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TWO-DIMENSIONAL ELECTRICAL RESISTIVITY IMAGING OF SOLID WASTE DUMPSITE AT UGWUAJI, ENUGU STATE, NIGERIA.

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ABSTRACT

Geophysical investigation using Two-Dimensional (2-D) electrical resistivity imaging method was conducted around a solid waste dumpsite at Ugwuaji in Enugu South L.G.A of Enugu State, Nigeria. This is aimed at investigating the effect of the solid waste on soil and groundwater resources in the area and environs. A total of two 2-D electrical imaging was acquired at the dumpsite using Wenner configurations, employing the roll-along method. A contaminant leachate plume was delineated in the 2-D electrical resistivity tomographic sections as low resistivity zones. The results were presented in terms of resistivity, thickness and depth. The suspected contaminant plume from the 2-D resistivity values as low resistivity zones (3.31-12.4Ωm). The plume was observed to have infiltrated to a depth exceeding 18.5m which poses serious health risks to the inhabitants of that area. Therefore, there is need for a geochemical analysis to determine the water quality in the area. A Sanitary Landfill is recommended near the Dumpsite in order to solve the problems of soil and groundwater contamination that may arise in the area.

Keywords: Electrical resistivity, dumpsite, leachate plume, groundwater, sanitary landfill.

INTRODUCTION

Solid waste management has been the major problem of our urban centers in Nigerian and other developing economies worldwide. In these centers, a lot of wastes are generated daily and disposed indiscriminately on roadsides, river channels, gutters and dumpsites without regards to the groundwater, local geology and human settlements. The intensity of man’s activities has led to increasing volume of solid waste worldwide, despite the current level of technological advancement and industrialization. In Enugu municipality, poor waste disposal and management practices, such as inadequately trained waste disposal personnel and equipment, poor waste collection, sorting and disposal methods, and indiscriminate location of disposal sites without regards to the local geology and the underground water, contribute significantly to the contamination of soil and groundwater in the area.

Careless dumping of refuse and poor management can greatly affect one’s health. Pollution from solid wastes always begins with precipitates carrying the leachates into the soil, surface water or groundwater. It is this contaminated liquid that permeates into the soil and groundwater system through the solid dumpsites. Leachate from municipal solid waste deposits is generally associated with high ion concentrations and hence very low resistivities. This makes geoelectrical techniques most adequate for mapping extent of leachate contamination around landfills (Bernstone and Dahlin, 1999).

The electrical resistivity method is used for electrical sounding and imaging. The electrical sounding provides information about vertical changes in subsurface electrical properties and thus, it is useful in the determination of hydrogeologic conditions such as the depth to water table, depth to bedrock, and thickness of soil (Zohdy, 1964). The electrical resistivity imaging maps groundwater contaminant leachate plumes, contaminant source, migration paths and depth (Griffiths and Barkers, 1993).

In the present study, attempts have been to investigate the subsurface lithology, map leachate plume and depth, at Ugwuaji solid waste dumpsite employing the 2-D electrical resistivity imaging method.

LOCATION OF THE STUDY AREA

Ugwuaji solid waste dumpsite is located in Ugwuaji, Enugu South Local Government Area, Enugu State, Nigeria (Figure 1). It is 1.6km away from the Enugu-Port Harcourt express way. It is lies between Latitude 6°26′ and 6°27′N and Longitude 7°32′ and7°33′E with an area extent of about 10sqkm. The area is accessible by roads, railway, footpaths and a major route (Enugu-Port Harcourt express way).

