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2D Resistivity Imaging Investigation of Solid Waste Landfill Sites in Ikhueniro Municipality, Ikpoba Okha Local Government Area ,Edo State, Nigeria.

Iyoha. A, Akhirevbulu O.E, Amadasun C.V.O and Evboumwan I.A
Department of Physics Ambrose Alli University, Ekpoma, Nigeria
Email: iyohaabraham@yahoo.com

Abstract
2-D resistivity imaging was used to study the aquifer vulnerability to surface pollutants near solid waste landfill sites in Ikhueniro, Edo state, Nigeria. Five 2-D resistivity tomography surveys were utilized for the subsurface aquifer characterization. The results of interpretation of the data suggest that with the aid of the 2-D resistivity tomography, two distinct pollutants were mapped and identified within and around the landfills. These are compounds of anomalously high resistivities between 808Ωm and 4069Ωm suspected to be landfill gases (Ammonia, Methane, Sulphur (IV) Oxide, or Carbon (IV) Oxide) at depths exceeding 17.2m, and low resistive leachate contaminant plumes of resistivities between 9.45Ωm and 86.6Ωm at depths between 0.75m to more than 14.4m, implying that the aquifer is contaminated. These contaminants are migrating in depths and distance away from the landfills because of the porous and highly permeable sandy layers into the aquifers. Due to the vulnerability of these aquifers to surface pollutants, the sitting of dumpsites without adequate lining of the base should be discouraged in the metropolis, considering their implications on the soil and groundwater.
Keywords: Solid Wastes, Aquifer Vulnerability, Leachate Plume

Introduction

Electrical resistivity surveys are commonly used for geotechnical investigations and environmental surveys(Loke, 2006). Due to its efficiency and effectiveness in producing images of the subsurface, resistivity-imaging methods have now becomes more popular in electrical exploration (Dahlin and Zhou, 2002). The two dimensional (2D) direct current (dc) electrical resistivity methods measure the apparent resistivity of the subsurface, which can be inverted to develop a model of the subsurface structure and stratigraphy in terms of its electrical properties. 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 materials. However, the resistivity data can be used to identify, delineate and map subsurface features such as electrically conductive contamination plumes, the vadose zone, and electrically conductive lithologic units such as clay. In this study Ikhueniro municipal solid waste
disposal sites have been surveyed it is located in Edo state. The overall goals of this study were identification and delineation of the extent of the contaminated leachate plumes as well as testing of the efficiency of 2D dc resistivity as a pre-characterization tool for tracing the properties of disposed waste and severity of the contamination underneath capped landfill sites.

Location and geology of study area

This study was carried out in Ikhueniro municipal landfill sites in Ikpoba Okha Local government area of Edo state, Nigeria. The study area is located within longitude 5^o 24' and 6^o 35' E and latitude 5^o 36' and 5$^{o.}$ Geologically, the area under study is a typical Niger Delta environment. The areas under study lie in the Benin formation and have been classified as coastal plain sand (Reyment, 1965). It consists of massive, high porous freshwater bearing sandstones with minor clay intercalation, and it is characterized by high permeability. The formation is generally water bearing and hence it is the main source of portable groundwater in the municipality (Etu-Efeotor, 1997).

