ISSN: 2394-3122 (Online)
ISSN: 2394-6253 (Print)
Impact Factor: 6.03

Volume 12 Issue 12, December 2025

SK International Journal of Multidisciplinary Research Hub

Journal for all Subjects

e-ISJN: A4372-3088
p-ISJN: A4372-3089

Research Article / Survey Paper / Case Study

Published By: SK Publisher (*www.skpublisher.com*)

A Monthly Double-Blind Peer Reviewed Refereed Open Access Multidisciplinary & Multilingual International Journal - Included in the International Serial Directories

Hydrogeophysical Characterization of Aquifers in the Odi Depocenter, Niger Delta: An Integrated Approach Using VES and Lithology

Ovuru Cyril[1]
Department of Geology, Niger Delta University, Bayelsa State, Nigeria.

Diepriye Okujagu[2]
Department of Geology, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria.
diepiriye.okujagu@uniport.edu.ng

Amgbare Peace Ebikomboere[3]
Department of Geology, Niger Delta University, Bayelsa State, Nigeria.

DOI: Available on author(s) request

***Abstract:** Sustainable exploitation of groundwater resources in complex deltaic environments cannot rely on the usual practice of "blind drilling" but must instead be informed by scientific principles. In many parts of the Niger Delta, the heterogeneous nature of the Quaternary Benin Formation makes it difficult to differentiate between freshwater aquifers, brine pockets and aquitards using surface geophysics alone. This paper demonstrates how Vertical Electrical Soundings (VES) data can be correlated with nearby borehole lithological logs in order to improve the hydrostratigraphic characterization of the subsurface in Odi (Kolokuma/Opokuma LGA, Bayelsa State). The VES survey employed Schlumberger configuration with current electrode half-spacing (AB/2) ranging from 1 to 100 meters and achieved penetration depths exceeding 35 meters. Partial curve matching of the resulting resistivity sounding curves followed by one dimensional computer iteration using standard filter coefficients was used to interpret the VES data. The geoelectrical models were then constrained by comparing them with borehole logs obtained at the same site through rotary drilling. Data from VES, borehole logs and previous hydrogeological studies suggest that there are four to five layers in the stratigraphy including conductive topsoil (30–60 Ωm), clayey sand to silty clay aquitards (140–180 Ωm) and distinct fine to medium grained sand aquifers. The study found strong positive correlations between the coarse-grained sandy aquifers encountered at depths of 20–36 meters in borehole logs and areas of high resistivity (>800 Ωm) from the VES survey as well as longitudinal conductance values that are less than 0. 1 ohm-1 (indicating weak to moderate clay confining layer protection). It also revealed that non-uniqueness still affects geoelectrical inversion although boreholes reduce ambiguity in interpretations but do not eliminate it completely. In Odi (and other locations where similar conditions prevail), sustainable exploitation of groundwater in the Benin Formation requires an integrated approach to subsurface characterization involving both electrical resistivity soundings AND borehole lithological logs among other data. This study provides a framework for such integration, identifies depths at which good yields are likely to be obtained from discrete aquifers AND enhances understanding of local groundwater flow in deltaic sediments.*

Keywords: Hydrogeophysics, Vertical Electrical Sounding, Aquifer Characterization, Lithostratigraphy, Niger Delta, Benin Formation, Longitudinal Conductance.

1. Introduction

1.1 Global and Local Water Context

No matter where in the world, people understand that beneath the earth is where fresh water can be stored for long and used to save the day when there is less rainfall or pollution of water at the surface. Nonetheless, it should be noted that accessing this resource is not the same everywhere. In the sedimentary basins of Southern Nigeria, particularly the Niger Delta, there is an irony; even though there is an abundance of surface fresh water due to heavy rains, drinkable water is still very difficult to come across. Surface water pollution, coastal zone saltwater intrusion, and inconsistent subsurface lithology all contribute to this problem.

With the spread of urbanization into places like Odi, a semi-urban area in Bayelsa State, reliable data for groundwater exploration in these locations are not keeping pace with the growing demand. People in this community mostly depend on private boreholes which may or may not be located following a certain scientific procedure. Many times this kind of drilling without regard to science leads to dry holes, weak water supplies or the interception of iron or saline enriched zones.

