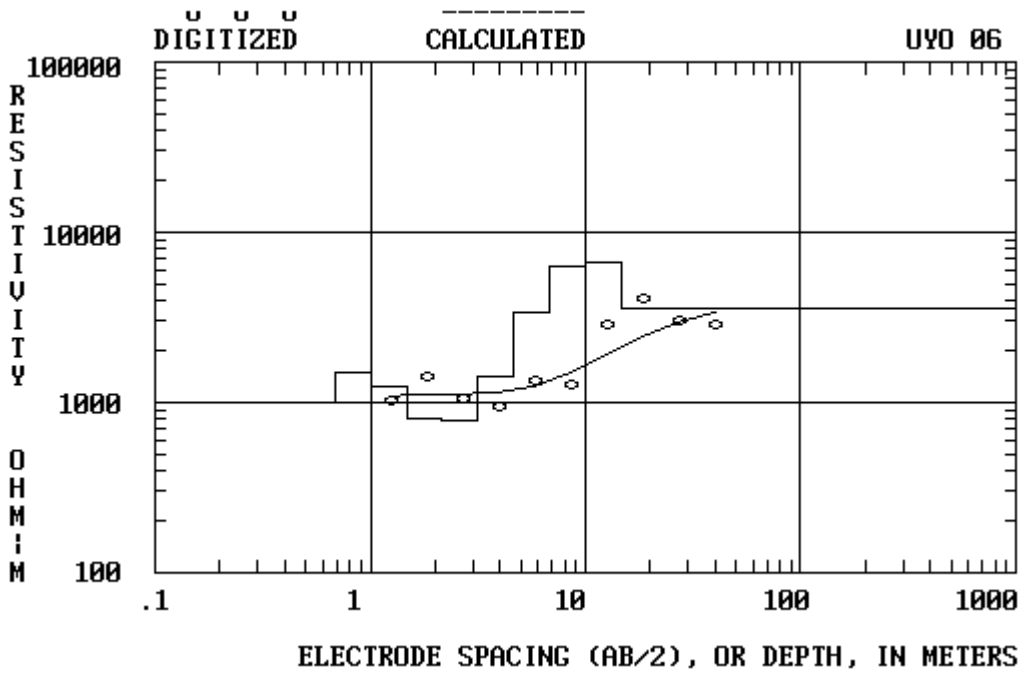

Fig 8 Model VES Plot of Location 6

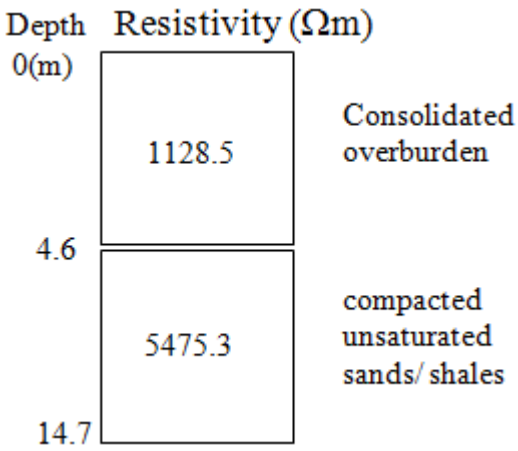

Fig 9 Geoeletric Model Section VES 6

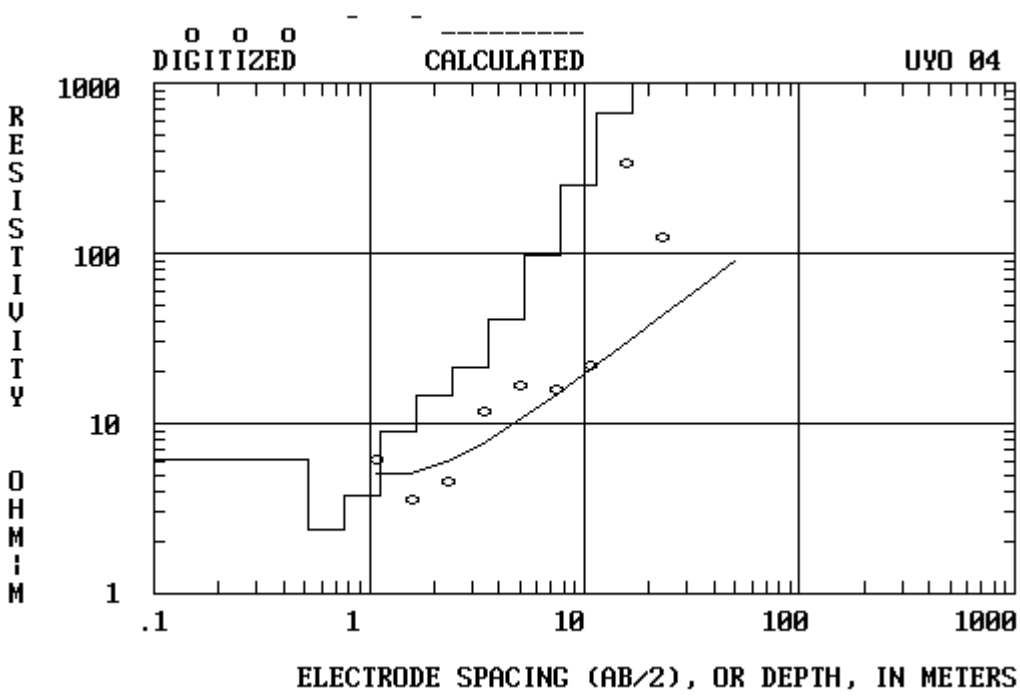

Fig 10 Model VES Plot of Location 4

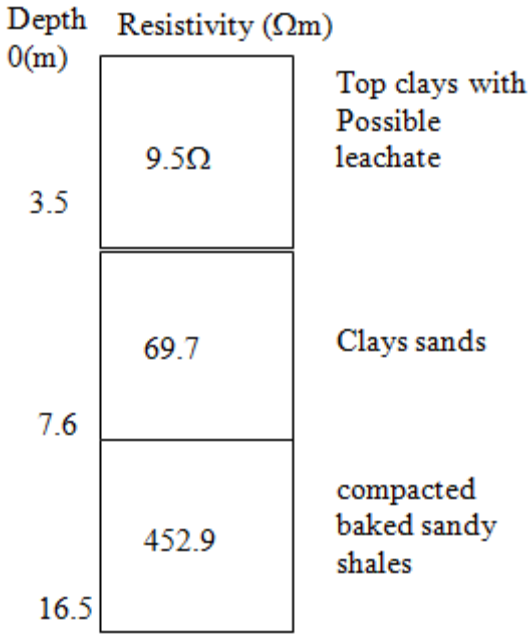

Fig 11 Geoeletric Model Section VES 4

