Lafia Journal of Scientific & Industrial Research (LJSIR), Vol. 3(1), 2025
p-ISSN: 3026 – 9288   e-ISSN: 3027 – 1800   pages: 55 – 63
https://lafiascijournals.org.ng/index.php/ljsir/index ⇒ Published by the Faculty of Science,
Federal University of Lafia, Nasarawa State, Nigeria

Evaluation of Aquifer Protective Capacity Using Electrical Resistivity Method: A Case Study of Osun State University, Osogbo Campus, Southwestern Nigeria

Akindeji Opeyemi Fajana* & Adebisi Samuel Arinloye
Department of Geophysics, Federal University, Oye-Ekiti, Ekiti State, Nigeria

Abstract

This study investigates the groundwater potential of Osun State University, Osogbo campus, southwestern Nigeria, through an electrical resistivity survey. Using 30 Vertical Electrical Sounding (VES) points and the Schlumberger array method, geoelectric parameters such as longitudinal conductance, reflection coefficient, and overburden thickness were analyzed. The resistivity data revealed ten distinct curve types (A, H, K, Q, HA, HK, KH, KQ, QH, and HKH), with the H curve type being the most prevalent, representing 30% of the total. The subsurface was characterized by 3 to 5 distinct layers, including topsoil, weathered layers (sandy, clayey, or lateritic), fractured basement, and fresh basement.Results showed a wide range of aquifer protective capacities. Approximately 30% of the VES points exhibited poor protective capacity, while 16.66% showed weak protection. Moderate protection was observed in 6.66% of the points, and fairly good protection in 16.67%. The remaining 13.33% had good protection, with only 3.3% rated as very good. Longitudinal unit conductance values ranged from 0.0563 to 1.1427, confirming the predominance of weak to moderate aquifer protection.Aquifers with low reflection coefficient values (r < 0.8) indicated a favorable groundwater potential but increased vulnerability to contamination. This suggests that while certain areas of the campus are vulnerable to contamination, others may offer better protection for long-term groundwater storage and use. The study underscores the importance of tailored groundwater management strategies, particularly given the rapid population growth and industrial expansion in the region, which could introduce future contamination risks. These findings are crucial for sustainable groundwater management in the campus area, ensuring protection against future contamination threats.

Keywords: Vertical electrical sounding, longitudinal unit conductance, reflection coefficient, groundwater yield potentials

Article History
Submitted
November 20, 2024
Revised
January 04, 2025
First Published Online
January 09, 2025

***Corresponding author**
A. O. Fajana ✉
akindeji.fajana@fuoye.edu.ng

doi.org/10.62050/ljsir2025.v3n1.369

Introduction

Groundwater, a crucial resource for sustaining human life and supporting various economic activities, is increasingly at risk due to contamination. As population growth, urbanization, migration, and industrialization surge, so do the demands on groundwater resources. These human activities, alongside a rise in production and consumption, contribute to the release of pollutants, which infiltrate the ground and percolate into aquifers, leading to potential contamination. Thus, the need for assessing groundwater vulnerability and establishing protective measures becomes essential, especially within regions facing rapid development pressures [1].

This study addresses the problem of groundwater vulnerability, specifically focusing on Osun State University's campus in Osogbo, Nigeria. The campus, located in a region dominated by the Precambrian Basement Complex, faces unique hydrogeological challenges. Aquifers in such areas are typically shallow, which makes them particularly susceptible to contamination from surface and near-surface sources. Margat first introduced the concept of groundwater vulnerability (GWV) [2], defining it as an inverse measure of an aquifer's natural barriers against contaminants. Building on this, the National Research Council of the United States of America [3], defines GWV as the likelihood of contaminants infiltrating a groundwater system following their release above the highest aquifer layer. According to Ball *et al.*, GWV is the propensity and probability of pollutants infiltrating the aquifer from the surface level [4].

The study of groundwater vulnerability takes two forms: intrinsic vulnerability, which is determined by natural geological and hydrological conditions, and specific vulnerability, which considers particular pollution sources [5, 6]. Multiple methods and techniques have been developed to assess GWV, many of which focus on analyzing aquifer characteristics [7]. The choice of an optimal methodology depends on the study's objectives, available data, and resources, as well as the complexity of the assessment process [8]. Among the principal approaches are process-based models, statistical models, GIS overlays, and index models, such as DRASTIC [9, 10]. DRASTIC, introduced by Aller *et al.* [11], remains one of the foremost GIS-based techniques for mapping groundwater vulnerability by overlaying physical and environmental factors associated with potential contamination. Arinloye

A pressing concern in groundwater management is the issue of over-extraction, as global evidence indicates that unsustainable groundwater withdrawals or "over-mining" may already be occurring in various regions. The World Bank Report estimates that global groundwater over-extraction accounts for nearly 40% of total groundwater use. In regions where the extraction rate exceeds the natural recharge rate, the long-term availability of groundwater becomes compromised. Hence, effective management of groundwater aquifersviewed here as "natural infrastructure" is imperative to ensure sustainable use. Protecting aquifers requires coordinated efforts among all stakeholders, including adherence to recommendations from hydrogeology and groundwater geophysics experts. Mismanagement, such as improper siting of boreholes and ignoring expert guidance, only exacerbates the risk of contamination and resource depletion.

