

Application of Geophysical Techniques in Investigating Soil Characteristics for Oil Palm Plantation Suitability in Iyede, Delta State, Nigeria

Ogheneovo Akpoyibo

Department of Pure and Applied Physics, Faculty of Science, Dennis Osadebay University, Asaba, Delta State

*Corresponding author's email: akpofavo@gmail.com Phone: +2348064393632

ABSTRACT

Ten Vertical Electrical Soundings (VES) and the Schlumberger simple array technique were used to analysis the subsurface changeable conditions of the oil palm plantation at Iyede, Delta State, Nigeria. Low resistivity values (34.7–123.0 Ωm) for VES 2, 4, 6, and 7 were found using the ABEM SAS 1000 Terrameter. These results indicate a variable high moisture level, loamy soil content, fine soil texture, and soil rich in nutrients that are favorable for oil palm germination and growth in the region. The formation of coarse-medium soils were indicated by areas with sporadic greater resistivity surpassing 140 Ωm (142.6-391.6 Ωm), which may have hampered root penetration and water retention for VES 1, 3, 5, 8, 9, and 10. Analysis of the Iyede soils revealed a pH range from mildly acidic (6.8) to acidic (4.7) and consistently low nitrogen content (0.16% to 0.40%). Potassium levels varied between 0.11 to 0.61 mg/kg, while available phosphorus varied significantly from 10.81 mg/kg to 46.89 mg/kg. Overall, potassium content were low (absolutely lesser than 78 mg/kg) across all locations, below the threshold required for optimal oil palm growth. Magnesium was not a limiting factor for oil palm development at the site studied, as exchangeable magnesium levels were consistently high (36–108 mg/kg). Plant growth was positively influenced by calcium (3.45 to 8.20 mg/kg) and sodium (0.42 to 1.92 mg/kg). The use of appropriate fertilizers can further support healthy palm oil development and enhance fruit production in some oil palm farms in the study area.

Keywords:

Assessment,
Geophysical,
Iyede,
Oil palm,
Soil.

INTRODUCTION

Crop growth can be influenced by climatic variables such as temperature, soil nutrients, sun radiation, humidity, and moisture content, as well as good land management techniques. The appropriateness of soil for the large-scale development of cash crops like oil palm depends on a number of physical characteristics, including pH, organic matter, moisture, effective depth, texture, nutrient status, drainage, and soil structure (Ganiyu et al., 2020). Determining the rooting depth and knowing how soil moisture content varies with depth can give a thorough grasp of how annual and cash crops compete for soil water. Plant development is greatly influenced by roots, which also perform a number of additional tasks, including absorbing water and nutrients from the soil, storing organic matter, synthesizing growth chemicals, and more (Ganiyu et al., 2020). Therefore, a farming system's ability to supply water at an appropriate effective depth for healthy plant growth is crucial. However, understanding the soil moisture content and keeping an

eye on its variations are crucial for ensuring a sufficient supply of water for crop growth on farmed farms. Due to its substantial contribution to both home and industrial applications, the processing of palm oil is of global economic relevance (Jeressa and Okolie, 2025). The most consumed/utilized vegetable oil in the world, which is palm oil is made from oil palm trees fruit, which are mostly found in tropical areas. It is well-known for having a higher production per hectare than other crops for oil (Jeressa and Okolie, 2025).

Because of its effectiveness, it is a vital supply of edible oil for many nations, contributing significantly to both economic growth and food security (Chiriaco et al., 2024). For the management of oil palm plantations, geophysical methods are essential. By evaluating soil characteristics and groundwater accessibility, these techniques aid in choosing a site and guarantee that new plantations are situated in appropriate locations (Akpoyibo and Vwawware, 2024). In order to facilitate managing soils and irrigation strategy, geophysical

surveys also assist in mapping soil characteristics such as texture, amount of moisture, and compaction (Okolie and Akpoyibo 2012; Vwavware et al., 2024a; Oghenevovwero et al., 2025; Akpoyibo et al., 2025; Ogholaja et al., 2025). This data is essential for determining regions with inappropriate soil conditions and optimizing oil palm tree yield.

Delineating underlying lithology for groundwater resources and evaluating aquifer characteristics are critical tasks for geophysical surveys (Akpoyibo et al., 2022, 2023; Vwavware et al., 2024b; Akpoyibo, 2025). A non-destructive (friendly) geophysical technique for tracking soil water kinetics/dynamics from the surface to an efficient depth and above without disturbing the soil is the electrical resistivity approach (Akpoyibo et al., 2022). Many researchers have used the electrical resistivity survey, particularly the soundings method, for agricultural purposes on grown arable harvest (oil palm) farms to forecast the behaviors of the root development structures of fruit from oil palm crops for an efficient nutrient and soil water use. This method is inexpensive, quick, and accurate for effortless forecasting of physical characteristics of soil. In order to identify the most promising sites for oil palm field cultivation in Iyede, this study intends to evaluate and characterize the soil's surface and underneath conditions via geophysical measurements and analysis of soil.

Location and Geology of Iyede Area

Iyede, which is in Delta State's Isoko North LGA, is an aspect of the Niger Delta Basin. It can be found between latitudes $5^{\circ}23'N$ ($6.42^{\circ}N$) and $5^{\circ}33'N$ ($6.52^{\circ}N$) and longitudes $6^{\circ}4'N$ ($6.04^{\circ}E$) and $6^{\circ}14'N$ ($6.24^{\circ}E$) (Figure 1) and is distinguished by a level, featureless plain that

gently slopes (pitch) seaward. It has been established that the blessed Delta State (Niger Delta) contains substantial oil and gas deposits. The geology of the Iyede area, which is located in the Niger Delta region, has been thoroughly studied in a number of studies (Akpoyibo et al., 2022; Vwavware et al., 2024a, 2024b; Akpoyibo and Vwavware, 2024; Akpoyibo, 2025; Akpoyibo et al., 2025; Ogholaja et al., 2025).

Iyede's primary economic activity, aside from gas, and oil production, is agricultural, which includes fishing, yams, plantains, palm oil, and cassava farming. The Benin Formation, which comprises a mix of continental and riverine sands and gravels, is the main layer that underlies the region. Viewable older formations like the Agbada and Akata Formations, which are found in the subsurface (Anomohanran et al., 2023), are covered by this describable formation, which is a sedimentary fill in the Niger Delta. Other papers, like Akpoyibo et al., 2023, 2025; Molua et al., 2024, and Akpoyibo, 2025, give clear summaries of typical and distinctive parts of these explainable formations. Dark gray sands (beach) and shale make up the Akata Formation's subsurface, which is mostly made up of coastal shale and measurable sand beds (deposits). This structure (division) is expected to have a thickness of around 7 kilometers (Esi et al., 2023; Ogholaja et al., 2025). The higher or top Agbada Formation is a succession of mostly sandstone and several shale dunes, according to Atakpo and Ayolabi (2009). It has shale at the bottom, while the upper part is primarily made up of sand with a small quantity of shale and has a thickness of almost 3.7 kilometers. The upper portion of Benin is covered in thin layers of laterite of various thicknesses in a number of locations, despite being considerably more open close to the coast.

