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Electrical Resistivity Tomography (ERT) for the Investigation of Erosion site in Oredide Village, Auchi in Etsako West LGA of Edo State, Southern Nigeria

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ABSTRACT: The Dipole –Dipole array was used for Constant Separation Traversing (CST) to investigate subsurface lithology in Oredide village, Auchi, Edo state with a view to determining the vulnerability or otherwise of the menace of erosion in the area. All the traverses were carried out with electrode spacing of 10 m with a spread of 200 m. The data was obtained using Pasi terrameter (16-GL) and processed with the Dipro software. The results revealed that the subsurface is underlain by the topsoil, lateritic sand, sand and sandstone. 2D results indicate topsoil with resistivity value range of 309 to 40130 Ωm within the depth range of 0 to 5 m. The second layer corresponds to sandy, lateritic sand, sand and sandstone having resistivity values ranging from 2186 to 60350 Ωm to a depth of 10.0 m. The third layer has resistivity values indicating lateritic sand, sand and sandstone layer with resistivity values ranging from 2186 to 60350 within the depth of 20 m. The fourth layer connotes lateritic sand, sand and sandstone to a depth of 30 m. The fifth horizon has resistivity values in the range of 585.2 to 35732.4 Ωm which is representative of sand and sandstone.The maximum depth imaged was 47.7 m.The inverted 2-D resistivity structure shows high resistivity distribution near-surface >1000 Ωm, which are indications of vulnerabilities to erosion in the study area with depth of scouring being 15 m.

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A more perfect model of the subsurface is a two-dimensional (2-D) model where the resistivity varies in the vertical direction, as well as in the horizontal direction along the survey line. In this case, it is taken for granted that resistivity does not change in the direction that is perpendicular to the survey line. In a number of cases, especially for surveys over elongated geological bodies, this is a logical assumption (Loke, 2001).However, at the present time, 2-D surveys are the most practical economic compromise between getting very perfect results and keeping the survey costs low (Dahlin and Loke, 1997).The resistivity of the 2D model is taken to vary both vertically and laterally along the survey line but fixed in the direction that is perpendicular to the survey line. The observed apparent resistivity values are often presented in pictorial form using pseudosection contouring (Figure 3) which gives a fairly accurate picture of the subsurface resistivity distribution. The shape of the contours depends on the type of configuration used in the investigation as well as the distribution of the true near-surface resistivity. The pseudosection plot serves as a beneficial guide for a detailed quantitative interpretation. Poor apparent resistivity measurements can easily be identified from the pseudosection plot. The pseudo-depth values are based on the sensitivity values or the Frechet derivatives for a homogenous half-space (Aizebeokhai, 2010).Two-dimensional (2D) geoelectrical resistivity imaging has been widely employed to map areas with fairly complex geology(Griffiths and Barker, 1993; Griffiths *et al*., 1990; Dahlin and Loke, 1998; Olayinka, 1999a; Olayinka and Yaramanci, 1999b; Amidu and Olayinka, 2006).Loke (2001) stated that the major inadequacy of the 2D geoelectrical resistivity imaging is that measurements taken with large electrode separation are often affected by the deeper sections of the near-surface as well as structures at a larger horizontal distance from the line of survey. It is most unique when the survey line is placed near a steep contact with the line parallel to the contact.Aigbogun *et al.*, (2020) used electrical resistivity tomography to investigate subsurface lithology in Auchi Polytechnic, Auchi, Edo state, Nigeria. The subsurface resistivity values ranged from 207 Ωm – 8357 Ωm. The results obtained from this survey classified the subsurface lithology into topsoil, clayey sand, sandy clay and sand. The maximum depth penetrated was 50 m. Oladele *et al.*, (2015) employed electrical resistivity imaging (2-D) using Wenner configuration on five (5) profiles measuring 180 m each to investigate the shallow subsurface electrical properties. Their survey was to unravel the possible reason(s) for structural instability resulting in the cracking and sinking of some buildings in the study area. Their results showed that anomalous low resistivity observed from the

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clayey materials in the stratigraphic make-up was responsible for the damages.

Nwankwo and Ugbena (2019) carried out a study to investigate the subsurface characteristics in a landslide area located in a community in Ohafia, Abia State by engaging electrical resistivity profiling using Wenner array configuration. The results of the survey delineated six (6) geoelectric layers with a depth of 55.0 m penetrated and recorded low resistivity values for the topsoil.The aim of this study therefore, is to determine the resistivity distribution, delineate the subsurface lithology of the study area using 2-D imaging with a view to identifying erosion prone areas and mitigating against them.