The primary aim of this study is to evaluate the protective capacity of aquifers beneath the Osun State University campus using an electrical resistivity survey. By assessing the geoelectric parameters, this study seeks to identify areas of the campus that are more vulnerable to contamination and those with better protective capacity. Given the ongoing development and population increase in the region, these findings will inform targeted groundwater management strategies to safeguard against future contamination threats. Specifically, the study focuses on assessing the subsurface's ability to protect the aquifer from pollutants, thereby contributing to a sustainable groundwater management framework for the campus.

Description of the study area

The study area is the Osogbo campus of Osun State University (Uniosun). The University was established in the year 2006 and with six campuses evenly scattered across the three senatorial districts of the state. One of the six campuses is located in Osogbo, this Osogbo campus houses the Schools of Sciences and Engineering of Uniosun. Osogbo. Fig. 1a gives the location map of the study area.

Uniosun (Osogbo campus) is located in the semi-urban and appreciably cultivated north-eastern part of Osogbo township, the campus is bounded by the range of latitude $7^{o}45^{'}26^{''}$ and $7^{o}45^{'}49^{''}$ and longitude $4^{o}35^{'}45^{''}$ and $4^{o}36^{'}5^{''}$. The elevation ranges between 327 and 343 m above sea level. The closest settlements to Uniosun are majorly agrarian communities of Boredun in the north and Ilase-Ijesa in the north-eastern part of the state (both in Obokun local government area of Osun State). In the southern part, the university campus shares a border with densely populated locals of Osogbo township local government. Cutting across from the west to the eastern direction within the campus is a large though gradually fading away tributary (owing largely tothe impact of climate change) of River Osun, the longest river in Osun state which envelopes the state with its tributaries and after which the state itself is named. The University (Osogbo campus) landmass is about 6 km^{2}, the climatic information of the area as a tropical rainforest revealed that the average annual precipitation is about 1120 mm with a relative humidity of about 83% and mean atmospheric temperature of between 28 and 31^{o}C. The dry season normally commences by November ending and ends by March on average. The university daily parades about ten thousand people, many of whom are permanent inhabitants (students, workers, visitors, and community dwellers tapping from the economic opportunities presented by the university) and with an ever-expanding and increasingly growing environs that help keep the population of the area booming at such an alarming rate as a result of ceaseless migration of people into the area in desperate attempts to tap from the commercial opportunities the presence of the university offers. The entire university community inhabitants and all the locals within the environs rely on Groundwater for both their domestic and industrial purposes.

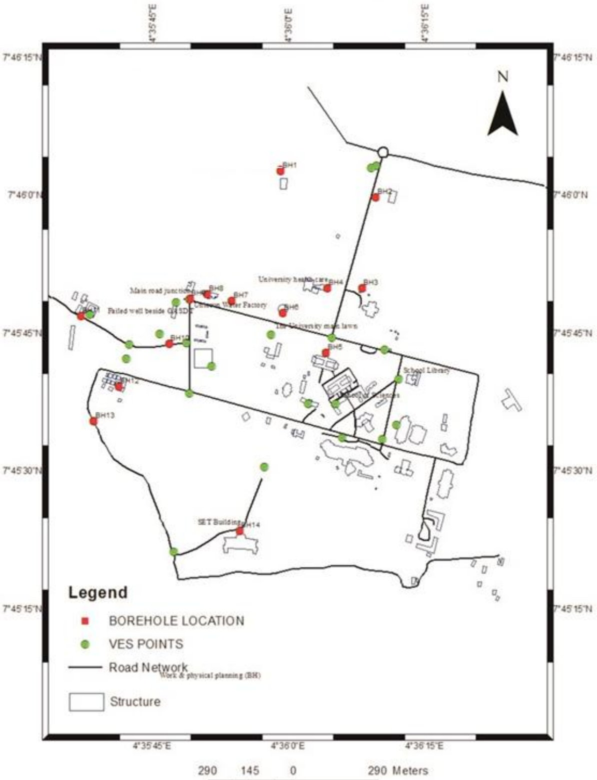


Figure 1a: Map of the study area showing the VES points

Geology of the study area

The research area, located between latitudes N7^{O} 45'26" and N7^{O} 45'46" and longitudes E4^{O} 35'46" and E4^{O} 36'4.97", is situated inside the Nigeria basement complex, distinguished by pre-Cambrian crystalline rocks (Fig. 1b) [12]. This indicates that the region is comprised of metamorphic rocks from the Pre-Cambrian basement complex. The predominant geological formations in the examined area consist of weathered porphyritic granite, migmatite (including quartzite and pegmatite), and schist quartzite, which are associated with quartzite ridges, hence creating the undulating terrain. The rocks exhibit significant variation in grain size and mineral composition, from very coarse-grained migmatite to fine-grained schist, and from acidic quartzite to basic rocks predominantly consisting of tourmaline pegmatite vein quartz. The rocks are extensively foliated and predominantly manifest as boulders, particularly in the central region of the study area. The predominant soils are ferruginous tropical red soils (laterites) associated with basement complex terrain [12].