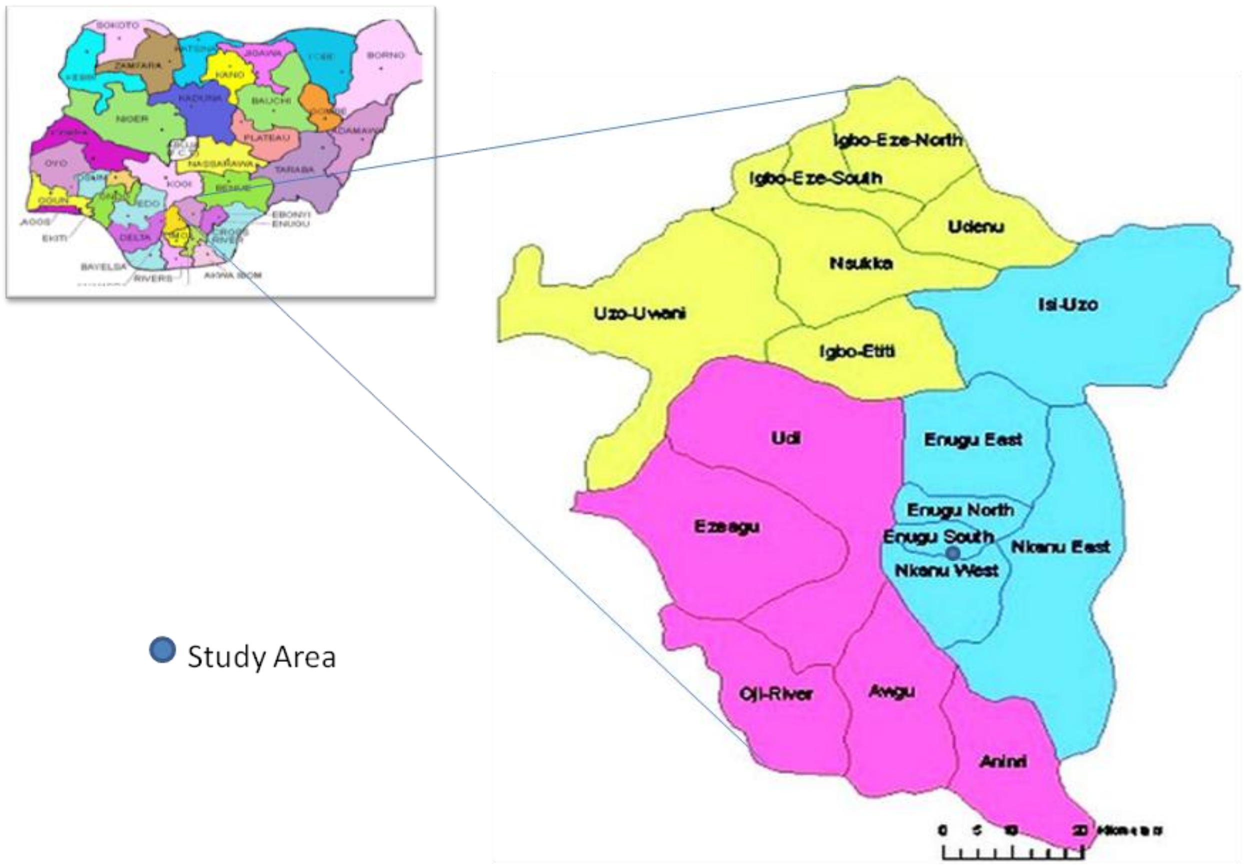

Figure 1: Map showing the location of the study area.

PHYSIOGRAPHY

The relief of the study area shows undulating low and high topography with the lowest elevation value of 120m and the highest elevation value of 270m (Figure 2). The Shale unit shows lowland while the Sandy-Shale unit shows highland towards WTC and Uwani TTC.