1.2 The Geophysical Challenge

In the deltic environments, it is very expensive to take continuous core samples and therefore the challenge is in describing the subsurface. Nevertheless, geophysical exploration techniques especially the use of direct current (DC) electrical resistivity method have been adopted as the best available due to cheap, fast, reliable and non invasive (in-situ) character. This involves the application of the vertical electrical sounding (VES) whereby four electrodes are positioned in the ground to measure how much electricity travels through the earth strata. The apparent resistivities obtained from this serve as indicators of different parameters such as lithology, porosity, fluid saturation among others (Koefoed, 1979).

Nonetheless, there is a fundamental problem called 'non-uniqueness' or equivalence in potential field geophysics. This refers to the fact that it is not possible to know exactly what kind of structure lies below the surface based on measurements taken at the surface alone since different configurations may give rise to identical data. For example, if one has a horizontally layered formation made up of sediments and there exists an extensive bed with moderate resistance properties, then it can resemble electrically identical to high resistant shallow layer. As a result, erroneous drilling decisions may be taken on account of isolated interpretation of VES data. To give an example, fresh water clayey sand could be equally resistive as brine sandy unit hence posing problems in determining productive aquifer and impervious layers (Seghosime, Ehiorobo, Izinyon, & Oriakhi, 2018).

1.3 Research Gap and Rationale

Though there are regional studies on the hydrogeology of Niger Delta, a few extensive correlation studies have been done in Odi community. Most of the literatures available concentrate on Port Harcourt, Warri or Yenagoa. Situated within a unique sedimentological setting, the Odi Depocenter lies on the floodplain of the Nun River where channel avulsion has resulted in rapid lateral facies changes. The localization of this setting invalidates previous generalizations made using regional means. Hence, there is an urgent call to go further than isolated geophysical surveys. The study fills this gap through coupling of surface VES models with direct subsurface data from borehole lithologs. The aim is to develop calibrated resistivity values for Odi through which subsequent investigations of groundwater can be reliably based upon.

1.4 Objectives of the Study

The research primarily aims to lessen the doubt that exists in exploring groundwater at Odi. Specifically, it intends to:

1. Collect VES data for plotting changes of subsurface resistivity with depth.
2. Take direct lithological specimens from bored holes to determine the actual order of rocks and water bearing levels.
3. Identify signature resistivity values of aquifers at Odi by matching VES geoelectric layers with lithostratigraphic units.
4. Determine the extent to which the top layers protect using geoelectric parameters (Longitudinal Conductance).
5. Suggest empirical measures for well construction and boring depths around the study locality.

2. Regional Geologic and Hydrogeologic Setting

2.1 Tectonic and Stratigraphic Framework

The study area Odi, which is located in the Niger Delta Basin, is an area known for its rich supply of hydrocarbon and groundwater resources. This basin originated in the Early Cretaceous era as the South American and African tectonic plates drifted apart. The basin contains an extensive progradational southwestward into the Atlantic Ocean clastic sequence.

Three large diachronous lithostratigraphic units make up the stratigraphy of the Niger Delta as identified by Etu-Efeotor and Akpokodje (1990):

1. **The Akata Formation (Paleocene to Recent):** Primarily made up of over-pressured marine shales, this forms the lowermost unit. Petroleum originates from it although because of its depth and high salinity, it is not important in relation to fresh water in the area under investigation.
2. **The Agbada Formation (Eocene to Recent):** On top of Akata formation, there is a sequence of paralic deposits made up of sandstones and shales in which each is alternately present. Hydrocarbon is present in it but sometimes there may be fresh water in the upper most part which is usually found at a depth greater than four hundred meters.
3. **The Benin Formation (Oligocene to Recent):** The study mainly concentrates on this topmost geological unit. It is commonly known as the "Coastal Plain Sands," and is made up of vast, non-marine sand deposits that have little amounts of shales and clay lenses in between.

2.2 Local Geology of Odi

Odi town is located in the floodplain of the Nun River, which is one of the channels formed by River Niger. On top of Benin Formation is the Quaternary Sombreiro-Warri Deltaic Plain deposits on the surface as observed geologically. Backswamp deposits, point bars, and channel fills predominate in the sedimentology at this location. These sands have great permeability making them good aquifers though some aspects like presence of lenses comprising silt and clay material of abandoned channel fills affect with regard to electric conductivity as well as hydraulic connection of the formation itself.