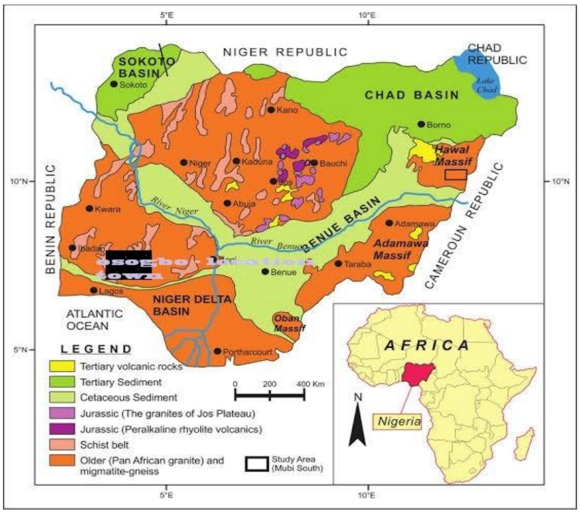


Figure1b: Geological map of Nigeria showing the study location town – Osogbo [12]

The research location features a humid tropical climate characterised by pronounced wet and dry seasons. The wet season generally commences in mid-March and concludes around November, whereas the dry season initiates in November and terminates in March annually. In the dry season, the North-East (NE) trade wind predominates, whereas the wet season is characterised by the South Westerly breeze. The annual average relative humidity is almost 80%. Precipitation transpires for approximately eight months annually, with total rainfall varying between 1300 and 1500 mm, reaching its zenith in September and occasionally in October. The annual precipitation averages approximately 1400 millimetres. Precipitation is predominantly cyclonic, exhibiting dual peaks in June/July and September/October. Convectional rainfall is prevalent because of the elevated intensity of solar radiation and an average relative humidity of 80%. The annual temperature is consistently elevated, fluctuating between 28 and 31°C, with a peak of 32°C documented in April.

Vegetation of the study area

The research area is characterised by evergreen forest vegetation with various hardwood species. This encompasses cultivated palm trees and other perennial crops. Forest segments exist on the eastern and western peripheries of the research area, comprising climbers, a variety of hardwood trees, and bamboo thickets along the principal tributary of the Osun River that traverses the study area's east-west axis. In the majority of the study area, natural vegetation has been considerably diminished due to human activities, notably bush clearing for diverse construction purposes (roads, lecture theatres, laboratories, workshops, and residential buildings), semi-large scale and subsistence agriculture, and research sites, thereby exposing a substantial portion of the land surface to erosion. Fig. 2. illustrates a Landsat-acquired image of Osogbo (the research site) and its vicinity, with the UNIOSUN Campus delineated.

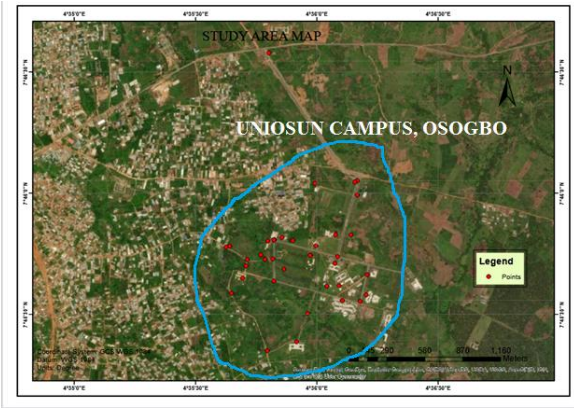


Figure 2: Landsat captured image of the study location town and its environs

Materials and Methods

The two geophysical parameters considered are obtained from the Vertical Electrical Sounding (VES) curves. The parameters are:

i. Longitudinal unit conductance
ii. Reflection coefficient

Longitudinal unit conductance (S): This can be described as a summation of the ratio of layer thickness to the layer's apparent resistivity. The higher the value of longitudinal unit conductance, the more protected the Groundwater stored within the aquifer. Conversely, a high value of longitudinal unit conductance is not favourable to the quantity of Groundwater accumulation. Longitudinal unit conductance is a geoelectric Groundwater influencing parameter that measures the degree of impermeability of runoff water from the agents of precipitation into the subsurface, it is a measure of the degree of resistance of materials overlain the aquifers to percolation of runoff water. Thus, the high values of Longitudinal unit conductance favour aquifers protection and hence Groundwater protection from contaminants intrusion.

Longitudinal unit conductance $S = \sum_{i=1}^{n} \frac{hi}{\rho i}$ ……… 1

Where $\sum$ is the summation sign
$\mathbf{h}_i$ = ***i*th** layer thickness
$\boldsymbol{\rho}_i$ = resistivity of the ***i*th** layer.

Reflection coefficient: Low reflection coefficient values imply a fractured and/or weathered bedrock and thus favourable to groundwater potential. Reflection coefficient value of greater than 0.8 ($r > 0.8$) is considered veryfavourable to aquifer protection [1, 13, 14]. Reflection coefficient more adequately measures the aquifer nature and the competence of the basement in resisting the infiltration of contaminants. Low reflection coefficient values imply a fractured and/or weathered bedrock, and thus favourable to groundwater potential.

Reflection coefficient (r) $= \frac{[(\rho n - \rho(n-1)]}{[(\rho n + \rho(n-1)]}$ 2

Where **ρn** is the layer resistivity of the nth layer, **ρ (n−1)** is the layer resistivity overlying the nth layer. The equation expressing **r** is modelled using a self-designed computation software using MatLab programming language for speedy computation.