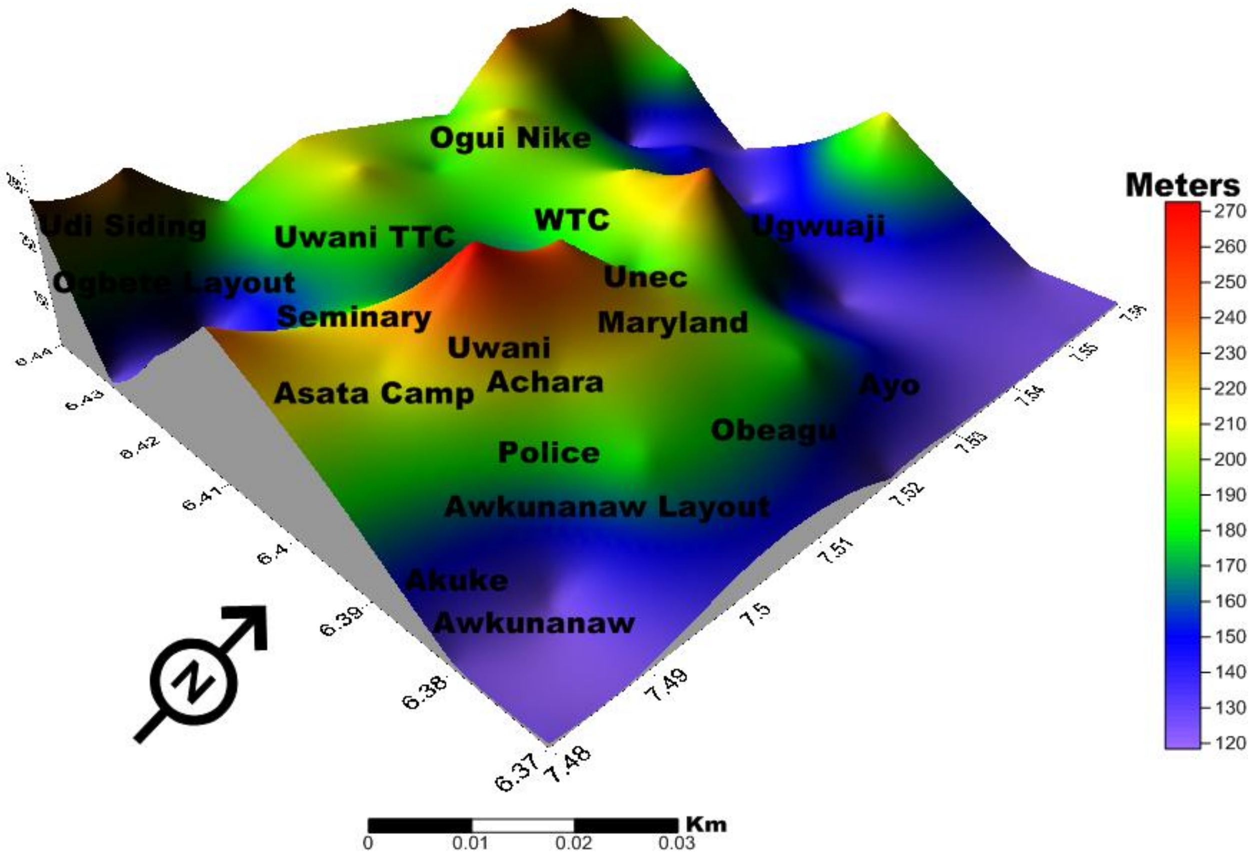

Figure 2: Surface map of the study area.

GEOLOGY

The study area falls within Anambra Basin geologic complex. Locally, the study area is underlain by two lithologic units – the Enugu Shale and Mamu Formation (Figure 3). The Enugu Shale consists of carbonaceous grey black shales and coals with interbeds of very fine sandstone/siltstone deposited in lower flood plain and swampy environment. The bedding planes are poorly defined with early diagenetic minerals such as pyrite and siderites. The sediments have a poorly developed foreshore and shoreface with extensive coastal swamps (Kogbe, 1970; Whiteman, 1982; Ladipo, et al, 1992).The Enugu Shale was assigned Campanian to Lower Maastrichtian, based on diagenetic species of palynomorphs such as Cingulatisporites ornatus and Tricolpites tienebaensis. (Reyment, 1965; Whiteman, 1982).

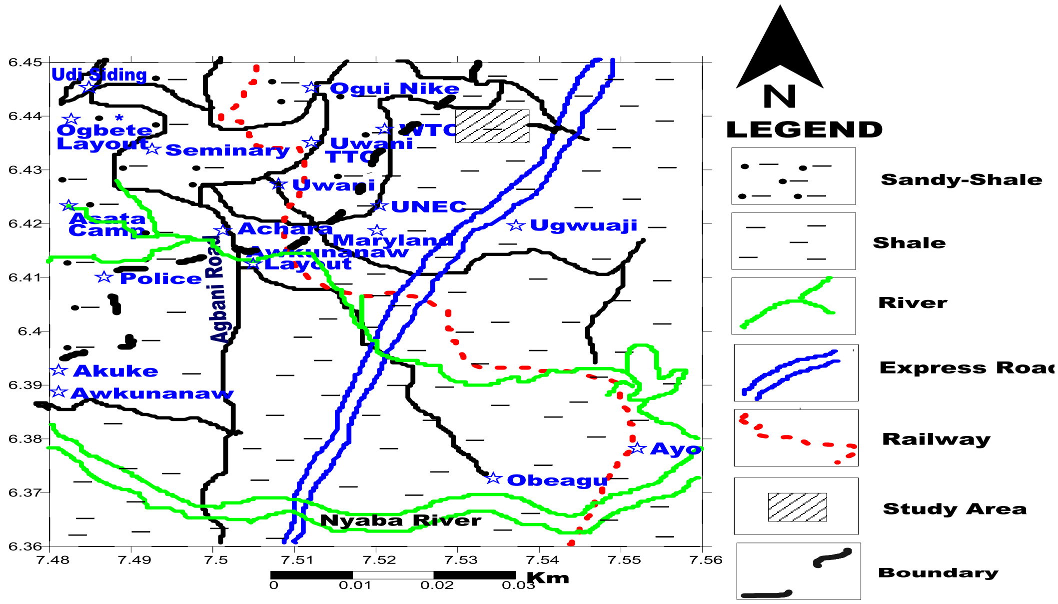

Figure 3: Geologic map of the study area.