MATERIALS AND METHODS

*Location of the study area:*The geophysical survey was carried out in Oredide village with the following coordinates: Latitude 07° 04' 04.64''and Longitude 006° 15' 01.13''. These coordinates were obtained using Garmin 12 Global positioning system (GPS).
Actual site observation and information from existing geological maps classify surface sand of the study area and its environs as members of the Ajali formation (Alile *et al.,* 2008).

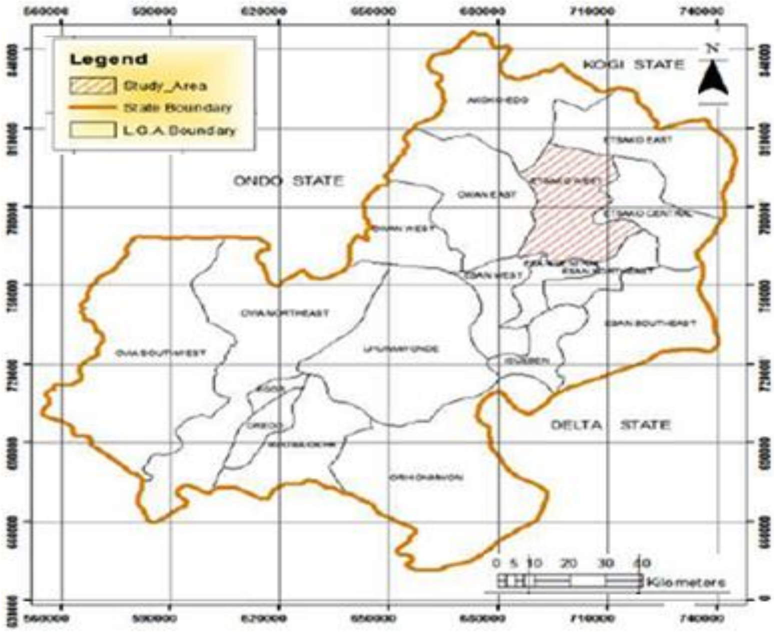

Fig. 1: Edo State showing Etsako LGA (Produced from Arcmap 10.1.2013)

a

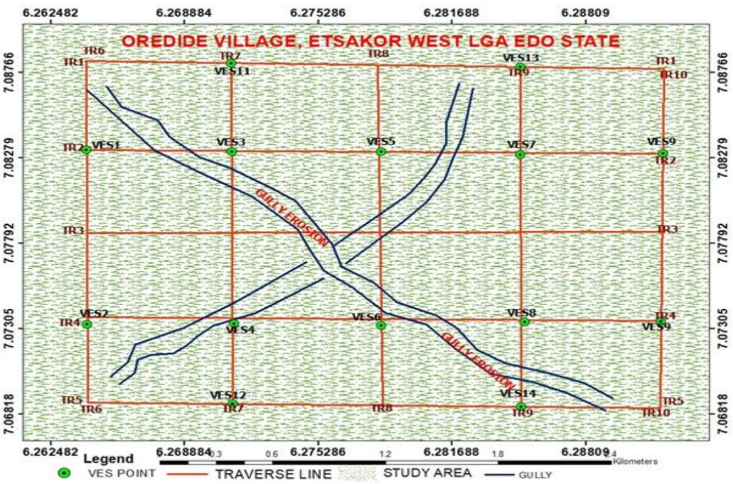

Fig2: Base map of Oredide village

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*Two dimensional (2D) Electrical Resistivity Imaging (ERI) Via Dipole-dipole Array:*Two-dimensional (2D) geoelectrical resistivity imaging can be achieved by integrating the techniques of vertical electrical sounding with that of electrical profiling. It involves apparent resistivity measurements from electrodes placed along a line using a range of different electrode spacings and midpoints. The method is repeated for as many combinations of current and potential electrode positions as defined by the survey configuration. 2D resistivity imaging can be seen as continuous vertical electrical sounding (CVES) in which a number of VES conducted in a grid are merged together or as a combination of successive profiles with increasing electrode separation. Two-dimensional (2D) resistivity surveys are usually carried out using large numbers of electrodes connected to multi-core cables. For a system with limited number of electrodes, the area covered by the survey can be extended along the line of survey using the roll-along technique (Dahlin and Bernstone, 1997). This can be achieved by moving the cables past one end of the line by several units of electrode separation, after completing a sequence of measurements.The 2D electrical resistivity study includes the utilization of PASI 16GL model Terrameter (resistivity meter) which is upheld by an outer battery (12 V, 60 Ah Battery), one Global Positioning System (GPS) for taking the directions of the investigation territory. An aggregate of ten (10) 2D crosses were obtained, as it appears in Figure 2, in a square grid design utilizing the dipole-dipole exhibit arrangement. This cathode setup was appropriate for steady division information obtaining, so numerous information focuses can be recorded at the same time for every current infusion. Approximations were made at successions of cathodes at n=1, n=2, n=3, n=4 and n=5 cross line utilizing four (4) anodes separated at 10 m with between navigate dividing of 50 m from one another with maximum length of 200 m each.Ten (10) traverses were profiled in the study area using the 2D electrical resistivity tomography. The Dipole - Dipole configuration was adopted in preference to the other configurations because of its high sensitivity to horizontal changes in resistivity and wider horizontal data coverage. The electrodes were arranged with a constant spacing of 10m.The data obtained were transferred to the computer for processing and inversion using DIPROfWin Software 4.01. The software inverts the data using the smoothness-constrained least-squares inversion algorithm to achieve stable results. The program uses the active constraint balancing (ACB) method which accounts for the use of variable Lagrangian multiplier at each of the parameterized blocks of the model during the inversion process to enhance both resolution and stability (Aminu*et al.*, 2014)