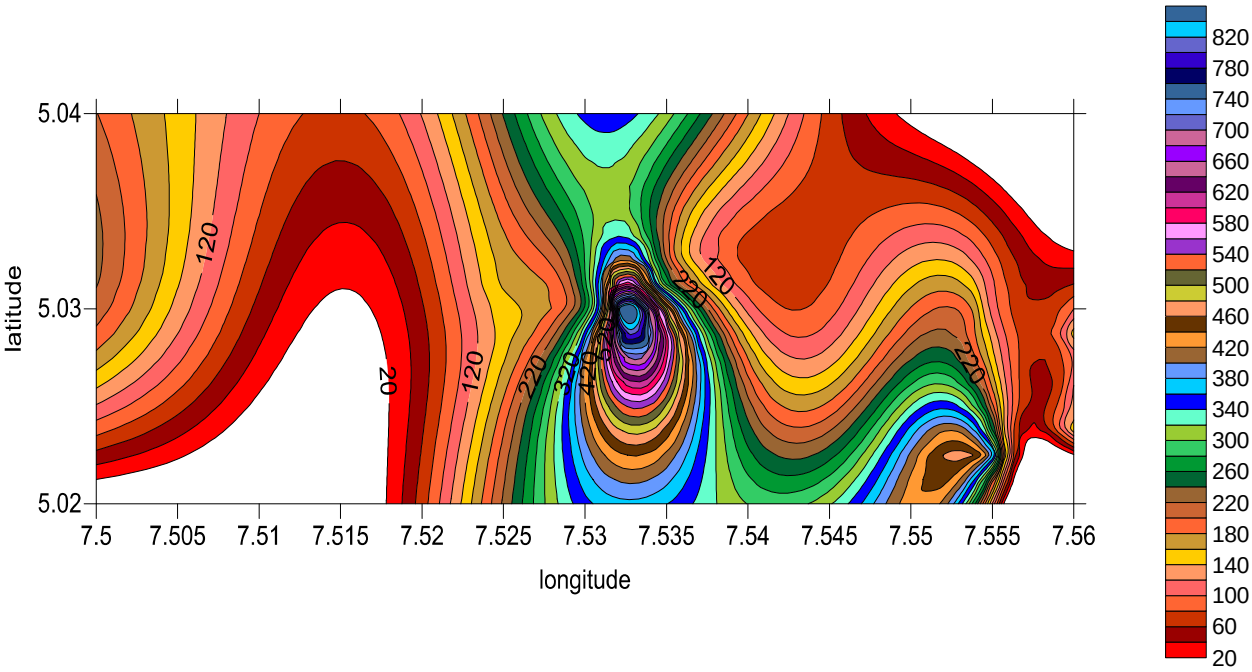

Fig. 12 2D Resistivity Model Map of Overburden (top layer) of the Study Area

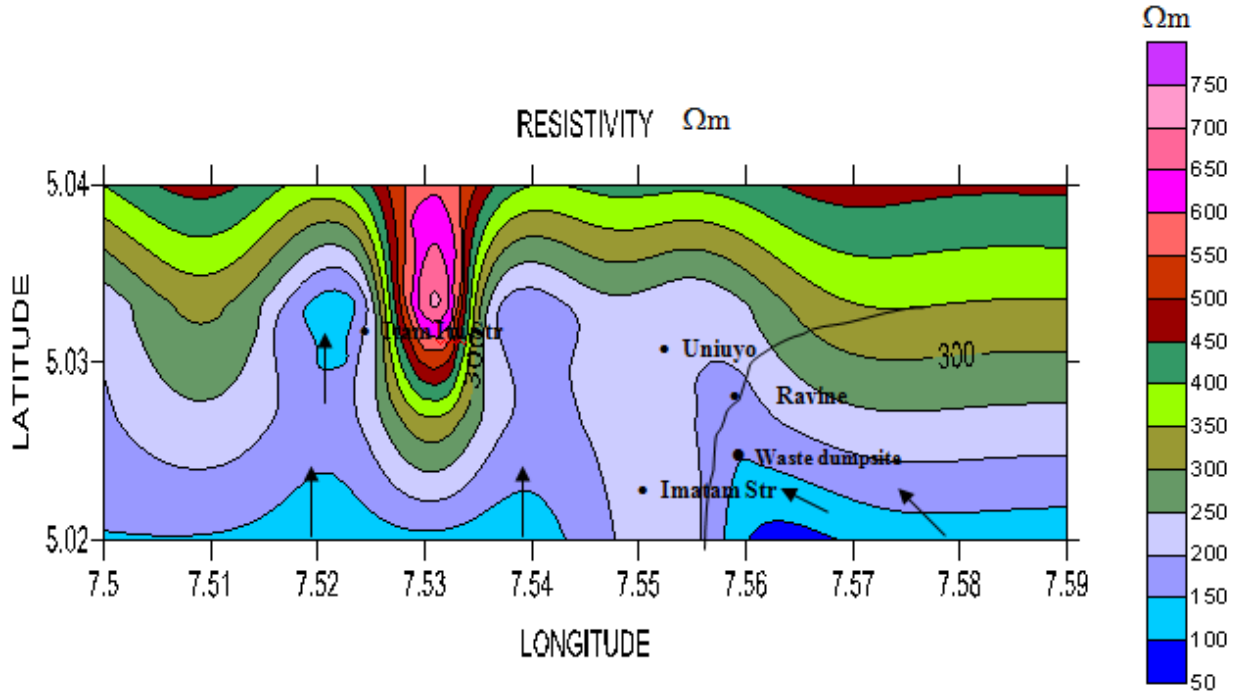

Fig. 13 2D Ground water model flow direction map of the study area

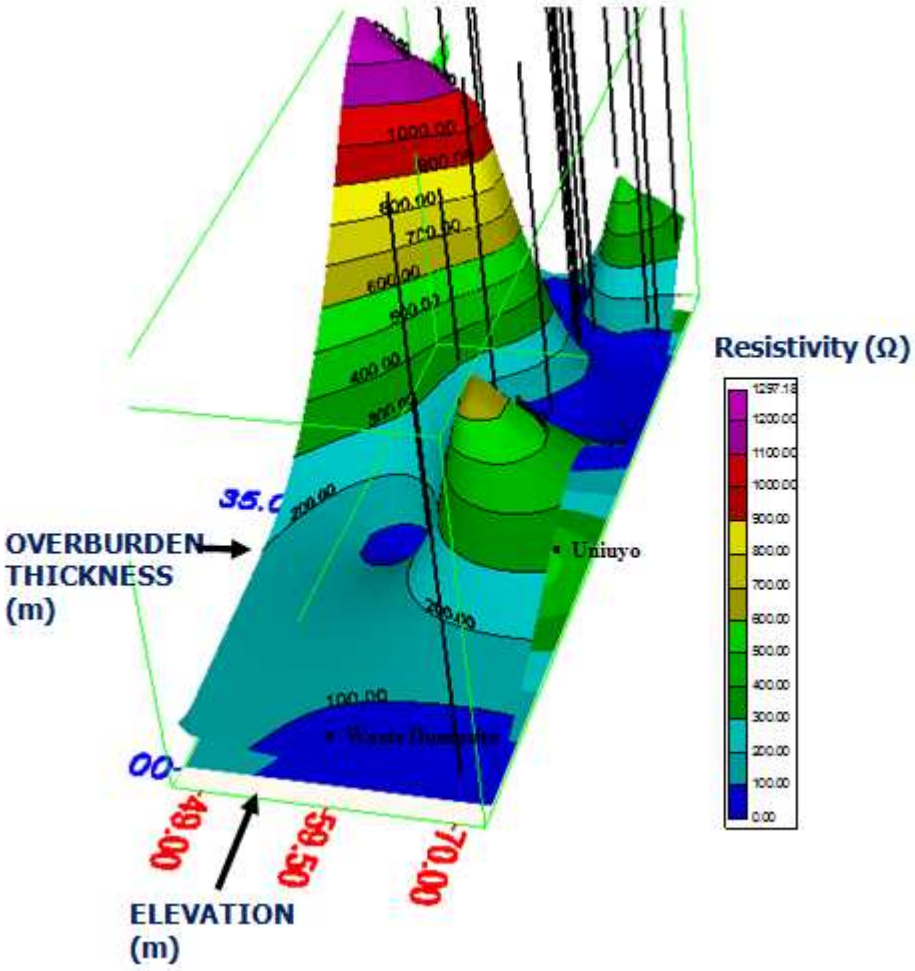

Fig. 14 3D Resistivity Model of waste Dumpsite

CONCLUSION

Though the results from 2D resistivity modeling of the top layer and 3D model of the waste dumpsite indicate a shallow depth penetration of the leachate < 10m and a localized spread of <100m. The inhabitants of Imatam Street, Effiong Udo Akpan Street which are in the downslope side of the groundwater flow direction be advised to avoid using shallow dug had wells to avoid the infiltration of the leachate contamination to shallow ground water levels. Only deep cased wells > 100m should be recommended for the inhabitants of these areas.

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