While Mamu Formation overlies the Enugu Shale conformably and contains sandstone, shale-mudstone, sandy-shale with coal seams in various horizons (Reyment, 1965). The sediment pile varies across the basin and ranges from 75m to over 1000m (Reyment, 1965; Ladipo et al, 1992). The possible environments of deposition are estuarine flood plain, Swamp and tidal flat flood plain. It is excellently exposed along the Enugu-Onitsha Road at the Miliken Hill and the outskirts of Enugu (Kogbe, 1974). The age of this formation is put at lower-middle Maastrichtian and has a significant thickness variation from about 100m in the south to as much as 100m in the central and northern part of the basin (Ladipo,etal, 2001).

MATERIALS AND METHOD

Theory of Method

Electrical Resistivity (ER) surveys are now commonly used for geotechnical investigations and environmental surveys (Loke, 1999). The ER imaging is a geoelectrical method of obtaining high-resolution 2D or 3D image of the complex geology of the subsurface (Griffiths and Barker, 1993). The ER method is based on measurements using two electrodes, of the potential distribution arising when electric current is transmitted into geological layers through two other electrodes. The resistivity of the subsurface is affected by porosity, amount of water in the subsurface, ionic concentration of the pore fluid and composition of the subsurface material

(Keller and Frischknecht, 1979). The electrical resistivity is the resistance offered by the opposite faces of a unit cube of material to direct current. The unit of resistivity is in the ohm.m. The resistance (R) of the material having a resistivity (p) over a length (L) and surface area of current flow (A) is given by R = pL/A. This is governed by ohms law. The inverse of resistance is termed as conductance (σ). The resistivity of the geological formation is generally very high under dry conditions and decreases in clayey rock. The presence of water containing salt even in minor amounts, geological formations make them relatively conductive and as the moisture increases the resistivity falls deeply. As the salinity of water increases the resistivity of the rock formation decreases internally.

It is one of the surface geophysical methods used in prospecting for groundwater, hydro-geological investigation, mining and geotechnical investigations as well as in environmental studies. Its technique is based on the response of the subsurface material to the flow of electric current transmitted through the current electrodes (AB) and with other two potential electrodes (MN) to record the resultant potential difference between them (Keller and Frischknecht 1979). Different arrays such as Wenner, Schlumberger, Dipole-dipole, and many others, can be used to carry out electrical survey on the solid dumpsite. Wenner array was employed for the present study.

In the Wenner array, the electrodes are uniformly spaced in a line. In spite of the simple geometry, this arrangement is often quite inconvenient for field work, and has some disadvantages from a theoretical point of view as well. For depth exploration using the Wenner spread, the electrodes are expanded about a fixed center, increasing the spacing “a” in steps. For lateral exploration or mapping, the spacing remains constant and all four electrodes are moved along the line, then along another line, and so on. In mapping, the apparent resistivity for each array position is plotted against the center of the spread. From the current (I) and voltage (V) values, an apparent resistivity (pa) value is calculated. $pa = 2\pi aR$, where $2\pi a$ equals k which is the geometric factor, that depends on the arrangement of the four electrodes. Resistivity meters normally give a resistance value, R = V/I, so in practice the apparent resistivity value is calculated by pa = k R. The calculated resistivity value is not the true resistivity of the subsurface, but an “apparent” value which is the resistivity of a homogeneous ground which will give the same resistance value for the same electrode arrangement. The relationship between the “apparent” resistivity and the “true” resistivity is a complex relationship. To determine the true subsurface resistivity, an inversion of the measured apparent resistivity values using a computer program must be carried out.

Data Acquisition

The survey adopted wenner configuration (Figure 4) with a digital readout Ohmega resistivity meter to acquire data in the study area (Figure 5). Two number 2-D resistivity imaging (profile 1 and profile 2) using Wenner configuration with 'a' spacing of 10m and the maximum spread of about 160-170m was acquired. The technique deploys continuous vertical electrical sounding (CVES) which is a data acquisition process that combines lateral coverage with vertical sounding using a multielectrode resistivity meter system (Ugwu and Ezema, 2013). For a system with limited number of electrodes, the area covered by the survey can be extended along the survey line using the roll-along technique (Dahlin and Bernstone, 1999). This can be achieved by moving the cables past one end of the line by several units of electrode spacing, after completing a sequence of measurements.