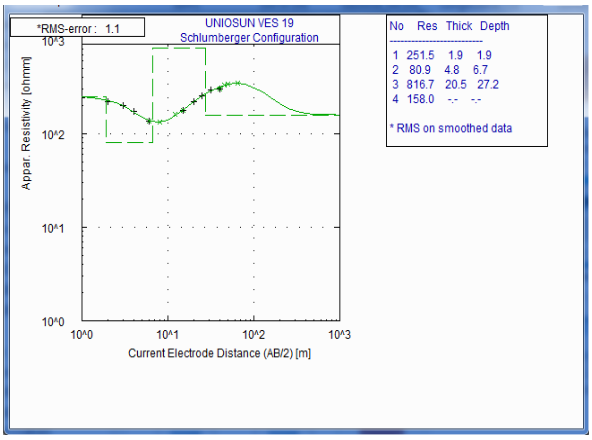
Result and Discussion

Frequency distribution of curve types

Table 1 presents the frequency distribution of the 30 vertical electrical sounding curves (Figure 3) derived from the field data. The curves were categorised into 10 types: A, H, K, Q, HA, HK, KH, KQ, QH, and HKH. The H curve type was the most prevalent, comprising 30% of the total VES points, followed by the HK curve at 23.3%, the HA curve at 20%, and the KH curve at 6.7%.

Table 1: Showing samples of the subsurface lithology delineated

VES point	Number of layers	Resistivity value (Ωm)	Curve type	Inferred lithology
3	1	461.7	H	Top layer
	2	195.9		Weathered layer
	3	1026.7		Fresh basement
6	1	1033.6	H	Top layer
	2	158.7		Weathered layer
	3	478.5		Fresh basement
7	1	668.2	H	Top layer
	2	192.1		Weathered layer
	3	5478.9		Fresh basement
8	1	619.4	H	Top layer
	2	167.6		Weathered layer
	3	3680.4		Fresh basement



```
No   Res   Thick  Depth
-------------------------
1  251.5   1.9    1.9
2   80.9   4.8    6.7
3  816.7  20.5   27.2
4  158.0   -.-    -.-

* RMS on smoothed data
```

Figure 3: Showing sample of the VES curves obtained from location 19

Geoelectric layer interpretation

The quantitative interpretation of the geoelectric data as obtained and provided in Table 2 revealed three (3) to four (4) geoelectric layers. The identified layers are Top layer, Weathered layer (sandy/clay/laterite), fractured basement and fresh basement. Protective capacity of aquifer is favoured by relatively high basement resistivity value [15, 16, 17, 18]. The resistivity values of the basement in this study ranged from 46–3423.7 Ωm.

The main aquifer unit is usually the weathered layer whereby the fractured layer offers an added advantage to Groundwater occurrence.

Reflection coefficient and longitudinal conductance (S)

The reflection coefficient (**r**) value measures more adequately, the basement's protective capacity,the low value of the reflection coefficient indicates fractured basement in a crystalline. This implies that reflection coefficient (**r**) like resistivity value (**ρ**) is indirectly proportional to Groundwater occurrence in basement terrain this implies low value of **r** indicates an aquifer with promising Groundwater potential but with equivalent vulnerability to pollution from runoff water. This is why it is considered more reliable to use **r** instead of **ρ** in both Groundwater occurrence modelling and aquifer vulnerability prediction evaluation [19, 20, 21]. Table 2 presents the samples of estimated values of the reflection coefficient for each VES point.

Table 2: Showing the Reflection coefficient and longitudinal unit conductance of sampled VESpoints

VES point	Number of layers	Reflection Coefficient	Longitudinal unit conductance
1	1		
	2		
	3	-0.363	0.2813
	4		
2	1		
	2		
	3	0.866	0.2129
	4		
3	1		
	2		
	3	0.680	0.1903
4	1		
	2		
	3	0.575	0.4444

Table 3: Showing the overburden thickness protective capacity rating based on Longitudinal unit conductance values adapted from [14]

Total longitudinal unit conductance	Overburden thickness protective capacity
<0.10	Poor
0.1 – 0.19	Weak
0.2 -0.79	Moderate
0.8 – 4.9	Good
5 – 10	Very good
> 10	Excellent

Using the modified model of longitudinal unit conductance (S) versus the protective capacity of overburden materials against contaminant infiltration, as proposed by Oladapo and Akintorinwa [14], (Table 3), values of S less than 0.1 are considered poor for aquifer protection, while values greater than 4.9 are considered excellent. Based on this model, the study area is largely dominated by aquifers with moderate and weak protective capacities when considering longitudinal unit conductance alone. Table 4 presents the classification samples by VES points, and Table 5 shows the frequency distribution of aquifer protective capacities. A pie chart in Fig. 4, illustrates these classifications, ranging from poor to good.

Table 4: Samples of the protective capacity rating of the overburden thickness of the study areabased on estimated longitudinal unit conductance values

VES point	No. of layers	Resistivity value (Ωm)	Longitudinal unit conductance	Protective capacity rating of overburden thickness based on longitudinal unit conductance values
1	1	209.5		
	2	10.5		
	3	835.1	0.2813	Moderate
	4	390.6		
2	1	216.0		
	2	54.7		
	3	244.9	0.2129	Moderate
	4	3423.7		
3	1	461.7		
	2	195.9		
	3	1026.7	0.1903	Weak
4	1	202.2		
	2	59.5		
	3	220.8	0.4444	Moderate
5	1	268.4		
	2	303.5		
	3	25.4	0.6912	Moderate
	4	90.1		

Table 5: Frequency distribution table of protective capacity ratings of overburden materials predicted at different VES points