2.3 Hydrogeology and Recharge

The region experiences a high recharge potential due to the infiltration of precipitation through the Benin formation. This is attributed to the fact that the aquifer is recharged mainly through direct infiltration of rainfall as observed by Etu-Efeotor (1981) in an area with an average annual rainfall of over 3000mm. On top of this, during the wet season, there is also recharge from an influent source through the Nun River. This occurs when the stage of the river rises above the local water table and pushes water into bank storage.

The general depth of the water table in Odi ranges from less than 3 meters during rainy season to about 6–8 meters in the dry season. Such a shallow water table renders the unconfined aquifers vulnerable to pollution by man-made activities on the surface emphasizing the importance of detecting protective clay horizons.

3. Theoretical Framework

3.1 Principles of Geoelectrical Sounding

Ohm's Law forms the basis of the electrical resistivity method. In a homogeneous isotropic medium, the electrical resistivity (ρ) is a bulk property of the material that describes how difficult it is to pass an electric current through it. In geological materials, rock matrix minerals (like quartz and feldspar) are typically insulators; therefore, current flows primarily through the pore fluids (electrolytic conduction) or along the interface of clay minerals (surface conductance) (Olorunfemi & Fasuyi, 1993).

The relationship between the resistivity of a porous rock formation and its fluid content is often described by Archie's Law:

$$\rho = a\phi^{-m} S_w^{-n} \rho_w$$

Where:

ρ is the formation resistivity.

ϕ is porosity.

S_w is water saturation.

ρ_w is the resistivity of the pore water.

a, m, n are empirical constants related to lithology and cementation.

This equation underpins the VES method: if porosity and water quality are relatively constant, changes in resistivity (ρ) directly indicate changes in lithology (e.g., clay vs. sand).

3.2 The Schlumberger Configuration

In the Schlumberger array used in this study, four electrodes are placed collinearly. The electric current (I) passes through the external electrodes A and B while the potential difference (ΔV) is recorded by the internal electrodes M and N. Apparent resistivity (ρa) is then determined by the formula:

$$\rho_a = K\left(\frac{\Delta V}{I}\right)$$

In the Schlumberger arrangement, the geometric factor K is given by:

$$K = \frac{\pi(L^2 - l^2)}{2l}$$

In this case, L stands for half of the space separating the electrodes of current (AB/2), while l is half of the space separating the potential electrodes (MN /2). Since the earth is not homogenous, the "apparent" resistivity is seen as a weighted mean value of resistivities from different layers affected by the current. When there is an increase in the spacing of potential electrodes (increase in AB/2), then the penetrating current goes deeper giving data at increased depth.

3.3 Inversion Theory

A sounding curve is produced by the raw field data (ρa vs. AB/2). Nevertheless, it needs to undergo inversion so that it can be turned into geological model data encompassing true resistivity and depth information. In this investigation, Koefoed (1979) approach of convolution with filter coefficients is applied. Iterative tuning of layered earth model is done such that there is convergence between theoretical and observed curves at an acceptable root mean square error (RMSE) value.

4. Materials and Methods

4.1 Study Area and Location

Odi town can be found at Kolokuma/Opokuma Local Government Area, Bayelsa State in the southern part of Nigeria as shown in figure 1. Geographically, it is positioned within the floodplain of Nun River; which is one of the main branches flowing into River Niger from that area. Its topography is mostly leveled or slightly sloping as you would expect from deltatic plain. It has an average altitude of about 15 meters or below above mean sea level.

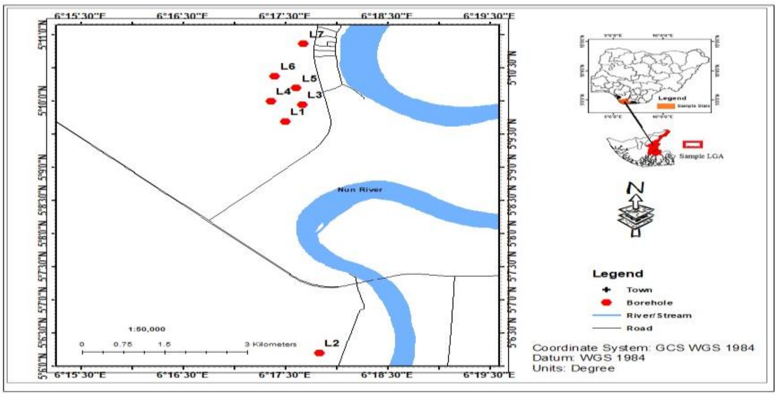

Figure 1: A representation of the study area indicating Odi Town, Nun River, as well as positions of VES sounding points and boreholes.