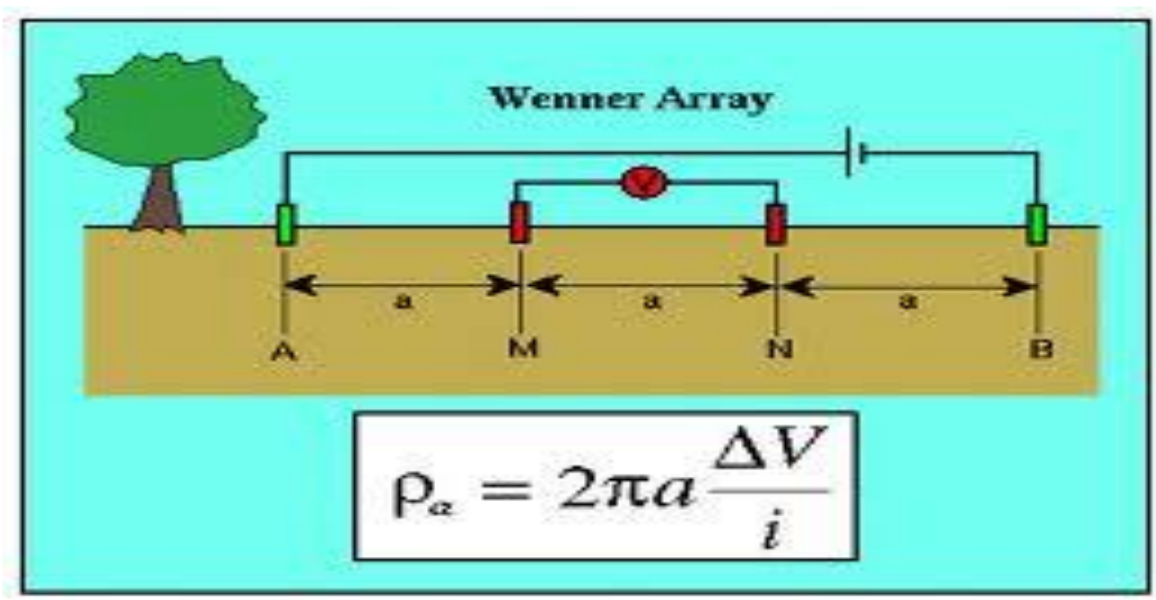

Figure 4: Wenner Configuration spread.