Protective capacity rating of overburden materials	VES points belonging to each rating category	Total VES points in each category of overburden materials protective capacity rating
Good	17	1
Moderate	1, 2, 4, 5, 6, 9, 12, 19, 23, 27, 28, 29	12
Weak	3, 8, 10, 11, 13, 14, 15, 16, 18, 20, 21, 22, 24, 25, 26, 30	16
Poor	7	1
Total		**30**

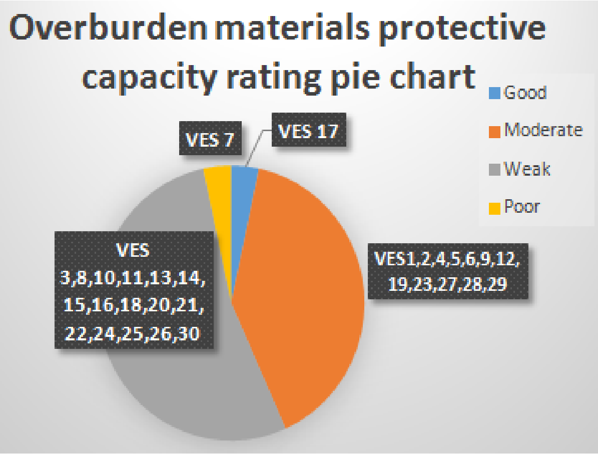


Figure 4: Showing the overburden materials protective capacity rating on the basis of longitudinalunit conductance values frequency distribution with respect to VES points

Spatial distribution of protective capacities

The results from the Aquifer Protective Capacity Rating Map (Fig. 5), based on longitudinal unit conductance values, reveal a spatial distribution of protective capacities across the study area. The majority of the VES points fall under the moderate to weak protective capacity classifications, indicating that the aquifers in these regions have limited defense against contamination. Specifically, areas with weak protection are more prevalent in the central and eastern parts of the map, encompassing VES points such as VES 3, VES 8, and VES 16. Meanwhile, regions with poor protective capacity, particularly in the northern and northeastern parts (e.g., VES 11, VES 22, VES 23), are most vulnerable to contamination due to the thin or permeable nature of the overburden materials.

Contrariwise, only a few areas exhibit good protective capacity, mainly concentrated in the northwestern and southeastern sections, as seen at VES points like VES 5 and VES 10. These areas indicate thicker or less permeable overburden, providing a stronger defense against contaminant infiltration. Overall, the results suggest that while a majority of the aquifers are moderately protected, a significant portion remains vulnerable, necessitating focused groundwater management, especially in areas with poor and weak protection.

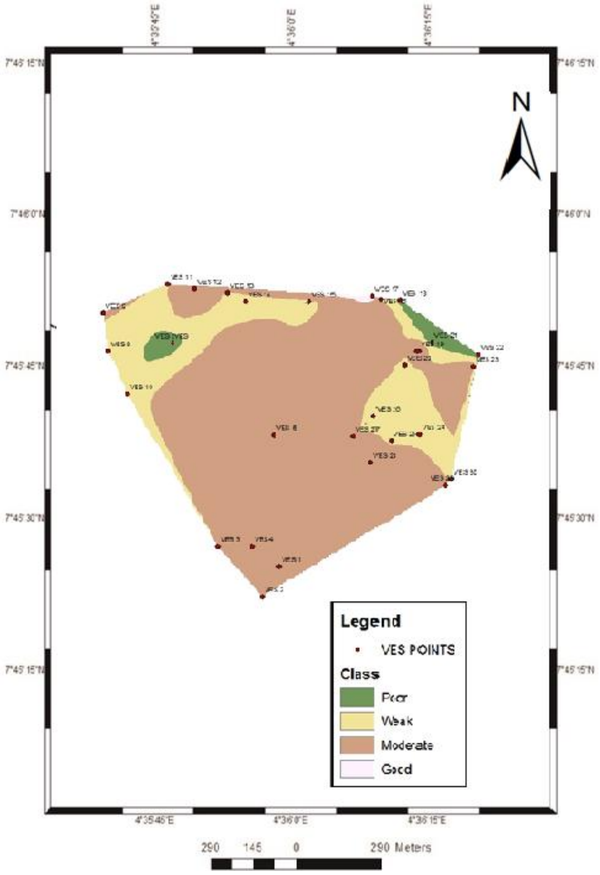


Figure 5: Aquifer protective capacity rating map as deduced from longitudinal unit conductance values

Table 6: Protective capacity ratings of overburden materials obtained at different VES points

Reflection coefficient range of values	Aquifer protective capacity
r > 0.8	Good
0.5 ≤ r ≤ 0.8	Moderate
≤ r ≤ 0.4	Weak
< 0.1	Poor

It is important to note that aquifer vulnerability to contaminants like runoff, sewage, and waste disposal is not solely determined by the vulnerability of the overburden materials. An aquifer with weak overburden protection may still have strong protective capacity due to its reflection coefficient (r), which measures the bedrock's ability to resist infiltration. A low reflection coefficient (r < 0.8) indicates fractured or weathered bedrock, favorable for groundwater potential [1, 13], Conversely, a high r-value indicates strong protective capacity of the basement. Table 6 presents aquifer protective capacity ratings based on the reflection coefficient, with the final protective capacity ratings shown in Table 7.