4.2 Field Data Acquisition

At predetermined places in Odi community, there was carrying out of geophysical survey to help describe the underground environment.

Instrumentation:

For data acquisition, we used the standard ABEM Terrameter (SAS 1000). The instrument uses Signal Averaging System (SAS) which stacks repeated measurement to improve signal to noise ratio especially when there are telluric or industrial noise.

Survey Parameters:

Method: Vertical Electrical Sounding (VES).

Array: Schlumberger.

Spacing: Starting from 1. 0 m, the half-spacing of the current electrode (AB/2) was increased up to 100 m. With such a maximum space, it is possible to study at depths of about one-third to one-fourth the entire current flow, which is estimated at 35–40 m.

Potential Electrodes: At first, the spacing of the potential electrode (MN /2) was kept little and increased just a while after the measured voltage went below the detectable limits. The increase in MN/2 was accompanied with overlap measurements meant to adjust on “static shift” due to near potential electrode local inhomogeneities.

4.3 Borehole Drilling and Logging

Two exploratory boreholes were drilled within 15 meters from the VES sounding centers for validation of the geophysical models.

Drilling Technique: The method of rotary drilling was applied. It involves the utilization of a turning drill bit as well as revolving drilling mud (bentonite slurry) that assist in penetrating through the formation and raising the cuttings to the top.

Lithologic Sampling: At every 1. 5 meters and also at each evident variation of formation (shown by drilling rate or vibration), samples of drill cuttings were taken from the mud return flow.

Sample Analysis: Drilling mud was washed from the samples before their visual and physical inspection with the aim of determining the sizes of the grains, as well as, the texture and color properties. A litholog was then made from all these observations.

4.4 Data Processing and Correlation Procedure

The research information was graphically represented through bi-logarithmic graphing in order to spot any inaccurate values as well as establishing the starting curve pattern. Subsequently, there was an employment of IPI2Win software for 1D inversion on a computer.

Correlation Strategy:

Overlaying the borehole lithologs with the geoelectric layers (depth and thickness), interpretation was possible. This helped in finding out:

1. Whether layer boundaries correspond with each other.
2. What is the resistivity of "aquifer" sand and "aquitard" clay in a given range?
3. Calculation of longitudinal conductance (S) in overburden layers for evaluating on top of an aquifer protection.

5. Results

5.1 Geoelectric Interpretation

It was found from studying the VES curves that beneath there was mostly 4 or 5 geoelectric strata. These were non-jagged bends implying very good data of about zero or minimum noise level. Table 1 gives an overview of the interpreted parameters for the correlation sites in relation to the layers.

Table 1: Summary of VES Interpretation and Geoelectric Layers.

Site	Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithological Interpretation (Geophysical)
Site A	1	50	2.0	0 – 2	Topsoil (Sandy clay)
	2	180	6.0	2 – 8	Clayey Sand
	3	450	12.0	8 – 20	Fine-to-Medium Sand
	4	900	>15.0	20 – 35+	**Coarse Sand (Aquifer)**
Site B	1	60	3.0	0 – 3	Topsoil
	2	140	7.0	3 – 10	Silty Clay
	3	380	12.0	10 – 22	Fine-to-Medium Sand
	4	820	>14.0	22 – 36+	**Coarse Sand (Aquifer)**

Site A Analysis:

At Site A, the sounding curve (as an example, see Figure 2) is characterized by an upward movement pattern of resistivity (A type). This implies that the near surface layer is conductive while the deeper layer is resistive in nature.

Layer 1 (0–2 m): This may be attributed to presence of wet topsoil with high organic matter content.

Layer 2 (2–8 m): The presence of sand and clay is suggested by the moderate resistivity of 180Ωm.

Layer 3 & 4 (8–35+ m): Initially, the resistivity increases drastically from 450 Ωm to 900 Ωm. In relation to the Niger Delta, fresh water sand is normally related with resistivity levels of over 400 Ωm. The rise of about 900 Ωm indicates that there is less silt but bigger grains (coarsening upward sequence).