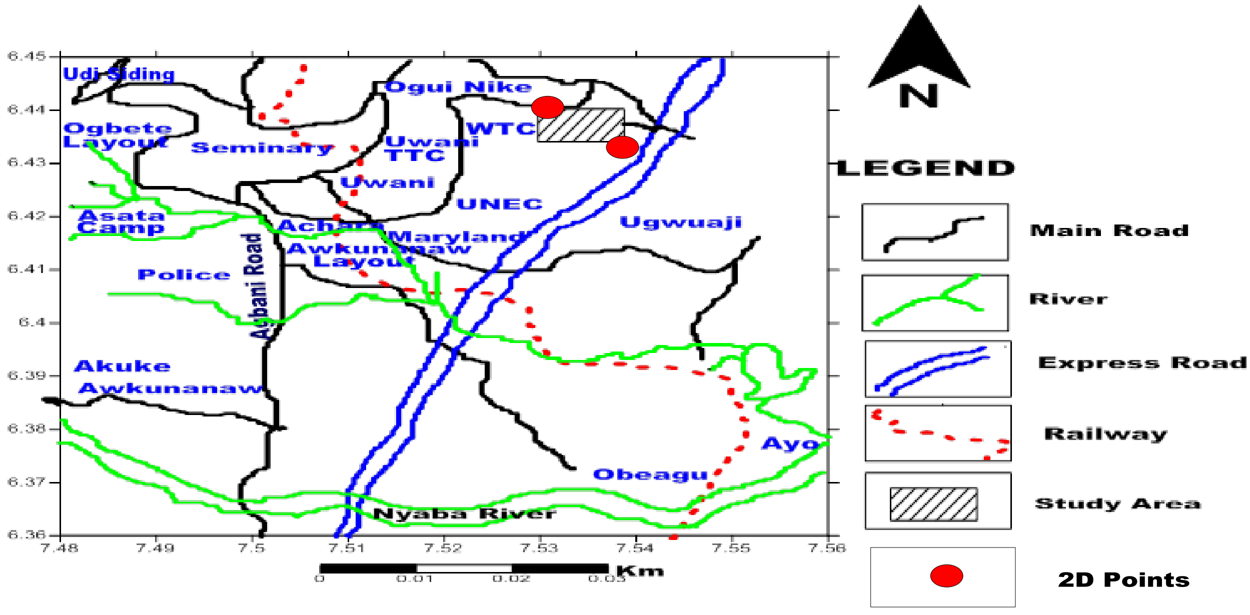

Figure 5: Map of the study area, showing position of the Ugwuaji dumpsite and 2-D points.

Data Processing.

The measured 2-D resistivity imaging data were processed using the RES2DINV inversion software (Loke, 1999). This program automatically subdivides the subsurface into a number of blocks and then uses a least squares inversion scheme to determine the appropriate resistivity values for each block so that the calculated apparent resistivity values agrees with the measured apparent resistivity values from the field survey. The results were displayed as inverted model resistivity sections verses depth of the subsurface (the Pseudosections).

RESULT AND DISCUSSIONS

Profile 1

This profile was acquired in a NE-SW trend direction of the dumpsite. In the pseudo section (figure 6), high resistivity zone (greater than 101 Ωm) existed near the surface with depth ranging from 2.50m-7.50m to the North and West of the section. This zone was interpreted as high resistive chemical compounds and its migration to near the surface is an indication that it is less dense. Underlying the zone of high resistive chemical compound is the zone of low resistivity (less than 5.40Ωm) with the depth ranging from 12.8m-18.5m. The bluish portion shows zone of low resistivity (contaminant leachate plume). The migration of the contaminant leachate plume to the bottom is an indication that it is denser than the chemical compound which float at the top.