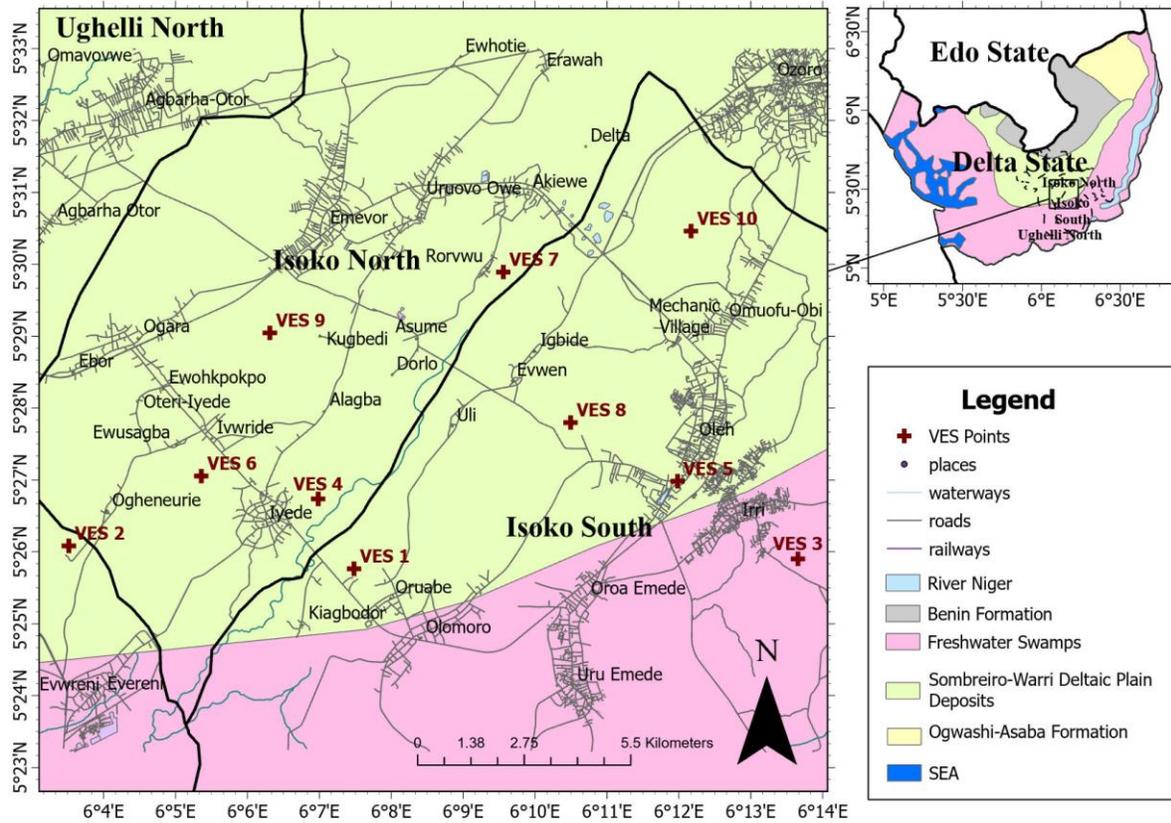


Figure 1: Base map showing Iyede VES points and others

MATERIALS AND METHODS

Geophysical Material and Analysis

It made use of VES and the Schlumberger sequence array. At ten distinct sites, we acquired and documented sounds (signals). The VES stations are evinced in Figure 2-11. The ABEM SAS 1000 transportable Terrameter, which features an inbuilt booster for greater and deeper depth, was used to collect the required data and the current terminals (AB) were separated by 1000 meters. Using quantitative computer processing and the Win Resist Software, which was created following Vander Velpen's (2004) research and the findings (results) from the electrical resistivity inquiry, the real resistivity and thickness of layers were ascertained (Table 1) with maximum RMS error of 5.4 from the generated iterated curves. These first-order variables (resistivity ρ_i and thickness h_i) were applied to create another second-order geoelectric variable, also called the Dar Zarrouk parameter, known as the total or overall longitudinal unit (section) conductance (S) (Atakpo, 2013; Esi and Akpoyibo, 2023; Ogheneovovwero et al., 2025). The total determined longitudinal component unit conductance is

$$S = \sum_{i=1}^n \frac{h_i}{\rho_i} \tag{1}$$

Thus, the overload protection capacity was established using the entire longitudinal division (section)

conductance figures (values) in the following equation (Henriet, 1976; Atakpo, 2013; Akpoyibo, 2025). The improved longitudinal conductance (mhos)/protective capacity categories by Akpoyibo (2025) were used to evaluate the protective capacity. These ratings are as follows: >10 = Excellent/distinction; 5 to 10 = Very Good; 0.7 to 4.9 = Good; 0.2 to 0.69 = Moderate; 0.1 to 0.19 = Weak; and <0.1 = Poor.

Laboratory Evaluation of Soil

For laboratory examination, twelve (12) sample soils were taken from every profile at depths between 0–14 cm and 14–28 cm. Soil augers and core samplers were used to gather soil samples. Before being examined in a soil testing facility, the obtained soil samples were allowed to air dry at room (moderate) temperature and then screened through a 2 mm sieve. The following physical and observed chemical characteristics of the resultant soil samples were examined: The Bray P-I method was used to assess the amount of available phosphorus (P), the macro-Kjeldahl method was used to calculate the amount of total nitrogen (N), and a pH meter was used to measure the pH of the soil in a 1:2 soil-to-water suspension (Oviasogie and Okoro, 2020). NH₄OAc buffered at pH 7.0 was used to remove exchangeable bases (Chukwunwike et al., 2024). A flame photometer was carefully used to

decisively measure sodium (Na) and potassium (K), while an atomic absorption spectrophotometer was utilized to measure quantifiable exchangeable calcium (Ca) and magnesium (Mg).

RESULTS AND DISCUSSION

The results of the probe are shown using sounding curves and a protective capacity image (map). Electrical

resistivity shapes of the AKH, AAK, QHA, HKH, and KQH types were discovered in five layers (Figure 2-11). Based on the longitudinal conductance values, a protective capacity map of the area was produced using SURFER 8 (2002) Terrain and 3D Surface simulation software (Figure 12).

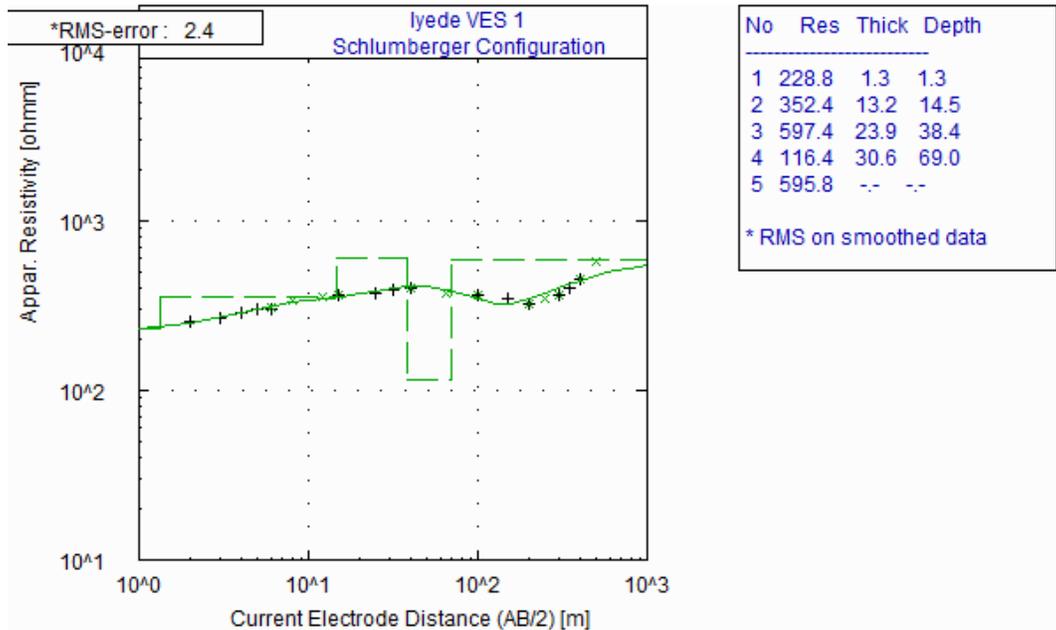


Figure 2: Typical AKH curve graph type (VES 1).