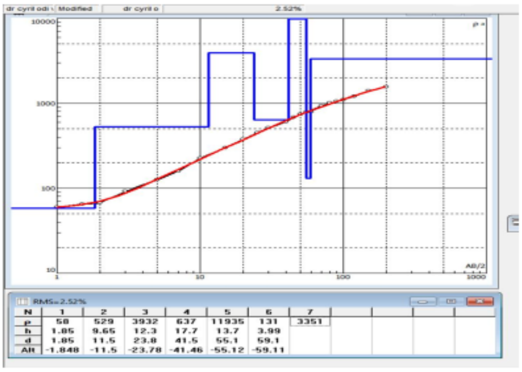

Figure 2: The model fit is exhibited by the curve of the Schlumberger depth sounding at Site A, which is of A-Type.

Site B Analysis:

The pattern is almost the same in Site B, although it is affected by some factors indicating lateral heterogeneity.

Layer 2: Its resistivity stands at 140Ωm, which is less than that of Site A (180Ωm). The decrease implies an increased content of either clay or silt fraction; hence it can be deduced to be a silty clay.

Aquifer: Even though it has a lower resistivity than Site A, the deep layer (Layer 4) still shows a significant resistivity of 820Ωm which further supports the idea that the primary aquifer unit is continuous throughout the area.

5.2 Lithostratigraphic Findings

The resistivity numbers could only be calibrated using the physical evidence of borehole logs.

Borehole 1 (BH1) – Near Site A:

Loose, unconsolidated sediments were penetrated by the drilling which passed through them in a sequence. The surface layer of 2 meters consisted of dark, organic sandy clay. Between 2 and 8 meters, it was noted that the formation consisted of "Clayey Sand" i.e., a blend of clay with sand particles. On reaching 8 m, there was a clear break and they entered into "cleaner" medium sand. Below 20 m, the cuttings were very much increased in size (gravelly sand) and indicated an environment of deposit with high energy.

Borehole 2 (BH2) – Near Site B:

The VES indication that there was a second layer of "clayier" nature was verified by this log. Between 3 and 10 meters gave us “Silty Clay” that had increased cohesiveness and plasticity as compared to Clayey Sand found at Site

A. From a depth of 10 down to 22 meters, we struck upon the fine to medium aquifer sands which changed into coarse ones at 22 meters and below.

5.3 Correlation and Integration

It is evident from the merged datasets (as depicted in Figure 3) that there exists a strong agreement between the two.

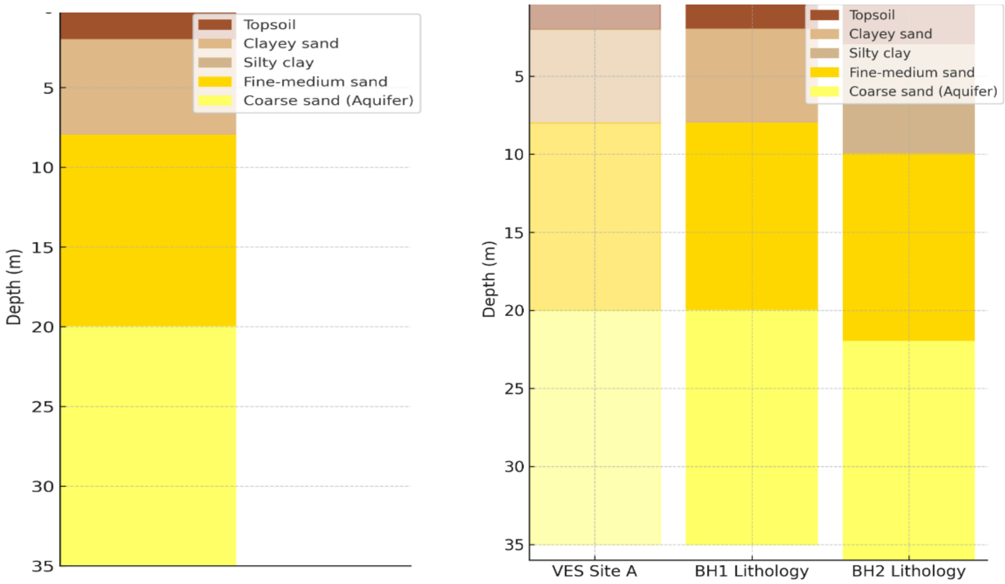

Figure 3: The comparison between Drillers' Lithologs (Left) and VES Geoelectric Layers (Right) at Site A and B is shown in the correlation chart.