RESULTS AND DISCUSSION

The results are given in a colour coded format consisting of the inverted 2D resistivity tomography of Oredide. The horizontal scale on the image is the lateral distance while the vertical scale is the depth and both are in metres. A maximum spread of 180 m with the corresponding depth of 30 m was investigated and modeled on the profiles as shown in Figure 3.

*2-D Resistivity Image along Traverse 1-10:*The 2D resistivity section along traverse 1 in Oredide is presented in Figure 3a. Lateral distance of 200 m was covered and a depth of 30 m was imaged. Resistivity values vary from 5227 – 217741 Ωm across the traverse (Figure 3). Three resistivity structures are delineated which are indications of sand, lateritic sand and sandstone. The resistivity of the sand varies from 5227 – 7911 Ωm and widely distributed along the traverse. The lateritic sand varies in resistivity from 13747 – 18120 Ωm and occurs at lateral distances; 0 – 40 m (from the surface to a depth of 30 m), 70 – 110 m (enclosing a sandstone structure from 5 – 30 m depth) and 110 – 158 m (as a near-surface structure). The sandstone occurs as isolated resistivity structures at lateral distances 80 – 105 m and 120 – 148 m respectively. The high near-surface resistivity values of the resistivity structures are indicative of dry and unconsolidated geologic earth materials which are highly erodible (Karim and Tucker-Kulesza, 2018; Karim *et al.*, 2019). The near-surface along this traverse is thus suspected to be prone to deep seated erosion due to deep distributions of the high resistivity values. The sandstone, due to its localized and consolidated nature may be less erodible along the traverse (Figure 3).

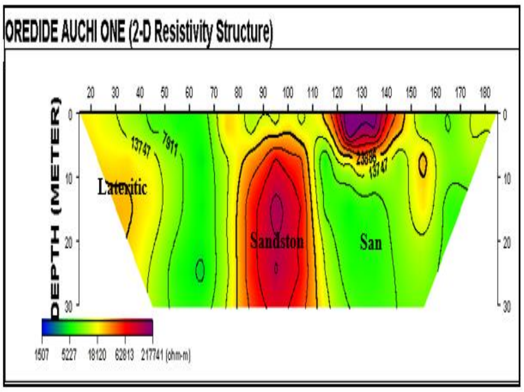

Fig 3: 2D electrical resistivity section along Traverse 1

In this study, the 2D resistivity tomography has succeeded in revealing the lateral and vertical subsurface information with varying resistivity distribution values. The results obtained from vertical electrical sounding (VES) done in the same location signify topsoil with resistivity values ranging from 632.7 to 32804.6 Ωm within the depth range of 0.6 to 0.9 m (Babaiwa and Airen, 2021). The 2D results indicate topsoil with resistivity value range of 309 to 40130 Ωm within the depth range of 0 to 5 m. Both results show that the topsoil is composed of shaly sand, lateritic sand and sand. The second layer on all the geoelectric sections is representative of lateritic sand

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and sand having resistivity values ranging from 1741.1 to 14548.6 Ωm and depth range of 2.2 to 14.9 m which corresponds to the 2D results signifying sandy lateritic sand, sand and sandstone having resistivity values ranging from 2186 to 60350Ωm to a depth of 10.0 m. The third geoelectric layer has resistivity values in the range of 3820.1 to 60494.3 Ωm within the depth range of 8.1 to 24.8 m which also corresponds with the 2D results indicating lateritic sand, sand and sandstone layer with resistivity values ranging from 2186 to 60350 within the depth of 20 m. The fourth geoelectric layer connotes lateritic sand, clayey sand and sand having resistivity values ranging from 792.3 to 16973.4 Ωm within the depth range of 19.7 to 57.4 m which corresponds with the 2D results representing lateritic sand, sand and sandstone to a depth of 30 m. The fifth horizon has resistivity values in the range of 585.2 to 35732.4 Ωm which is representative of sand and sandstone. The depth range could not be determined due to current termination within this region.