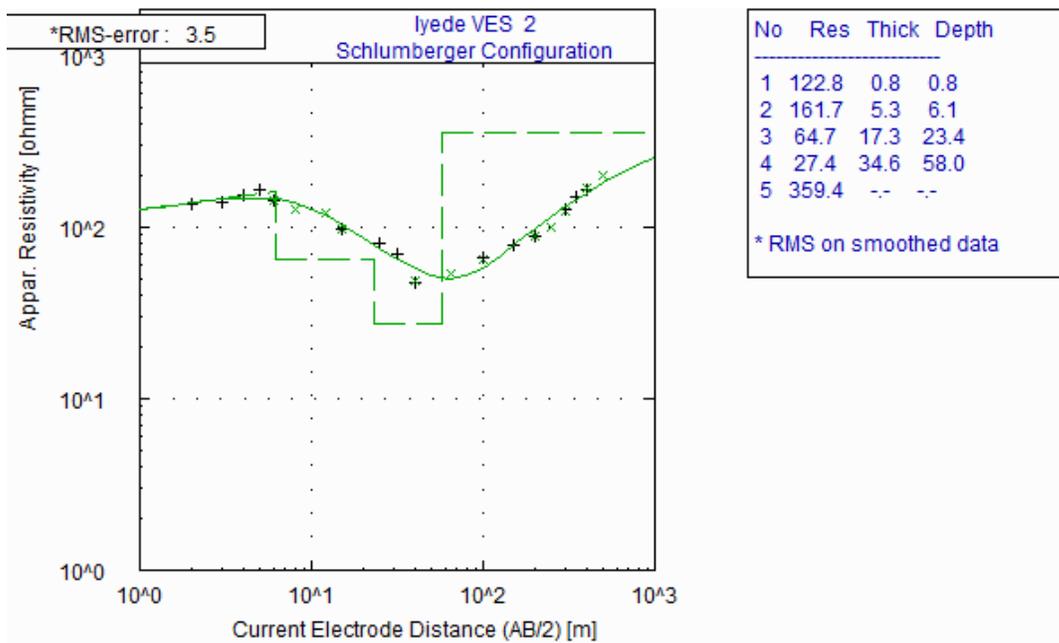


Figure 3: Typical KQH graphical curve type (VES 2).

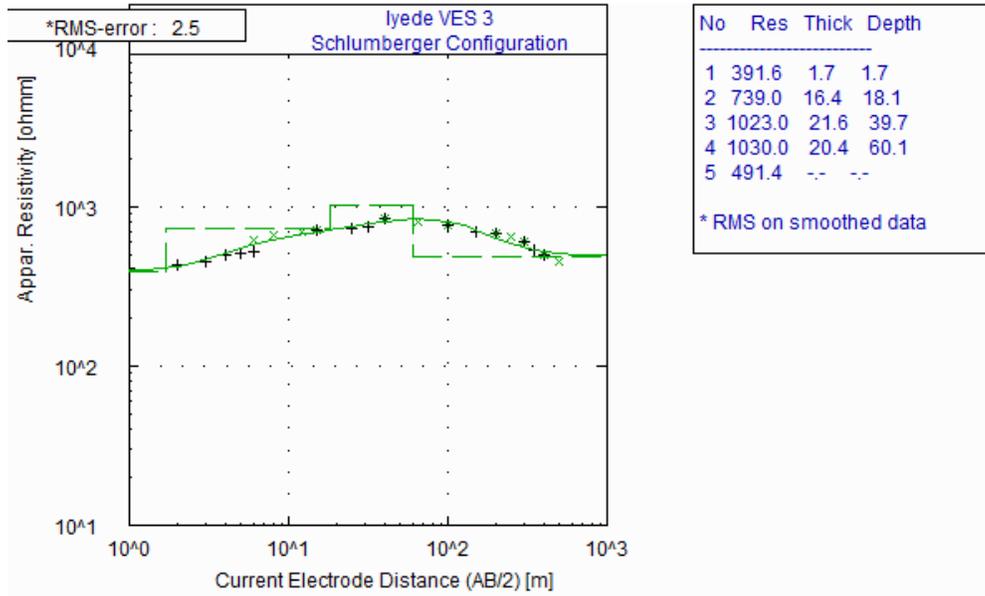


Figure 4: Typical Iyede AAK curve type (VES 3).

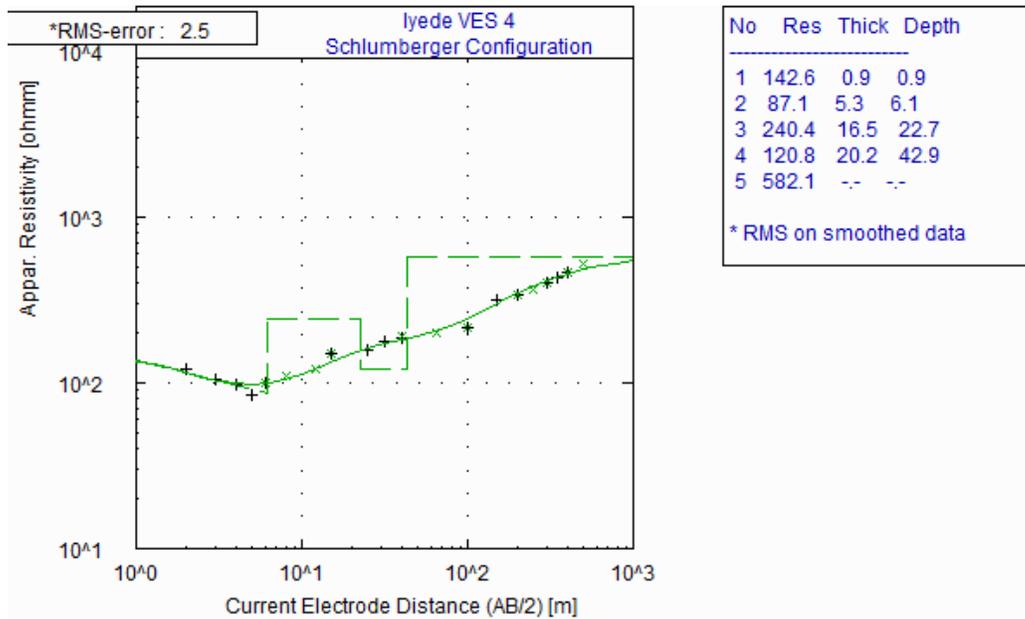


Figure 5: Typical HKH curve configuration type (VES 4)