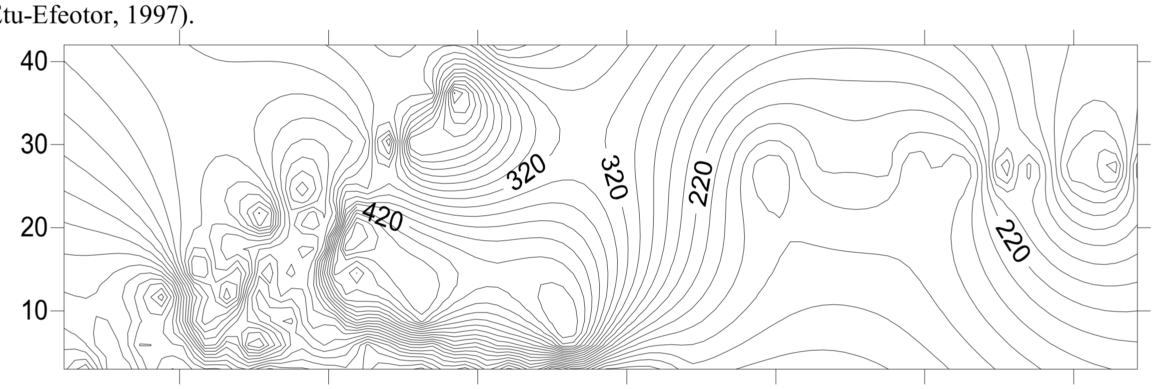


Fig 1 Iso resistivity Contour map of the study area

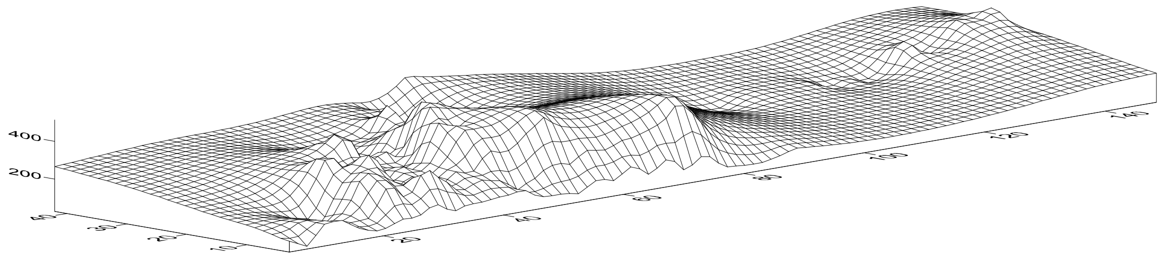


Fig.2 3D view to the depth of the bedrock of the study area

Fig 3 Photo view of the dumpsite

Methods

The geophysical surveys of the municipal waste dump have been based on the use of electrical resistivity imaging. A total of five 2-D imaging surveys were used for the study. The 2-D resistivity imaging uses a multi-electrode system with equal electrode spacing "a" ranging from 3-42m for successive measurement electrodes. A Werner-alpha configuration was adopted for the survey. The Werner-alpha configuration was adopted because of its good signal strength and its continuous coverage. The apparent resistivity values were calculated from the field resistance values using the equation:

$$\rho_a = 2\pi aR \qquad (1)$$

Where a = electrode spacing, R = field resistance value

The values of the apparent resistivities, electrode spacing and the x-locations were entered in a text file for processing using RES2DIV inversion soft ware (Loke, 1999). The software uses the least square inversion by Quasi -Newton method to achieve the apparent resistivity pseudosection (Loke and Barker, 1996). The iteration process is continued until the RMS error between the measured and calculated apparent resistivity was minimized. The ideal RMS error is less than 5% although this was not always obtainable. The pseudosection image of apparent resistivity serves as a means of portraying the measured field values. In each image, the horizontal (X) axis represents distance (m) along the surface and also spacing between electrodes while the vertical (Y) axis represents depth (m). Colour legends at the bottom of the image indicate either apparent resistivity or subsurface resistivity values. Figure 3 shows the arrangement of electrode for a 2D electrical survey and the sequence of measurements used to build a pseudo section.

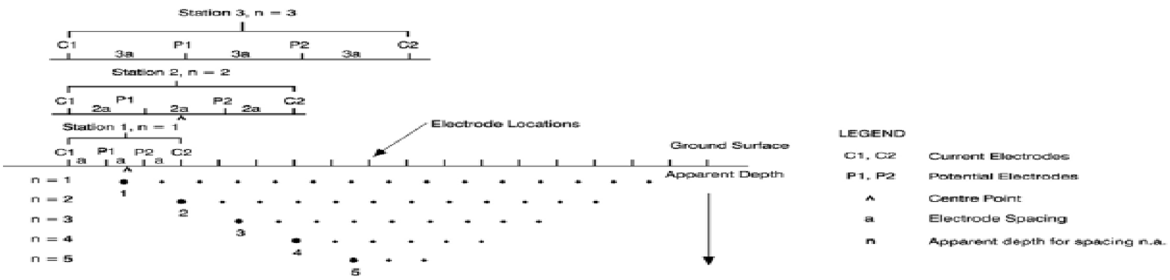
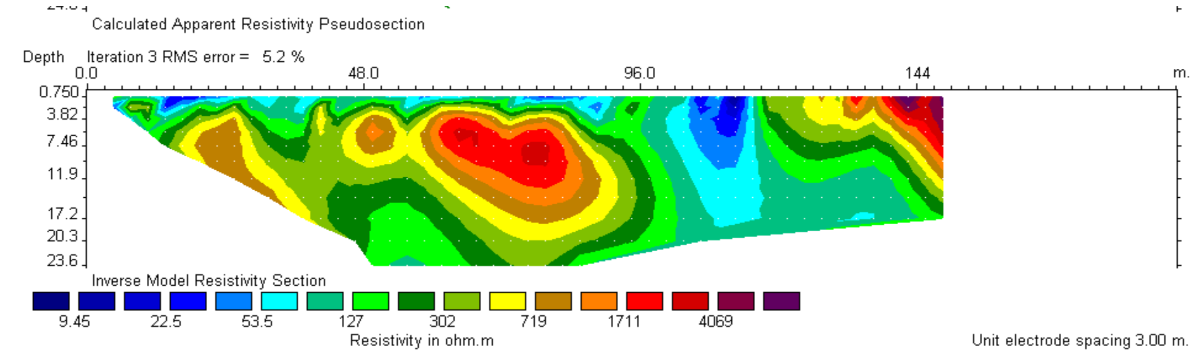