Table 7: Aquifer protective capacity rating based on reflection coefficient values

VES point	No. of layers	Rv. (Ωm)	Thic. (m)	Depth (m)	RC	Apcr.
1	1	209.5	0.6	0.6		
	2	10.5	2.6	3.4		
	3	835.1	25.7	29.1	-0.363	Poor
	4	390.6				
2	1	216.0	4.0	4.0		
	2	54.7	8.8	12.8		
	3	244.9	8.2	21.0	0.866	Good
	4	3423.7				
3	1	461.7	20.2	20.2		
	2	195.9	28.7	48.9		
	3	1026.7			0.680	Moderate
4	1	202.2	15.1	15.1		
	2	59.5	22.0	37.1		
	3	220.8			0.575	Moderate
5	1	268.4	9.3	9.3		
	2	303.5	6.9	16.2		
	3	25.4	16.1	32.3	0.560	Moderate
	4	90.1				

Rv = Resistivity value; **Thic.** = Thickness; **RC** = Reflection coefficient; **Apcr.** = Aquifer protective capacity rating

Aquifer protective capacity based on reflection coefficient

The Aquifer Protective Capacity Rating Map based on the Reflection Coefficient (Fig. 6) illustrates the spatial variation in the ability of aquifers to resist contaminant infiltration across the study area. The map categorizes the aquifers into four protection classes: poor, weak, moderate, and good, represented by different colors. Most of the study area is dominated by moderate to weak protective capacities. The moderate protection areas, depicted in brown, are primarily situated in the central and western parts of the map, such as around VES points 5, 2, and 10, indicating a relatively balanced aquifer defense against contaminants. Weak protective capacities, shown in yellow, are scattered across the map, particularly around VES points 17, 7, and 16. These areas are moderately susceptible to contamination due to the less fractured nature of the basement rock, which offers limited protection.

Conversely, areas with poor protective capacities, indicated in green, are more vulnerable to contamination. These regions are concentrated in the northern and eastern sections of the map, such as around VES points 11, 12, and 24. The high vulnerability in these regions suggests that the aquifers here are less capable of preventing contaminants from infiltrating, possibly due to fractured or weathered bedrock. A small portion of the map, represented in light pink, demonstrates good protective capacity, found near VES point 30. This indicates that the aquifers in this area are more robust, with a high reflection coefficient value suggesting strong resistance to contaminant infiltration. Overall, the results indicate that while some areas show moderate to good protection, a significant portion of the study area remains at risk, particularly in regions with weak and poor protective capacities. Table 8 showstheAquifer Protective Capacity Rating of Each VES Point based onthe Reflection Coefficient while Fig. 7 shows the Pie chart representativeof the protective capacity rating of Aquifers based onthe Reflection Coefficient

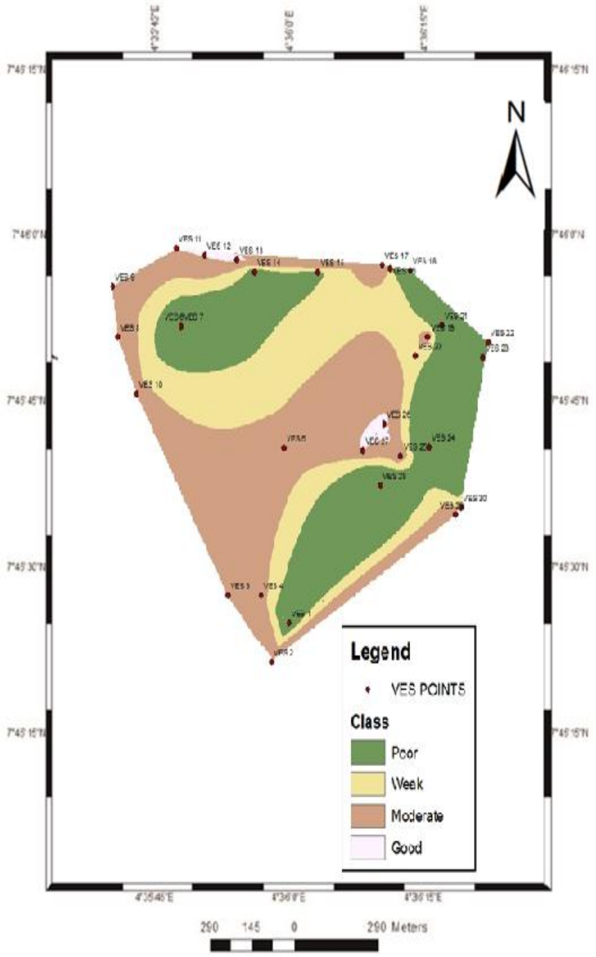


Figure 6: Aquifer protective capacity rating map on the basis of reflection coefficient

Table 8: Aquifer protective capacity rating of each VES point based on reflection coefficient

Aquifer protective capacity rating	VES points	Total VES points	% of VES points in each category
Good	2, 9, 12, 13, 24, 26, and 27	7	23.33
Moderate	3, 4, 5, 8, 10, 17, 19, 25, and 29	9	30
Weak	16, 20, and 30	3	10
Poor	1, 6, 7, 11, 14, 15, 18, 21, 22, 23, and 28	11	36.67
Total		**30**	**100**