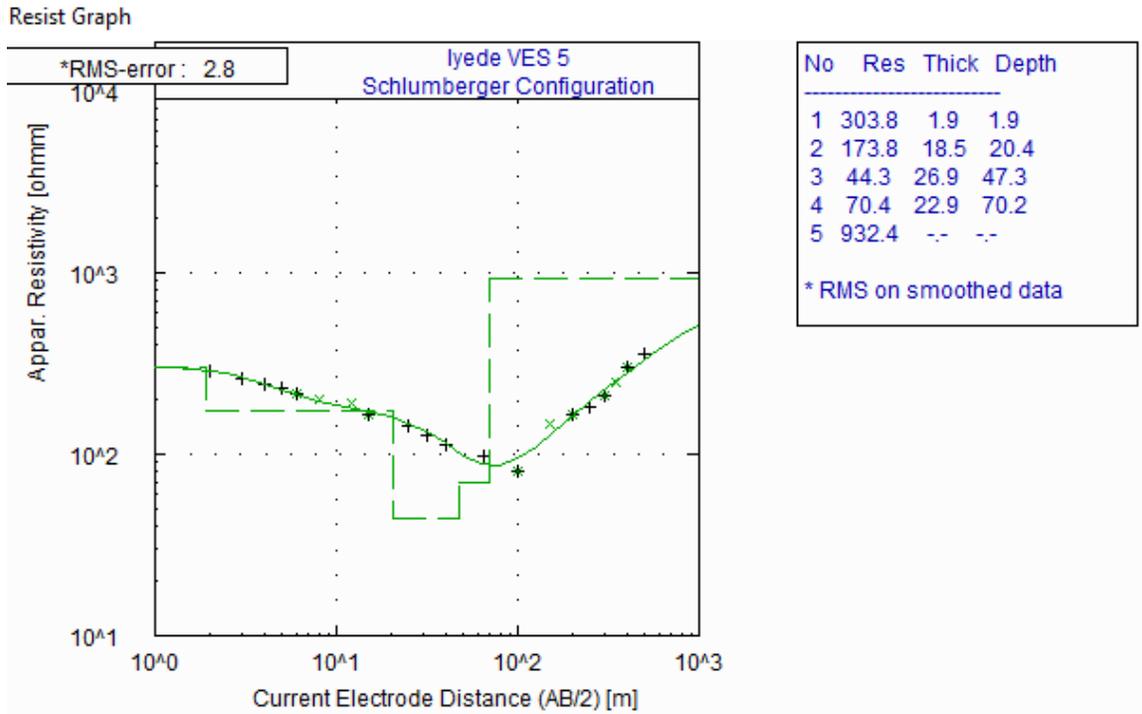


Figure 6: Typical QHA bend type (VES 5).

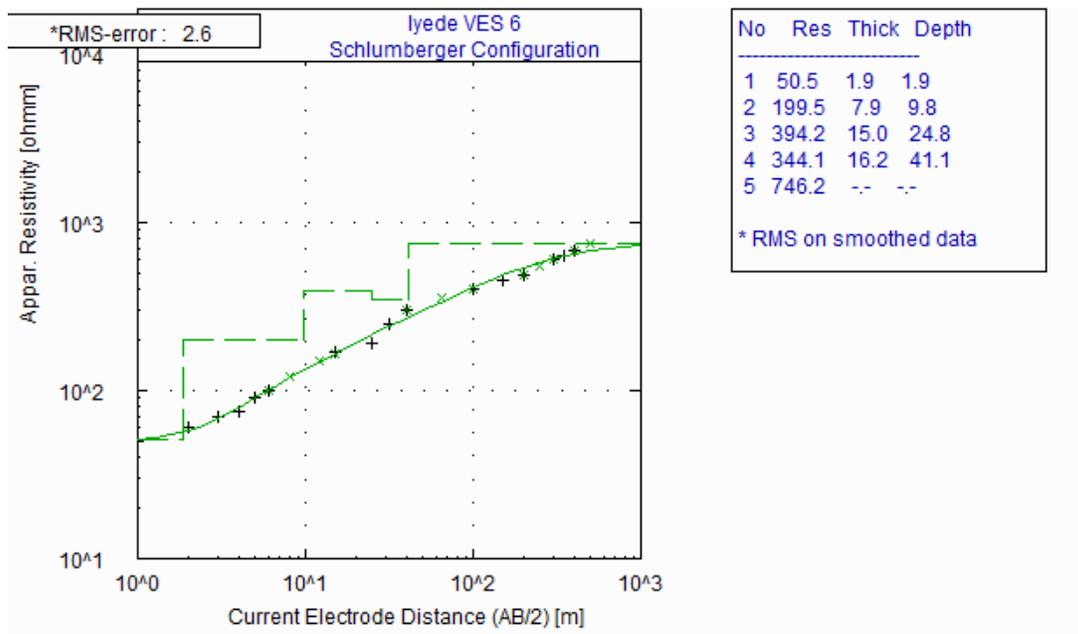


Figure 7: Typical AKH iterated curve type (VES 6).

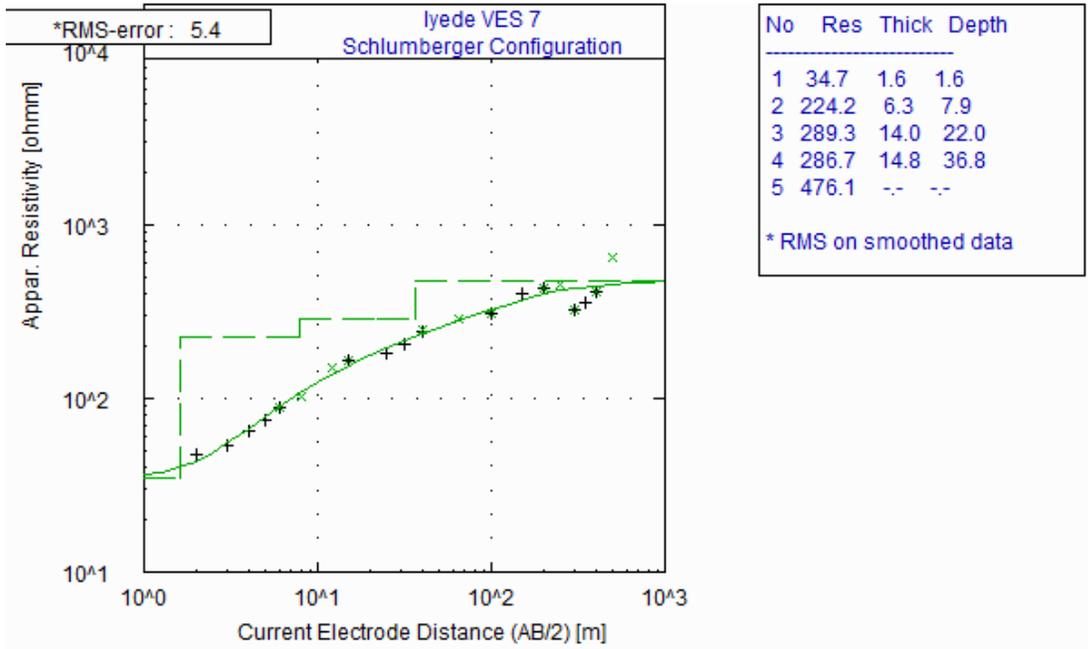


Figure 8: Typical AKH curved shape type (VES 7).