Layer Thickness Correlation:

At site A, VES approximated the thickness of the uppermost aquifer (Coarse Sand) at about 20m which was also experienced by the drilling machine at the same depth. At Site B, VES predicted 22.0 m, and the drill encountered it at 22.0 m. This near-perfect match validates the use of the Schlumberger array for depth sounding in this environment.

Lithology-Resistivity Calibration:

By comparing the datasets, we can establish specific resistivity "bins" for Odi:

1. Topsoil/Clay:< 100Ωm
2. Silty Clay/Clayey Sand:140–250Ωm
3. Fine-Medium Sand:300–600Ωm
4. Coarse Sand (Productive Aquifer) :> 800Ωm

6. Discussion

6.1 Reliability of the Integrated Approach

The results of this study fundamentally validate the premise that VES, when constrained by borehole data, is apowerful tool for subsurface mapping. In many geophysical surveys lacking borehole control, a resistivity of 140Ωm (Layer 2, Site B) might be ambiguously interpreted. The layer might comprise of freshwater clay or even sandy stratum with some salinity. Nevertheless, the borehole log revealed that it was Silty Clay.

One should take note of the subtle but significant difference in electrical resistivity between the "Clayey Sand" with a value of 180 Ωm at site A and the "Silty Clay" having 140 Ωm at site B. This shows that the electrical method can recognize lateral facies changes with sensitivity; in particular, the change of increased clay content but only slightly. Such sensitivity matters a lot in the Niger Delta because these are not continuous but lenticular "sand bodies" as commonly described.

6.2 Hydrogeological Implications

It is clear that the main focus of extracting groundwater in Odi lies on the sand level which is found beneath 20-22 meters and is composed of larger grains.

Transmissivity: With resistivity values above 800 Ohm meters, it means that the formation factor is very low while permeability is very high. The relation between hydraulic conductivity (K) and the effective grain size (d10) squared can be given as K ~ (d10) 2, and this is often estimated using Hazen's formula. The observation of coarse sands within the borehole indicates that this is a highly transmissive aquifer capable of supporting motorized pumps in community water schemes.

Water Quality: Water quality is also indicated by the high resistivity levels. When we talk about formation resistivity being related to pore water resistivity (ρw), then low TDS is implied by high ρ values. It can be concluded that the first 35 meters do not show any signs of saltwater penetration in the study area.

6.3 Aquifer Vulnerability Assessment (Longitudinal Conductance)

It is very important in hydrogeology to determine the degree at which an aquifer is shielded against pollution from the top. For this, the longitudinal conductance (S) of the overburden layers is employed and computed using the equation:

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

Where h_i is the thickness and ρi is the resistivity of the i-th layer above the aquifer. The aggregate of calculated longitudinal conductance appears in Table 2.

Table 2: Longitudinal Conductance (S) and Aquifer Protective Capacity Ratings

Site	Overburden Thickness (m)	Longitudinal Conductance (S) (Siemens)	Protective Capacity Rating
Site A	**8.0**	**0.073**	**Weak**
Site B	**10.0**	**0.100**	**We**

Interpretation:

According to the vulnerability classification by Fatoba, Dare, and Adigun (2014):

S > 10: Excellent protection

5 < **S** < 10: Very Good

0.7 < **S** < 4.9: Good

0.2 < **S** < 0.69: Moderate

0.1 < **S** < 0.19: Weak

S < 0.1: Poor

In the case of Odi, the longitudinal conductance which was computed to be 0. 073 and 0. 10 Siemens respectively can be categorized under "Poor to Weak". This is very important. It means that the impermeable layers composed of clayey sand and silty clay which cover the porous zone are either too thin or not conductive enough with high amounts of clay to prevent penetration of contaminant at the surface into it. As a result, it is possible for septic tanks, agricultural runoff as well as hydrocarbon spillage to pollute the high yielding groundwater in Odi.

6.4 Comparative Analysis

The outcomes from Odi are in line with those of similar studies carried out in the region albeit having some unique local features. In their general classification of the Niger delta aquifers, Etu-Efeotor and Akpokodje (1990) provided a basis which this investigation attempts to modify in relation to the Nun River floodplain. The resistivity values obtained conform with observations made elsewhere in the delta by Egai, Paaru, and Victor-Gow (2024), who also experienced problems distinguishing sandy clays from sands unless there were borehole data. Nevertheless, it can be inferred that the aquifers within

Odi are at a shallower depth of about 20 m compared to greater depths usually found in upland parts of the delta (> 40 m), probably as a result of being close to and influenced by scouring action of Nun River's active channel.