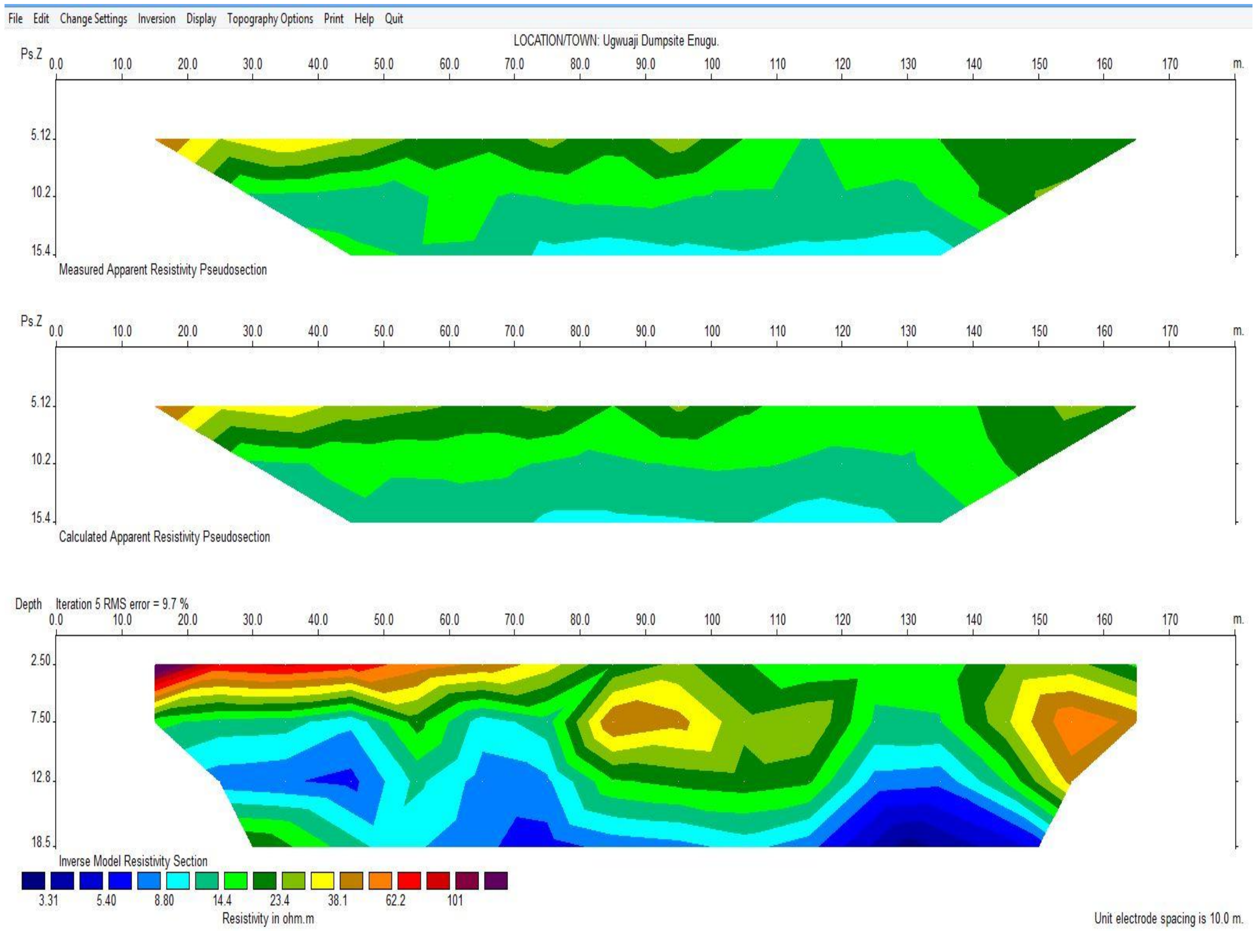

Figure 6: Electrical resistivity tomography – profile 1.

Profile 2

The profile 2 was run parallel to the profile 1 (figure 7). The high resistivity zone (greater than 58.1Ωm) existed near the surface with the depth ranging from 2.50m-7.50m to the North and East of the section. This zone was equally interpreted as high resistive chemical compounds and due to it is less dense, it accumulated at the top. Underlying the zone of high resistive chemical compounds is the zone of low resistivity (less than 9.07Ωm) with the depth ranging from 12.8m-18.5m as in the profile 1. The bluish zone is the zone of low resistivity of the contaminant leachate plume which accumulated at the bottom due to it is denser and it indicates the contamination of soil and groundwater within this area.