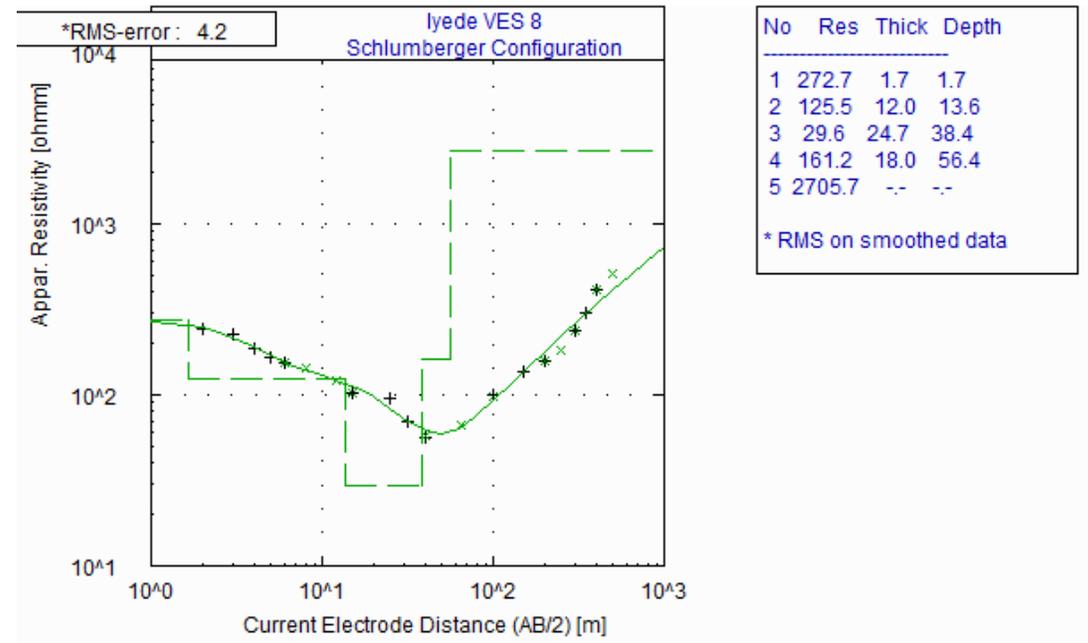


Figure 9: Typical QHA bend type (VES 8).

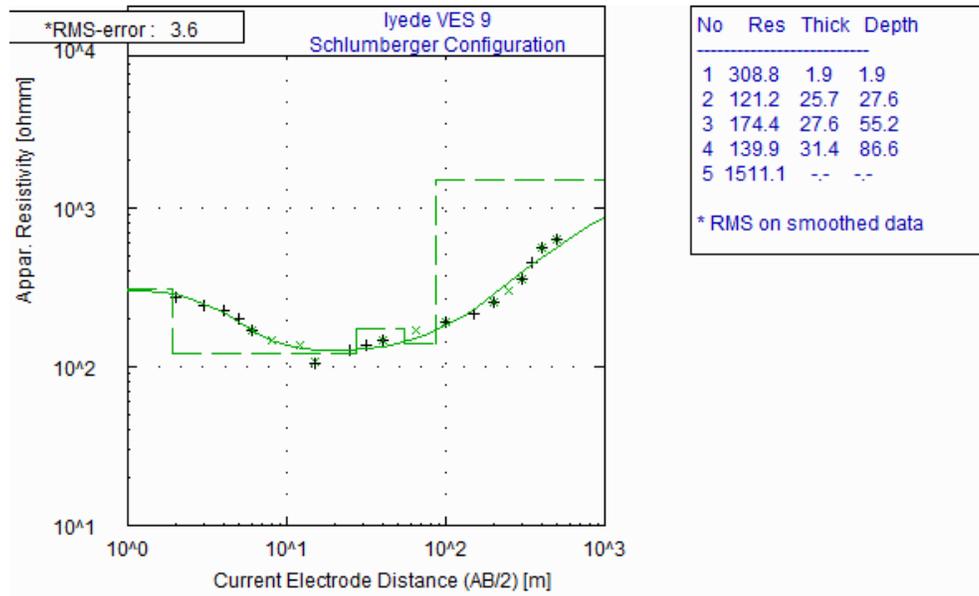


Figure 10: Typical HKH shape type (VES 9).

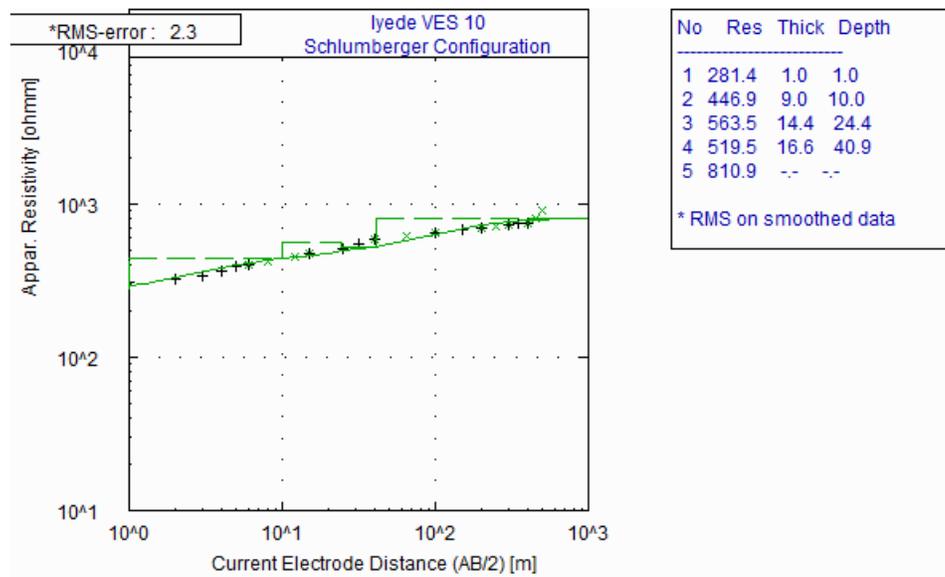


Figure 11: Typical AKH formation curve type (VES 10).

Table 1: Longitudinal conductance readings and VES-interpreted values

VES	Strata	Resistivity	Thickness	Lithology	$S = \sum_{i=1}^n \frac{h_i}{\rho_i}$	Protecting Longitudinal Conductivity	Strata
VES 1	1	228.8	1.3	Topsoil	0.005682	0.086508	
	2	352.4	13.2	Laterite	0.037457		
	3	597.4	23.9	Fine sand	0.040007		
	4	116.4	30.6	Sandy clay	0.262887		
	5	595.8	----	Fine sand			
VES 2	1	122.8	0.8	Topsoil	0.006515	0.392364	
	2	161.7	5.3	Laterite	0.032777		
	3	64.7	17.3	Clay	0.267388		
	4	27.4	34.6	Clay	1.262774		
	5	359.4	----	Fine sand			