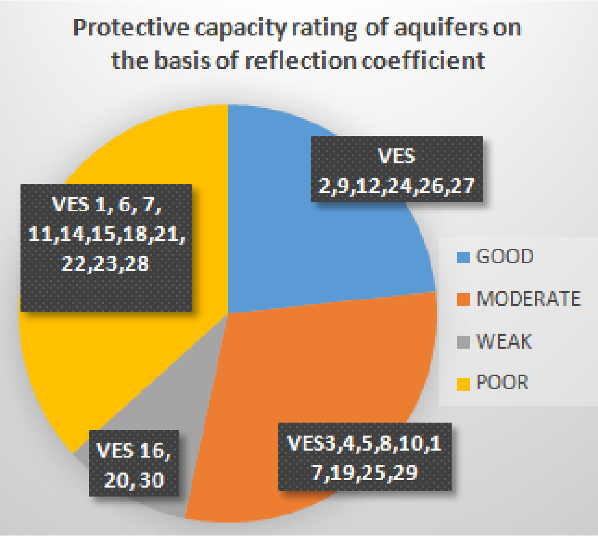


Figure 7: Pie chart showing the protective capacity rating of aquifers based on reflection coefficient

Harmonized groundwater protection assessment

Table 9 presents a logical framework for harmonizing groundwater protection ratingsbased on the combination of two critical parameters: overburden materials protective capacity andaquifer protective capacity. By integrating these parameters, a comprehensive assessment of groundwater vulnerability to contamination is achieved. Each row of the table demonstrates how varying levels of protection from the overburden and aquifer interact to produce a harmonized rating, which gives a more accurate picture of the groundwater's overall susceptibility to contaminants.

Table 9: Logic of the harmonized groundwater protection rating from contaminants

Overburden materials protective capacity rating	Aquifer protective capacity rating	Harmonized rating of Groundwater protection from contaminants by combining the two parameters
Poor	Poor	Poor
Weak	Weak	Weak
Weak	Poor	Very weak
Poor	Moderate	Weak
Moderate	Weak	Fairly moderate
Moderate	Moderate	Fairly Good
Good	Poor	Moderate
Good	Moderate	Good
Good	Good	Very Good

The first three rows indicate that when both the overburden and aquifer protection levels are low (poor or weak), the harmonized rating is also low, reinforcing the heightened vulnerability of such areas. For instance, when both are rated "poor," the overall groundwater protection is consistently rated as poor, and in cases where the overburden is weak but the aquifer protection is poor, the harmonized rating becomes very weak, indicating extreme vulnerability. This emphasizes that weak or poor overburden materials exacerbate aquifer susceptibility.

The Table further reveals that when moderate or good protective capacities are present in either the overburden or aquifer, there is an improvement in the harmonized rating. For example, when the overburden is poor but the aquifer protection is moderate, the rating improves to weak, suggesting that moderate aquifer protection can somewhat mitigate weak overburden. Similarly, when both the overburden and aquifer are rated as moderate, the combined rating is fairly good, showing balanced protection. The highest rating of very good is assigned when both parameters exhibit goodprotective capacities, indicating areas with the least vulnerability to contamination. This Table (9) effectively demonstrates the significance of combining multiple protective factors to generate a more holistic groundwater protection assessment.

Conclusion

An electrical resistivity investigation was conducted to assess the groundwater potential of Uniosun, Osogbo campus, southwestern Nigeria, focusing on both storage capacity and water quality. The study utilized three key geoelectric parameters—longitudinal conductance, reflection coefficient, and overburden thickness—to evaluate groundwater potentiality. Data was collected from 30 Vertical Electrical Sounding (VES) points using the Schlumberger and half Schlumberger arrays with a maximum current electrode spacing (AB/2) of 80 to 100 meters at each point, employing the Geosensor DDR2 resistivity meter. Analysis of the data, using Winresist software, identified ten distinct curve types in the study area, including A, H, K, Q, HA, HK, KH, KQ, QH, and HKH. The H curve type was the most dominant. The geoelectric results revealed that the subsurface of the study area is composed of 3 to 5 distinct rock layers: topsoil, clay or clayey sand, sand or laterite, fractured basement, and fresh basement. In terms of aquifer protective capacity, the study found a range of ratings from poor to very good. The poor protective capacity was most prevalent, covering 30% of the VES points. The remaining 70% of the points exhibited protective capacities ranging from weak to very good. This suggests that while certain areas within the campus are vulnerable to contamination, other areas may offer more protection, making them more suitable for long-term groundwater storage and use. The results indicate that groundwater management strategies in the region should consider these varying levels of protective capacity to mitigate potential contamination and ensure a sustainable water supply.It is important to note that this study’s assessment of aquifer protective capacity is predictive, and validation depends on the presence of contamination threats. At the time of this study, there was little to no groundwater contamination threat in the Uniosun Osogbo campus area. Therefore, the conclusions are based on theoretical analysis and comparison of the results obtained from the two protective capacity parameters considered. However, given the rapidly growing population and influx of medium-scale industries driven by the university’s expansion, the area is likely to face significant waste disposal challenges in the future. As a result, the groundwater in Uniosun, Osogbo campus could face a considerable contamination threat in the years to come.

Conflict of interest: The authors declare that there is no conflict of interest whatsoever.

References

[1] Bayewu, O. O. (2018). Geoelectric investigation of aquifer vulnerability and groundwater quality assessment. *Nigerian Journal of Geology*, 62(2), 115-125.

[2] Margat, J. (1968). Vulnerability of groundwater contamination. Proceedings of the International Symposium on Groundwater Pollution, Warsaw, Poland.