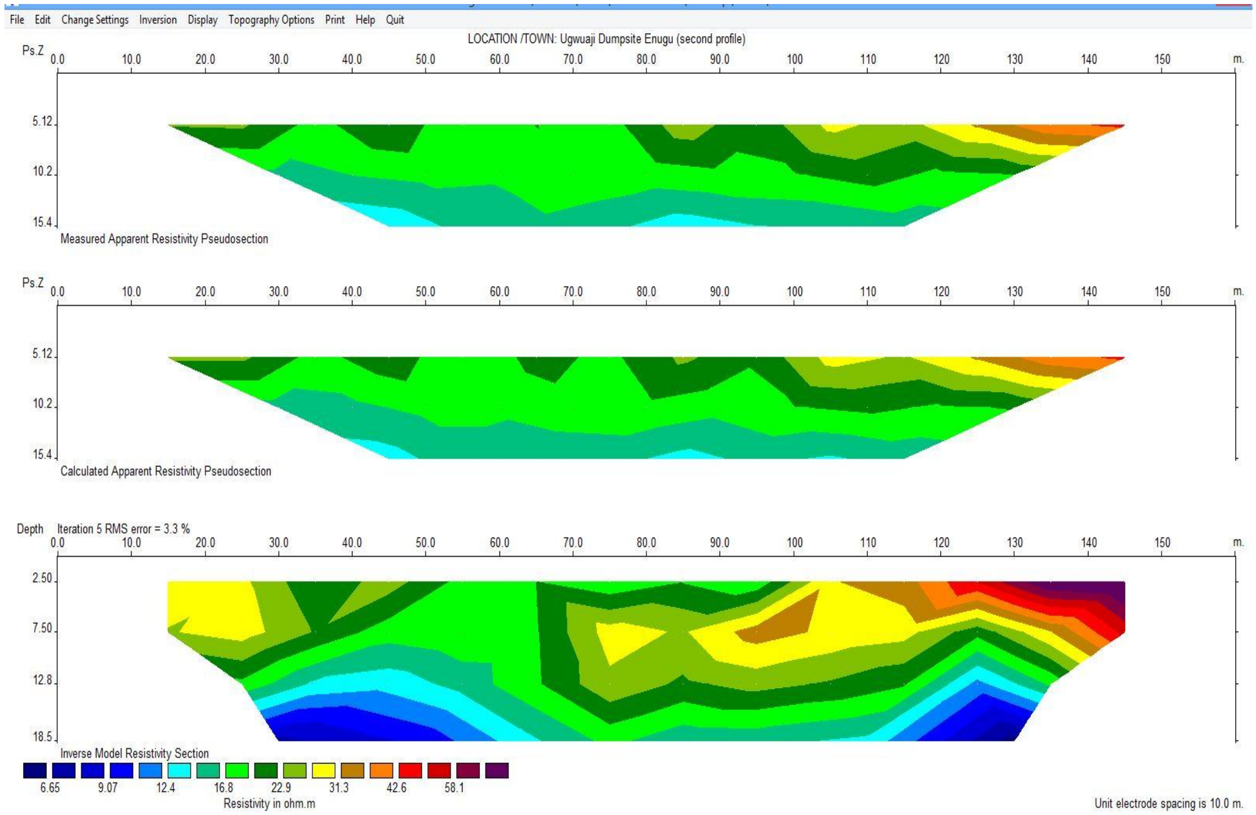

Figure 7: Electrical resistivity tomography – profile 2.

CONCLUSION

A contaminant leachate plume was delineated in the 2-D electrical resistivity tomographic (Figure 6 and Figure 7) sections as low resistivity zones. The leachate was identified and mapped as bluish zones of low resistivity between 3.31Ωm-12.4Ωm and depth between 12.6m-18.5m in the entire inverse model sections. The plume was observed to have infiltrated to a depth exceeding 18.5m which has contaminated the soil and threatens the groundwater in the area and poses serious health risk to the inhabitants of the area. The percentage distribution of the rock type is about 90% all shale and 10% sandy shale. The distribution of rock types indicates that the study area is dominated by Shale and to a lesser extent by Sandy-Shale. Therefore, it is suitable for the construction of a landfill or for dumpsite as it is used in the area. Penetration of leachate into the groundwater horizon can only be enhanced through fractures in the shale.

REFERENCES

- Bernstone, C. and Dahlin, T., 1999. Assessment of Two Automated DC Resistivity Data Acquisition Systems for Landfill Location Surveys: Two case studies. Journal of Environmental and Engineering Geophysics. 4(2)1;13 – 121.
- Griffiths, D.H., and Barkers, R.D., 1993. Two- dimensional resistivity imaging and modeling of complex geology. Journal of applied geophysics. 29: 211-226.
- Keller, G.V. and Frischknecht, F.C., 1979. Electrical Methods in Geophysical Prospecting. Pergamon Press Inc.: New York, NY. 519: 38-39.
- Kogbe, C.A., 1970. Notes on some upper Cretaceous and lower Tertiary algae from Southern Nigeria, In: African Geology (Dessauvagia T.F.J and Whiteman, A.J., Eds). Univ of Ibadan press, Nigeria., 301-304.
- Kogbe, C.A., 1974. The upper Cretaceous Abeokuta Formation of South-Western Nigeria. Nigerian field. 101(4), Dec 1974.
- Ladipo, K.O., Ekweozor, C., and Nwajide, C.S., 2001. Geological Field Trip to the Anambra Basin and the Lokpanta Oil Shale: NAPE conference Port Harcourt.
- Ladipo, K.O., Nwajide, C.S., and Akande, S.O., 1992. Cretaceous and Paleogene sequences in the Abakaliki and Anambra Basins, Southeastern Nigeria: a field guide. International Symposium on Geology of Deltas, Port Harcourt. May, 1992.
- Loke, M.N., 1999. Rapid 2D Resistivity and IP Inversion using the Least-Squares Method. Advanced Geosciences, Inc.: Austin, TX. 57.
- Reyment, R.A., 1965. Brief review of the Stratigraphic sequences of West Africa (Anglo-Senegal). Prog. 2^{nd} N African Micropa. Coll. (Ibadan 1965)., 162-175.
- Ugwu, G.Z and Ezema, P.O., 2013. 2D Electrical Resistivity Imaging for the Investigation of the subsurface structures at the proposed site for Kauridan estate at Ibagwa-Nike, Southeastern Nigeria. International Journal of Scientific Research in knowledge (IJSRK), 1(12) p.528-535.
- Whiteman, A., 1982. Nigeria: its petroleum geology, resources and potential. Graham and Trotman, London, 381pp.
- Zohdy, A.A.R., 1964. Earth resistivity and seismic refraction investigation in Clara County, California, Ph.D thesis (Unpublished), Stanford University., 131-135.