*Conclusion:*The study showed that erosion with intense scouring is expected because of the high resistivity values near the surface. The scouring depth ranges from 10 – 15 m.It has been established from this study, that it is possible to use geoelectrical method to identify erosion prone areas, so that those in authority can avail themselves of the information provided to urgently take steps that will curb or nip this menace in the bud.

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REFERENCES

Aigbogun, CO; Babaiwa, DA and Mujakperuo, BJO (2020). Application of 2-Dimensional Tomography to Investigate Subsurface Lithology in Auchi Polytechnic, Auchi, Edo State. *Nig. J. Tech.*39(3). 925–931

Babaiwa, DA and Airen, OJ (2021). Characterizing Soil Erosion Potential Using Vertical Electrical Sounding (VES) in Oredide Village, Auchi in Etsako LGA of Edo State, Southern Nigeria. (Accepted).

Aizebeokhai, AP (2010). 2D and 3D Geological Resistivity Imaging: Theory andField Design. *Sci. Res. and Essays.*5 (23). 3592 – 3605.

Alile, O; Amadasun, CVO and Evbuomwan, AI (2008). “Application of verticalelectrical sounding method to decipher the existing subsurface stratification and groundwater occurrence status in a location in Edo North of Nigeria”. *Inter. J. Phys. Sci.* 3 (10). 245-249.

Amidu, S;Olayinka, AI (2006). “Environmental assessment of sewage disposalSystems using 2D electrical resistivity imaging and geochemical analysis: A case study from Ibadan, Southwestern Nigeria”. *J.Environ. Engineer.Geosci.* 7(3), pp. 261-272.

Aminu, MB,Akande, TM;Ishola, OA (2014). 2D Geoelectric Imaging of the Uneme-Nekhua Fracture Zone. *Inter. J. Geophysics.* 1-8

Dahlin, T and Bernstone, C (1997). A roll-along technique for 3D resistivity dataacquisition with multi-electrode arrays. *Proceedings of SAGEEP’97*, Reno, Nevada, pp. 927-935.

Dahlin T;Loke, MH (1997). Quasi-3D resistivity imaging-mapping of three-Dimensional structures using two-dimensional DC resistivity techniques.*Proceedings of the 3rd Meeting of the Environ. Eng. Geophy. Soc.*, pp. 143-146.

Dahlin, T;Loke, MH (1998). Resolution of 2D Wenner resistivity imaging asassessed by numerical modeling. *J ApplGeophys 38*(4), pp. 237–248.

Griffiths, DH; Turnbull, J;Olayinka, AI (1990). Two-dimensional resistivitymapping with a complex controlled array. *First Break*, 8(4). 121-129.

Griffiths, DH; Barker, RD (1993). Two dimensional resistivity imaging andmodelling in areas of complex geology. *J. Appl. Geophy.* 29: 211- 226.

Karim, MZ; Tucker-Kulesza, SE (2017).Two-dimensional soil erosion profileusing electrical resistivity surveys. *Geotech Frontiers*; ASCE, Reston, VA.

Karim, MZ; Tucker-Kulesza, SE (2018).Predicting soil erodibility usingelectrical resistivity tomography. *J.Geotech.Geoenviron.Eng*; 144(4), 04018012

Karima, MZ, Tucker-Kuleszaa, SE; Bernhardt-Barry, M (2019). Electricalresistivity as a binary classifier for bridge scour evaluation. *Trans Geotech*, 19. 146-157.

Loke, MH (2001).*Electrical Imaging Surveys for Environmental and EngineeringStudies: A Practical Guide to 2D and 3D surveys*.

Nwankwo, CN and Ugbena, GK (2019). Electrical Resistivity and Seismic RefractionMethods of Investigating a Landslide Area: A case Study of Alu Community, AbiaState, Nigeria". *World Sci.News.* 129. 135 – 146.

Oladele, S., Oyedele, KF;Dinyo, MO (2015). Pre-construction geoelectrical andgeotechnical assessment of an engineering site at Alapere/Agboyi, Lagos, Nigeria". *Ife J. Sci.* 17(3). 543-552.

Olayinka, AI (1999a). Advantage of two-dimensional geoelectrical imaging forGroundwater prospecting: case study from Ira, southwestern Nigeria. *Water Res. J. Nig. Assoc.Hydrogeol.* 10. 55-61.

Olayinka, AI;Yaramanci U (1999b). Choice of the best model in 2-D geoelectricalimaging: case study from a waste dump site. *Eu. J. Environ. Eng. Geophy.*3: 221-244.