VES	Strata	Resistivity	Thickness	Lithology	$S = \sum_{i=1}^n \frac{h_i}{\rho_i}$	Protecting Longitudinal Conductivity	Strata
VES 3	1	391.6	1.7	Topsoil	0.004341	0.016863	
	2	739.0	16.4	Laterite	0.022192		
	3	1023.0	21.6	Fine sand	0.021114		
	4	1030.0	20.4	Medium sand	0.019806		
	5	491.4	----	Fine sand			
VES 4	1	142.6	0.9	Topsoil	0.006311	0.075754	
	2	87.1	5.3	Clay	0.060850		
	3	240.4	16.5	Fine sand	0.068636		
	4	120.8	20.2	Sandy clay	0.167219		
	5	582.1	----	Fine sand			
VES 5	1	303.8	1.9	Topsoil	0.006254	0.261302	
	2	173.8	18.5	Laterite	0.106444		
	3	44.3	26.9	Clay	0.607224		
	4	70.4	22.9	Clay	0.325284		
	5	932.4	----	Medium sand			
VES 6	1	50.5	1.9	Topsoil	0.037624	0.040579	
	2	199.5	7.9	Laterite	0.039599		
	3	394.2	15.0	Fine sand	0.038052		
	4	344.1	16.2	Fine sand	0.047079		
	5	746.2	----	Medium sand			
VES 7	1	34.7	1.6	Topsoil	0.046110	0.043556	
	2	224.2	6.3	Laterite	0.028100		
	3	289.3	14.0	Fine sand	0.048393		
	4	286.7	14.8	Fine sand	0.051622		
	5	476.1	----	Fine sand			
VES 8	1	272.7	1.7	Topsoil	0.006234	0.261994	
	2	125.5	12.0	Laterite	0.095618		
	3	29.6	24.7	Clay	0.834460		
	4	161.2	18.0	Sandy clay	0.111663		
	5	2705.7	----	Coarse sand			
VES 9	1	308.8	1.9	Topsoil	0.006153	0.150226	
	2	121.2	25.7	Laterite	0.212046		
	3	174.4	27.6	Sandy clay	0.158257		
	4	139.9	31.4	Clayey sand	0.224446		
	5	1511.1	----	Coarse sand			
VES 10	1	281.4	1.0	Topsoil	0.003554	0.020301	
	2	446.9	9.0	Laterite	0.020139		
	3	563.5	14.4	Fine sand	0.025555		
	4	519.5	16.6	Fine sand	0.031954		
	5	810.9	----	Medium sand			

Longitudinal Unit Conductance Map and Lithologic Identification

Five geoelectric strata: topsoil, laterite, clay-based sand, sandy clay, both clay and sand (fine to coarse-grained) were outlined from the lithologic sections. The topsoil's thickness fluctuates visibly between 0.8 and 1.9 m, and its resistivity measurements viewable range from 34.7 to 391.6 Ωm . Because it is a close surface area zone, this layer provides important information that is essential for evaluating potential and feasible palm oil plantation cultivations. The clayey, loamy soil, organic or biological matter, and high moisture content found in VES 2, 6, and 7 top soils are essential for the production of palm oil

because they affect the development of roots and uptake of nutrients.

Considering the soil can affect the soil's fertility and retention of moisture due to its small resistivity numbers which help oil palm establishment of roots, VES 2, 6, and 7 locations (122.8 Ωm , 50.5 Ωm , and 34.7 Ωm , respectively) can be referenced for plantation oil palm farming and growth. Comprising clay, laterite, and sand, the second geoelectric layer is 5.3 to 25.7 m deep and has resistivity described values between 87.1 to 739.0 Ωm of certain less conductive elements (partially decreasing moisture content). Sands and compacted soils make up this layer's more densely and dry stratum, which is

essential for assessing water penetration and drainage, which are critical for the growth and production of palm oil.

Only the good soil (87.1 Ωm , 125.5 Ωm , and 121.2 Ωm) in the second layer of VES 4, 8, and 9 describes the vital character of the soil with necessary nutrients. Because of the inadequate soil nutrients and the coarse form of those ingredients, VES 1, 2, 3, 5, 6, 7, 9, and 10 of the second layer are not ideal for good oil palm produce. It is also not advisable to use such sounding places for adequately and productive palm oil produce.

The third studied stratum, which has resistivity extent values between 29.6 and 1023.0 m and thickness between 14.0 and 27.6 m, describes a variety of lithologies that indicate moderate, large resistive and dry material. These include heavy sandstone or rock foundations, shale or cracked, varied moisture content, and a mix of sandy or gravely formed rocks (made up of clay, sandy clay, and fine sand) that affect storage of water and root permeation, both of which are key for the survival and development of palm oil plantations. Therefore, VES 2, 5, 8, and 9 (64.7 Ωm , 44.3 Ωm , 29.6 Ωm , and 174.4 Ωm respectively) have soil stability and water availability. The third layer of soil still promotes palm oil sprouting, growth, and advancement for palm oil manufacture. For a couple of sounding VES, specifically VES 1, 3, 4, 6, 7, and 10, these strata also function as aquifer layers, providing aquifer reservoir water supply and soil durability for plantation sustainability.

A transitional zone with moisture fluctuations and clay-rich ingredients found within slightly formations of rock that impact water accessibility and nutrient conveyance relevant for maintaining palm oil efficiency is indicated by the fourth stratum, which has resistivity depicted values from 27.4 to 1030.0 Ωm . Fine sand, sandy clay, clay, clayey sand, and medium sand are diagnostics of this stratum. The aquiferous subdivision for VES 3, 6, 7, and 10 is indicated by this geoelectric stratum, which improves root penetration and nutrient transmission. Adequate soil nutrients, clay-based elements, and a range of water or moisture degrees are found in VES 1, 2, 4, 5, 8, and 9 (116.4 Ωm , 27.4 Ωm , 120.8 Ωm , 70.4 Ωm , 161.2

Ωm , and 139.9 Ωm , respectively) to promote oil palm yield.

With estimated moderately to high resistivity figures that vary from 359.4 to 2705.7 Ωm , the fifth geoelectric layer represents the aquiferous unit and is indicative of satisfactorily fine to coarse-grained sand. It contains weather rock, semi-consolidated particles, or a mixture of materials that have various moisture contents, which are essential for determining the general balance of the soil and its potential to store water for improvement, management, and sustainable cultivation of palm oil. There were strong similarities between the inferred geoelectric data and the lithologic log of a working borehole dug in the study area. All areas of the study area had poor, weak, and moderate protective performance ratings, according to the longitudinal conductance map (Figure 12).

The VES geophysical research resistivity distributions show significant variations throughout the plantation spots with diverse subsurface factors able to support palm oil continuing existence, with topsoil resistivity differ from 34.7 to 391.6 Ωm . VES 2, 4, 6, and 7 with resistivity below 145 Ωm were found to be with a high percentage of moisture, fundamental soil rich-nutrients, organic matter, and beneficial soil texture conducive for palm oil development. Consequently, the low obtainable value of the protective capacity is caused by the absence of substantial and enough amount of clay as an overburden impermeable material in the study area, which fosters the percolation of harmful substances into the aquifer. Therefore, in an instance of petrochemical pollutions, the aquifer in the Iyede community is susceptible to contamination in the majority of regions.

However, a resistive zone of more than 150 Ωm was shown to be suggestive of rock formations, including coarse, fine, and medium texture soils, which present significant obstacles to the growth of oil palm. To guarantee the best growing conditions for palm oil agriculture, VES 1, 3, 5, 8, 9, and 10 are the targeted soils with less favorable circumstances that show high topsoil resistivity values. These soils can be improved by adding soil amendments and providing enough irrigation.