7. Conclusion and Recommendations

7.1 Conclusion

The Odi depocenter was effectively characterized using an integrated hydrogeophysical approach in this study. The research combined Vertical Electrical Sounding and borehole lithostratigraphy to address the issue of non-uniqueness that arises when using resistivity methods alone.

The key conclusions are:

1. **Stratigraphy:** The underground portion is composed of a five layer system; the topsoil is followed by weakly confining clayey / silty layer then fine sand and finally coarse sand aquifer at the bottom.
2. **Aquifer Definition:** At depths of 20 m to 36 m, the aquifer zone with the highest productivity is the coarse sand layer which has a resistivity of over 800Ωm.
3. **Methodological Validity:** After calibration, the VES method was capable of predicting aquifer depths that were accurate to within ±1. 5 meters as compared to drill logs.
4. **Vulnerability:** Because the overburden offers poor protection ($S \leq 0.1$ Siemens), it means that the groundwater is very vulnerable to any kind of spill or leak from the surface.

7.2 Recommendations

Taking into consideration the scientific findings, it is suggested that the policy and practice should adopt the following recommendations:

1. **Drilling Depth Standards:** In Odi, the drilling of water boreholes must go as deep as 25 meters at least but should not exceed 40 meters so as to penetrate through the coarsed sand aquifer. The shallow wells which are less than fifteen meters draw from fine sand giving cloudy water that dries up during certain seasons of the year.
2. **Sanitary Protection:** Because the protective capacity was calculated as "Weak", there is a need to implement very tight sanitary seals (grouting) in the upper 10 meters of every borehole. In addition, boreholes must be located at a minimum distance of 30 meters uphill of septic tanks or refuse pits.
3. **Pre-Drilling Surveys:** The validation of VES correlation through its success. The use of VES surveys should be imposed as a must for any borehole project meant for communal or industrial use in the region so as to determine impeding factors on flow like local clay lenses.
4. **Data Archiving:** To aid in the development of an all-inclusive 3D hydrogeological structure for the Benin Formation within Bayelsa State, there must be a centralized repository containing lithological logs and VES data.

References

Egai, A. O., Paaru, M., & Victor-Gow, A. (2024). Aquifer delineation using Vertical Electrical Sounding (VES) and correlation of borehole logs in Opolo-Epie, Yenagoa Bayelsa State, Nigeria. Global Journal of Earth and Environmental Science, 9(2), 69–81. https://doi.org/10.31248/GJEES2024.153

Etu-Efeotor, J. O. (1981). Preliminary hydrogeochemical investigation of the sub-surface waters in parts of the Niger Delta. Mining and Geology, 18(1), 103–105.

Etu-Efeotor, J. O., & Akpokodje, E. G. (1990). Aquifer systems of the Niger Delta. Journal of Mining and Geology, 26(2), 279–284.

Fatoba, J., Dare, O., & Adigun, E. O. (2014). Using geoelectric soundings for estimation of hydraulic characteristics of aquifers in the coastal area of Lagos, southwestern Nigeria. International Letters of Natural Sciences, 11, 30–39. https://doi.org/10.18052/www.scipress.com/ILNS.11.30

Koefoed, O. (1979). Geosounding principles, 1: Resistivity sounding measurements. Elsevier Science.

Olorunfemi, M. O., & Fasuyi, S. A. (1993). Aquifer types and geoelectric/hydrogeologic characteristics of part of the central basement terrain of Nigeria (Niger State). Journal of African Earth Sciences, 16(3), 309–317.

Seghosime, A., Ehiorobo, J. O., Izinyon, O. C., & Oriakhi, O. (2018). Aquifer mapping in the Niger Delta region: A case study of Edo State, Nigeria. Nigerian Journal of Environmental Sciences and Technology (NIJEST), 2(1), 118–129.

:::. Cite this article .:::

Cyril, O., Okujagu, D., Ebikomboere, A. P. (2025). Hydrogeophysical Characterization of Aquifers in the Odi Depocenter, Niger Delta: An Integrated Approach Using VES and Lithology. SK INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH HUB, 12(12), 1–11. https://doi.org/10.61165/sk.publisher.v12i12.1