[3] National Research Council of the United States of America (NURCUSA) (1993). Groundwater vulnerability assessment: Contamination potential under conditions of uncertainty. *National Academy Press*.

[4] Ball, J. W., Nordstrom, D. K., & Zachara, J. M. (2004). Geochemical processes controlling groundwater quality in a small coastal watershed. *Water Resour. Res.*, 40(10), W10408. https://doi.org/10.1029/2003WR002785

[5] Gogu, R. C. & Dassargues, A. (2000). Current trends and future challenges in groundwater vulnerability assessment using overlay and index methods. *Env. Geology*, 39(6), 549-559. https://doi.org/10.1007/s002540050466

[6] Vrba, J. & Zaporozec, A. (1994). *Guidebook on Mapping Groundwater Vulnerability*. International Contributions to Hydrogeology, Vol. 16. Int. Association of Hydrogeologists.

[7] Javadi, S., Kavehkar, N., Mousavi, S. F. & Mohammadi, K. (2011). Modification of DRASTIC model to map groundwater vulnerability to pollution using nitrate measurements in agricultural areas. *Journal of Hydrology*, 511, 461-472. https://doi.org/10.1016/j.jhydrol.2014.01.001

[8] Liggett, J. E. & Talwar, S. (2009). Groundwater vulnerability assessments and integrated water resource management. *Water Resources Management*, 23(11), 2459-2489. https://doi.org/10.1007/s11269-009-9404-7

[9] Nobre, R. C. M., Rotunno Filho, O. C., Mansur, W. J., Nobre, M. M. M. & da Silva Barros, M. T. L. (2007). Groundwater vulnerability and risk mapping using GIS, modeling, and a fuzzy logic tool. *Env. Geol.*, 49(1), 802-813. https://doi.org/10.1007/s00254-006-0177-6

[10] Tesoriero, A. J., Voss, F. D. & Wolock, D. M. (1998). Groundwater vulnerability to nitrate contamination: A study of modeling and vulnerability mapping. *Water Reso Res.*, 34(3), 309-319. https://doi.org/10.1029/97WR03434

[11] Aller, L., Bennett, T., Lehr, J. H., Petty, R. J. & Hackett, G. (1985). DRASTIC: A standardized system for evaluating groundwater pollution potential using hydrogeologic settings. *National Water Well Asso. and Robert S. Kerr Env. Res. Laboratory*. EPA/600/2-85/018

[12] Rahaman M. A. (1976) Review of the basement geology of Southwestern Nigeria. Geology of Nigeria, pp. 41-58.

[13] Olayinka, A. I. (1996). Geophysical siting of boreholes in crystalline basement areas of southwestern Nigeria. *Journal of African Earth Sciences*, 20(3), 185-198. https://doi.org/10.1016/0899-5362(95)00102-6

[14] Oladapo, M. I. & Akintorinwa, O. J. (2007). Hydrogeophysical study of Ogbese southwestern Nigeria. *Global Journal of Pure and Applied Sciences*, 13(1), 55-61. https://doi.org/10.4314/gjpas.v13i1.16726

[15] Akinlalu, A. A., Omosuyi, G. O. & Bayewu, O. O. (2017). Geophysical characterization of groundwater potential in parts of southwestern Nigeria. *Environmental Earth Sci*., 76(8), 337. https://doi.org/10.1007/s12665-017-6642-3

[16] Anwar, H. S., Khan, M. R. & Mahmood, S. (2003). Groundwater contamination vulnerability using the DRASTIC model. *Hydrogeology Journal*, 11(2), 312–329. https://doi.org/10.1007/s10040-003-0241-1

[17] Fajana, A. O. (2020a). Groundwater aquifer potential using electrical resistivity method and porosity calculation: A case study. *NRIAG J. of Astronomy and Geophy*., 9(1), 168–175. https://doi.org/10.1080/20909977.2020.1728955

[18] Fajana, A. O. (2020b). Integrated geophysical investigation of aquifer and its groundwater potential in Phase-1 and 2, Federal University Oye Ekiti, South-Western Basement Complex of Nigeria. *Modeling Earth Systems and Environment*, 6(3), 1707–1725, https://doi.org/10.1007/s40808-020-00739-4

[19] Meju, M. A., Fontes, S. L., Oliveira, M. F. B., Lima, J. P. R., Ulugergerli, E. U. & Carrasquilla, A. A. (1999). Regional aquifer mapping using combined VES-TEM-AMT/EMAP methods in the semiarid eastern margin of Parnaiba Basin, Brazil. *Geophysics*, 64(2), 337–356. https://doi.org/10.1190/1.1444539

[20] Omosuyi, G. O. (2000). Investigation of the geoelectric parameter, Dar Zarrouk parameters and aquifer characteristics of some parts of North-Central Nigeria. *J. Sci. Engr. Tech*., 7(4), 2835–2848.

[21] Omosuyi, G. O. (2010). Geoelectric assessment of groundwater prospect a vulnerability of overburden aquifers at Idanre, Southwestern Nigeria. *Ozean J. Appl. Sci*., 3(1), 19–28.

Citing this Article

Fajana, A. O. & Arinloye, A. S. (2025). Evaluation of aquifer protective capacity using electrical resistivity method: A case study of Osun State University, Osogbo Campus, Southwestern Nigeria. *Lafia Journal of Scientific and Industrial Research, 3*(1), 55 – 63. https://doi.org/10.62050/ljsir2025.v3n1.369