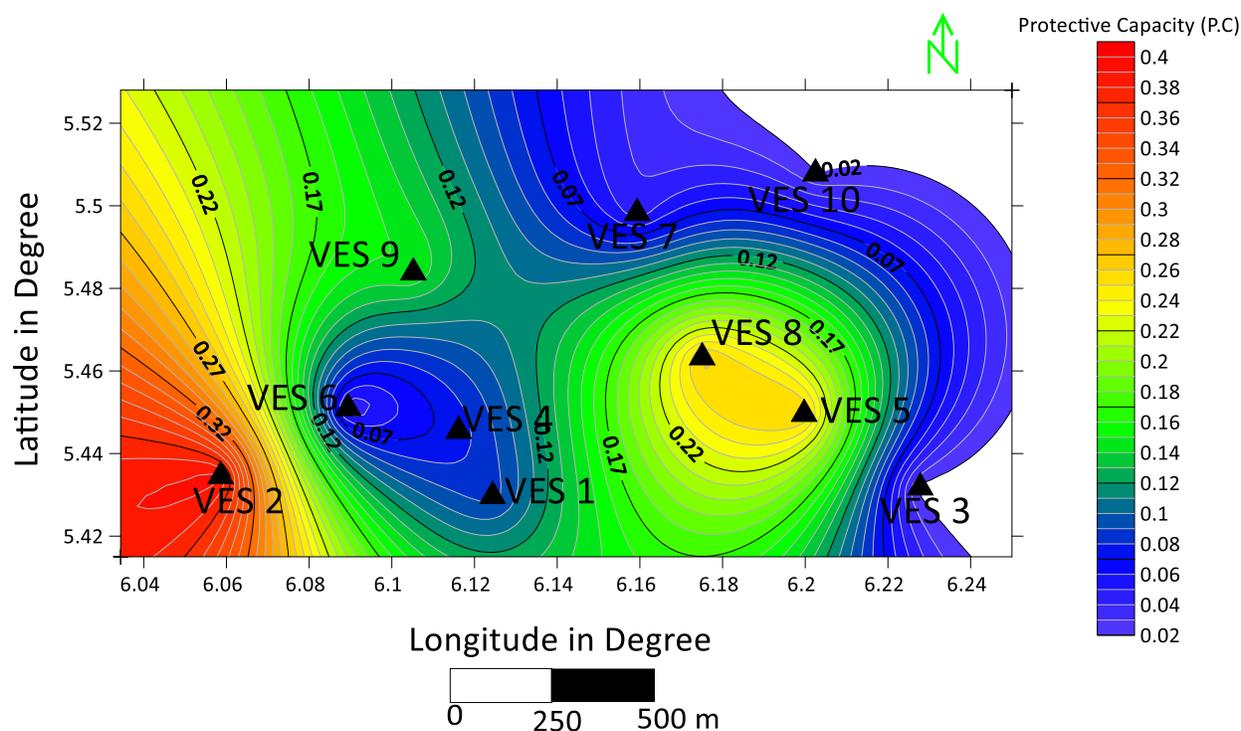


Figure 12: Protective capacity (P.C.) obtainable map of Iyede study area

Soil Analysis Results

Table 2: Constituents quantities in soil in Iyede VES stations

Soil samples points/depth (cm)	pH	N (%)	P(mg/kg)	K	Mg	Ca	Na(cmol/kg)
VES 1 0-14	5.1	0.18	22.60	0.18	0.38	3.80	0.65
VES 1 14-28	4.8	0.16	19.67	0.16	0.30	3.45	0.63
VES 2 0-14	6.5	0.40	46.89	0.45	0.89	8.20	0.80
VES 2 14-28	6.5	0.37	41.50	0.42	0.57	8.00	0.76
VES 3 0-14	4.8	0.22	16.22	0.13	0.35	3.50	0.44
VES 3 14-28	4.7	0.21	15.64	0.11	0.34	3.46	0.42
VES 4 0-14	6.6	0.34	39.80	0.56	0.86	7.20	1.43
VES 4 14-28	6.4	0.33	37.00	0.54	0.83	6.84	1.41
VES 5 0-14	5.0	0.25	14.76	0.25	0.55	4.10	0.55
VES 5 14-28	4.9	0.23	10.81	0.24	0.43	3.98	0.53
VES 6 0-14	6.8	0.29	33.84	0.61	0.90	6.88	1.92
VES 6 14-28	6.5	0.28	32.01	0.54	0.81	6.78	1.86

Soil Properties of Sounded Points

When tested with water, the pH of the earth's soil was found to be somewhat acidic, in the range of 4.7 to 6.8, and was deemed extremely appropriate (Table 2). With the exception of VES 2, where it stays constant, the pH dropped with depth in every location. The impact of farming and the leaching of vital cations along the soil profile may be the cause of this. Oviasogie and Okoro (2020), who noted a general decline in values of pH in the lower value profile, are nearly in agreement with this observation. With values varying between 0.16 to 0.40 percent (Table 2), the nitrogen concentration was relatively low at all of the places under examination;

nonetheless, it was high at the surface comparison to the deeper depths and was given a low rating.

The available phosphorus concentration was graded as somewhat appropriate and varied irregularly with increasing soil depth, ranging from extremely low (10.81 mg/kg) to exceedingly high (46.89 mg/kg) (Table 2). In every point that was analyzed, exchangeable magnesium was typically high (higher than that of 0.25 cmol/kg or 30 mg/kg); this finding is also in line with Oviasogie and Okoro's (2020) assertion that magnesium is not an issue of concern for oil palm output. For select VES locations (VES 1, 3, and 5), the usage of inorganic fertilizer is essential to provide the basic essential nutrients needed by

the oil palm due to the low levels of N and P present in these soils.

Sodium and Calcium had very low effective cation (ion) exchange capacities (<10 cmol/kg). This is less than what is needed to produce oil palm. The research area's low ECEC values are consistent with those of Oviasogie and Okoro (2020), who found low ECEC levels in the soils of Nigeria's Southern Guinea Savanna Region. In order to maintain favorable the state of the soil for long-lasting oil palm agriculture, management measures that promote the integration of organic wastes can address the low ECEC and low organic (biomass) matter, which are signs of insufficient soil fertility levels.

CONCLUSION

For the objective of fostering economic growth and revenue diversity, this study used an electrical resistivity strategy (tool) to examine the soil conditions underlying the surface of palm oil farms in Iyede, an oilfield-producing settlement in Delta State, Nigeria. The first-order geoelectric variables were determined by quantitatively analyzing the VES data through computer iteration via the Resist software, which led to the defining of the VES curves. Ten Schlumberger vertical electrical surveys (soundings) were conducted with a highest electrode space of 1000 meters. The findings indicate that several VES locations have distinct geological settings with differences in moisture in the soil content, texture, biomass, rich soil nutrients, and stability. According to the study, some locations have a good chance of producing oil palm and larger resistivity ranges from 143 to 392 Ωm , which indicates the presence of the formation of rocks or medium/coarse-grained soils that hinder palm oil development of roots, whereas areas exhibiting low resistivity showing values from 34.7 to 123.0 Ωm within the topsoil indicate appropriate and dependable soil for palm oil agriculture. In order to improve palm oil root development in a sustainable and ongoing manner, it is advisable that regions with higher or increased resistivity values or deficient soils should be recovered through various methods such as managing soils (irrigation and soil aeration processes), the cultivation of cover crops, routine monitoring, and the application of soil adjustments like organic matter, fertilizers, and balanced compost manure. It is therefore recommended that further investigations and comparison should also be carried out in both seasons of the year were oil palm plantations are cultivated in the study area of Iyede to delineate areas that need urgent remediation.