Fig. 4.0: The arrangement of electrodes for a 2-D electrical survey and the sequence of measurements used to build a pseudo section (Adapted from Loke, 1999)

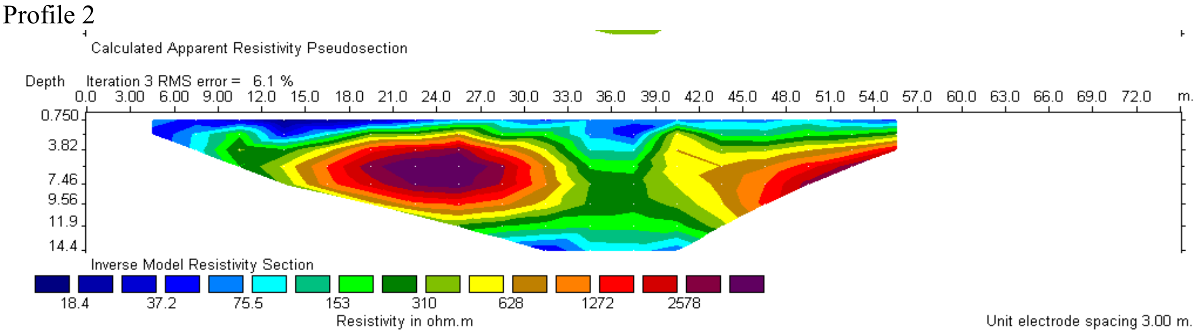
Results

A total of five 2-D imaging surveys (profile1 to 5) were used for this study. The interpretation of this 2D model provides the following results:

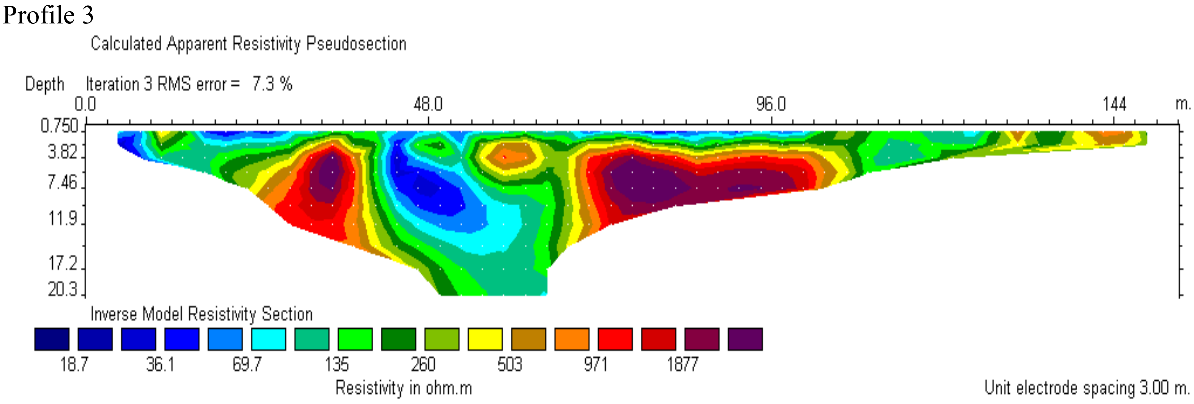
Profile1



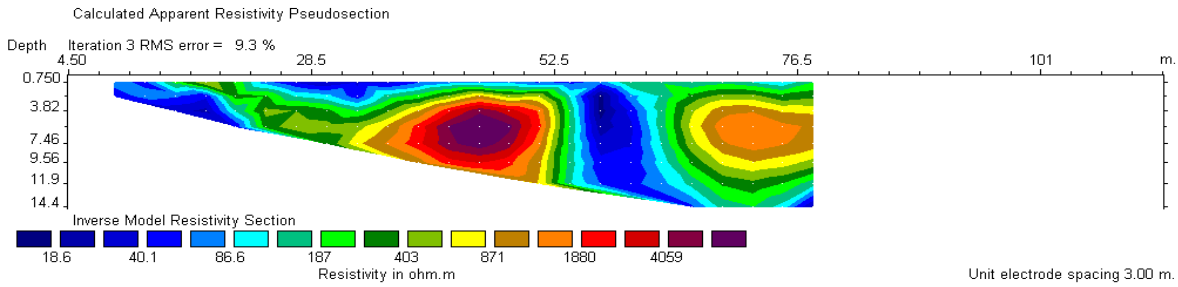
Profile 2



Profile 3



Profile 4



Profile 5

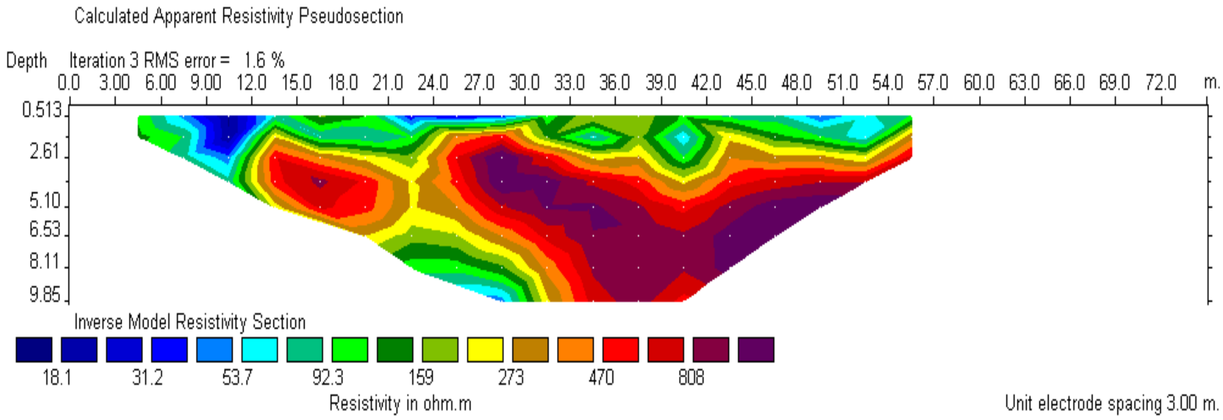


Fig. 5: Inverted resistivity sections of the profiles

The low resistive zones identified as (deep blue) having resistivity ranging from 9.45Ωm to 86.6Ωm were interpreted as leachate contaminant plumes containing dangerous pathogens, dissolved organic and inorganic constituents. These features manifests at depths ranging from 0.75m to more than 14.4m in the study areas and are observed to have seeped from surface points to depths exceeding 14.4m. This observed seepage is enhanced by the porous and permeable nature of the dominant sandy formations of the aquifer materials.

Layers of high resistivities (Green to Yellow) with resistivities ranging from 127Ωm to 871Ωm were also mapped and identified as porous and permeable sandy layers of varying grain sizes and moisture contents.

Finally, compounds of anomalously high resistivities between 808Ωm and 4069Ωm (Red to purple) suspected to be landfill gases (Ammonia, Methane, Sulphur(IV)Oxide, or Carbon(IV)Oxide) at depths exceeding 11.9m

Based on the above results of the 2-D imaging, no appreciable clay/shale impermeable was delineated and hence, the major lithological units are Sandy formation of varying grain sizes.

Conclusion

The results of the investigation of leachate plume contamination of the groundwater aquifer system using 2-D resistivity data is quite revealing. It shows that the surrounding groundwater around the landfill may have been contaminated. Weak zone identified in the imaging survey profile-1, 3 and -4 revealed that there is a chance for downward movement of leachate to the groundwater. With the aid of these tomograms, two distinct contaminant plumes had been mapped and identified with an intermediate resistivity layers within the study sites. They are:

(a) Highly conductive leachate contaminant plumes seeping from surface points to the aquifers; and

(b) Highly resistive gaseous contaminants that are probably due to landfill gases (Ammonia, Methane e.t.c) obtained as a result of the anaerobic decomposition of the landfill organic wastes.

The hydrogeologic features of the study areas indicated that contaminants derived from the waste disposal sites infiltrate through the vulnerable sandy aquifer and hence to the groundwater flow. This suggests that the soil and the groundwater system had been contaminated beyond the depth of 14.9m in the study areas.

Recommendation

There is a need to monitor leachate migration process to safeguard the groundwater resources. It is strongly recommended that a thorough study of any waste disposal site be done before any operation so as to know whether the aquifer is naturally sealed or not. And the presence of impermeable layer above the aquifer must be sought for before choosing any site for waste disposal.

The usage of the Ikheunero waste disposal site which is without a geologically impermeable ground like clay above the groundwater aquifer must be discouraged. More detailed integrated studies involving geochemistry, drilling of monitory boreholes, and chemical analysis of water samples are recommended to ascertain the nature of pollutants.

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