REFERENCES

Akpoyibo O., Abriku, E. O., Ugbe, F. C., Anomohanran O. (2025): Geophysical and geotechnical assessment of Obiaruku-Agbor road failure in Western Niger-Delta, Nigeria, *Journal of the Nigerian Society of Physical*

Sciences, 7 (1) 2328:1-9. <https://doi.org/10.46481/jnsps.2025.2328>

Akpoyibo, O. (2025): Assessment of Aquifer Protective Capacity and Soil Corrosivity in Umunede, Delta State, using Depth Probing Resistivity Inversion. *FUDMA Journal of Sciences*, 9(7), 102 - 113. <https://doi.org/10.33003/fjs-2025-0907-3587>

Akpoyibo, O. , Anomohanran, O. and Ossai, C. (2022): Application of 2-D Imaging Survey for Ascertaining The Cause(s) of Road Failures Along Sapele/Agbor Road In Delta State, Nigeria, *Scientia Africana*, 21(3): 215-232. <https://dx.doi.org/10.4314/sa.v21i3.17>

Akpoyibo, O. and Vwavware, O. J. (2024): Assessing the Impact of Gas Flaring Activities in Ebedei, Southern Nigeria. *Nigerian Journal of Physics (NJP)*, 33(2):137-145. <https://doi.org/10.62292/njp.v33i2.2024.247>

Akpoyibo, O., Abriku, O.E., Ugbe, F. C. and Anomohanran, O. (2023): Engineering assessment of Lateritic soils of Obiaruku highway sections in South-southern, Nigeria. *Nigerian Journal of Theoretical and Environmental Physics (NJTEP)*, 1(1): 72-79. DOI: <https://doi.org/10.62292/njtep.v1i1.2023.16>

Anomohanran O., Nakireru O.F, Ofomola M.O, Anomohanran E.E. and Abrika E.O. (2023): Assessment of groundwater potential of Somebreiro-Warri Plain sand of Ughelli, Nigeria, *Sustainable Water Resources Management* 9(1):1-26. <https://doi.org/10.1007/s40899-022-00797-9>

Chiriaco, M. V., Galli, N., Santini, M., & Rulli, M. C. (2024): Deforestation and greenhouse gas emissions could arise when replacing palm oil with other vegetable oils. *Science of the Total Environment*, 914, 169486.

Chukwunwike O., Akpoyibo O., Vwavware O. J. and Ogholaja R.E (2024): Soil Exploration and groundwater prospect in Etua, Delta State Nigeria. *Standard Scientific Research and Essays*, 12(7):196-202. <https://doi.org/1015413/ssre.2024.0179>

Egheneji, A., Molua, O. C., Vwavware, O. J., Osuhor, P., Akpoyibo, O. and Eseka, K. (2023): Investigation of Linear and Mass Attenuation Coefficient of Ozanogogo Kaolin, Agbor, Delta State. *Open Journals of Environmental Research (OJER)*, 4(2): 1 - 11. <https://doi.org/10.52417/ojer.v4i2.540>

Esi, E. O. and Akpoyibo, O. (2023): Estimation of aquifer transmissivity for typical oil producing communities of western Niger Delta using electrical resistivity survey.

- COAST, Journal of the School of Science, 5 (2): 893 – 908. <https://doi.org/10.61281/coastjss.v5i2.2>
- Esi, E.O., Akpoyibo, O., Nwankwo, R. C. and Vwavware, J.O. (2023): Estimation of the variability of sand deposits in chosen communities in parts of Niger delta, Southern-Nigeria using geophysical techniques. *Solid Earth Sciences*, 8:267–282. <https://doi.org/10.1016/j.sesci.2023.10.001>
- Esi, O.E. and Akpoyibo, O. (2024): Geophysical Survey and Radiometric Assessment of Aquifer Strata and Vulnerable Groundwater Quality of Ukwuani Communities in Delta State. *Scientia Africana*, 23(2):88-103. <https://doi.org/10.4314/sa.v23i2.9>
- Ganiyu, S.A., Olurin, O.T., Oladunjoye, M.A., and Badmus, B.S.(2020): Investigation of soil moisture content over a cultivated farmland in Abeokuta Nigeria using electrical resistivity methods and soil analysis. *Journal of King Saud University – Science* 32 (2020) 811–821. <https://doi.org/10.1016/j.jksus.2019.02.016>
- Ikegu, O., Esi, E.O., Olomukoro, J.O and Akpoyibo, O. (2024): Assessment of Physicochemical Parameters and Heavy Metals in Okpare Creek Drinking Waters, Delta State, Nigeria *Academy Journal of Science and Engineering (AJSE)*, 18(1): 60-78. <https://ajse.academyjsekad.edu.ng/index.php/new-ajse/article/view/349>
- Jeressa, I.E. and Okolie, E.C. (2025): Assessment of Optimal Subsurface Conditions for Palm Oil Plantation in Abraka using Geophysical Data and Soil Analysis. *Nigerian Journal of Science and Environment*, 23 (1): 196 – 212. <https://doi.org/10.61448/njse2312516>
- Molua, O.C., Ogholaja, E.R., and Akpoyibo, O. (2024): Identification of Groundwater-Dependent Wetlands Physical and Hydrological Characteristics and Ecosystem Relationship in Nun River, Niger Delta Region, Nigeria *J. Appl. Sci. Environ. Manage.*, 28 (8): 2333-2340. DOI: <https://dx.doi.org/10.4314/jasem.v28i8.9>
- Ofomola, M.O, Umayah, O.S. and Akpoyibo, O. (2017): Contamination Assessment of Dumpsites in Ughelli, Nigeria using the Leachate Pollution Index method. *Journal of Applied Science and Environmental Management*, 21(1): 77-84. <http://dx.doi.org/10.4314/jasem.v21i1.8>
- Oghenevovwero, E. E., Peretomode, E., & Ogheneovo, A. (2025): Nuclear geophysical assessment of aquifer groundwater quality in Okerenkoko community, Niger Delta: Implications for human health risk. *Water Science*, 39(1), 96–108. <https://doi.org/10.1080/23570008.2025.2464978>
- Ogholaja, R. E. , Akpoyibo O., Vwavware, O. J and Chukwusa, F. O. (2025): Application of Dipole-Dipole Electrical Resistivity for Subsurface Probing Within Golf Club Centre of University of Benin Teaching Hospital, Benin City. *Nigerian Journal of Theoretical and Environmental Physics (NJTEP)*, 3(1): 1-9. DOI: <https://doi.org/10.62292/njtep.v3i1.2025.65>
- Okolie, E.C. and Akpoyibo, O. (2012): Investigation of subsurface lithology and prolific aquifer using VES in Edjekota, Delta State, Nigeria. *International Journal of Research and Reviews in Applied Sciences*, 12(3): 468 – 476. <https://www.researchgate.net/publication/266165735>
- Oviasogie, P. O and Okoro, D. (2020): Suitability Assessment of Soils for Oil Palm Cultivation in Ofunwengbe, Ovia North East Local Government Area of Edo State, Nigeria. *FUPRE Journal of Scientific and Industrial Research*, 4 (3):80-94. <https://journal.fupre.edu.ng/index.php/fjsir/article/view/114>
- Vwavware, O. J.; Ojobeagu, O. A.; Akpoyibo, O. and Omoyibo, S. E. (2024a): Climate Change and Crop Adaptation: Geophysical Data on Soil Moisture Changes and Agricultural Strategies. *International Journal of Agriculture and Animal Production*, 4(2):1-13. DOI: <https://doi.org/10.55529/ijaap.42.1.13>
- Vwavware, O.J, Akpoyibo, O., Ojobeagu, O.A. and Omoyibo, S.E (2024b): Assessment of Groundwater Resource Potential and Long-Term Sustainability in Abavo Agricultural Farmland through Geophysical Techniques. *International Journal of Agriculture and Animal Production*, 4(5):40-50. <https://doi.org/10.55529/ijaap.45.40.50>