

# Discovery Nature

## To Cite:

Uchegbulam O, Igben JL. A comparative analysis of aquifer depths and accessibility to portable water in Western Niger Delta Nigeria. *Discovery Nature* 2025; 2: e10dn3139  
doi: <https://doi.org/10.54905/disssi.v2i4.e10dn3139>

## Author Affiliation:

<sup>1</sup>Department of Applied Geophysics, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria.

<sup>2</sup>Department of Geology and Petroleum Studies, Western Delta University, Oghara, Delta State, Nigeria.

## \*Corresponding Author

Okezie Uchegbulam,  
Department of Applied Geophysics, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria  
Email: [uchegbulam.okezie@fupre.edu.ng](mailto:uchegbulam.okezie@fupre.edu.ng)  
ORCID ID: 0000-0003-3850-1532  
Phone No: +2348033194598

## Peer-Review History

Received: 03 June 2025  
Reviewed & Revised: 16/June/2025 to 27/September/2025  
Accepted: 07 October 2025  
Published: 14 October 2025

## Peer-Review Model

External peer-review was done through double-blind method.

Discovery Nature  
pISSN 2319-5703; eISSN 2319-5711



© The Author(s) 2025. Open Access. This article is licensed under a [Creative Commons Attribution License 4.0 \(CC BY 4.0\)](http://creativecommons.org/licenses/by/4.0/), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

# A comparative analysis of aquifer depths and accessibility to portable water in Western Niger Delta Nigeria

Okezie Uchegbulam<sup>1\*</sup>, Jomata Lucky Igben<sup>2</sup>

## ABSTRACT

Most studies on household's accessibility to portable water focus mainly on associated problems of demand and supply with little or no emphasis on the depth of water table in relation to availability of water. This study aims to determine the depth of aquifers in the three selected settlements in Delta and Edo States in the Western Niger Delta region and assess the physical distance traversed by the population to points of portable water. Data were obtained from an admixture of comparative experimental and survey research. Earth Resistance Meter (Petrozenith-Terometer) was used to obtain Vertical Electrical Sounding (VES) data and questionnaires were randomly administered on fifty (50) households to ascertain the population's accessibility to portable water. Data were analysed using descriptive statistics and ANOVA. The study reveals that water table depths of 46m, 63m and 288m for Koko, Ibusa and Ekpoma respectively influence the households' accessibility to portable water as 31.3% move over 1km to access portable water. Moreover, there was significant variation F ( $F = 1.267$  and  $2.067$  for Koko and Ibusa;  $0.671$  and  $6.850$  for Koko and Ekpoma,  $p < 0.5$ ) in the distance to points of portable water. The study recommends infrastructural development to facilitate the supply of water to areas where accessibility is poor.

**Keywords:** Accessibility, aquifer, groundwater, resistivity, VES

## 1. INTRODUCTION

The scientific study of water in its various locations is known as hydrology. Water is ubiquitous and is found in the various components of Earth; namely, atmosphere, hydrosphere, lithosphere and biosphere (Igben, 2012). In the lithosphere, water is found on and beneath the surface of the Earth, as surface water and groundwater respectively. Furthermore, underground water is found in the different layers of the lithosphere and the amount is dependent upon the retentive capacity of the rocks. The water-retaining or bearing layer where most water is found is the aquifer, where underground water is explored and harvested for domestic and other purposes.

The depth of water bearing rocks or aquifers varies from one location to another even in regions that have similar geology because of topographic complexities, local

geology, varied seepage of water into the subsurface and other reasons. These have posed concern to water exploration in some regions and the consequent scarcity of portable water in some places. However, in areas where potable water is not available on the surface as a result of adverse climatic conditions or pollution, the local population depends on harvesting water from the aquifer to meet their needs; thus the accessibility to water is linked to depth of the aquifer. In other words, the availability and accessibility of water whether surface or groundwater has a direct relationship with human habitation and economic growth of an area.

Groundwater exploration is concerned with identification of water bearing sands and the depth where groundwater can be exploited in wet and dry seasons using different geophysical methods. The electrical resistivity method is the preferred geophysical method for this study because aquifer units have different electrical conductivity compared to other formations in the subsurface. The method is non-invasive and the equipment is readily available. For instance, in the sedimentary terrain of the Niger Delta Region (NDR), depths of aquifer units have been delineated using electrical method. Water bearing sands vary in the region as reported by some researchers (Akpoborie et al., 2011; Uchegbulam and Eruotor, 2024).

Several studies on the accessibility to portable water in Nigeria dwell on significant challenges of demand and supply with varying levels of access and availability in different regions of the country. For instance, Chimezie et al., (2020) studied the sources, availability and accessibility of potable water in the three senatorial zones; namely, Okigwe, Owerri, Orlu zones of Imo State, Nigeria. The study identified borehole water as the primary (65.4%) source of drinking water among the 800 respondents interviewed. More than half (53.8%) of the respondents have their water source situated in less than 50m from their houses, of which 33% have their boreholes within their compounds. About half of the respondents (46.2%) visit water bodies daily at a distance. The study area is urban and there were infrastructural facilities for the supply of water to the population; hence the short distance to points of portable water by over 50% of the residents. Other empirical studies on accessibility to portable water were done in Oyo State, Solihu and Bilewu, (2021), Lagos Metropolis (Akoteyon, 2019), two selected rural communities of Plateau State, (Okoh et al., 2021) and Ikole-Ekiti (Oloye et al., 2022).

However, (Fashae et al., 2024) considered the influence of geology on the accessibility of portable water. The authors' study revealed that selected area in Ibadan metropolis experienced severe water shortage due to their rocky geological composition which coupled with poor infrastructural deficiency of communal boreholes, and irregular power supply contributed immensely to erratic water supply particularly during the dry season.

Water is life (Domènech, 2011) and is essential for human existence and economic growth of individuals and a country. Hence its availability and accessibility are necessary for human existence. Since there is much reliance on ground water because surface water like rivers and streams are polluted in most cases while sea water has some degree of salinity, there is the need to explore and document aquifer units in various locations vis-à-vis households' accessibility to portable water. Therefore, the objectives of the study are to; determine the depth of aquifers in the selected settlements and to assess the physical distance the population traversed to points of portable water. The study is predicated by the null hypothesis that there is no significant variation in the distance to points of portable water.

### **The study area**

The study covers three settlements; namely, Koko and Ibusa in Delta State and Ekpoma in Edo State, all are situated in the Western part of Niger Delta Region as shown in Figure 1. Koko is in Warri North Local Government Area (LGA) of Delta State. It lies between latitude 6° 00' – 6° 10' N and longitude 5° 26' 30" - 5° 28' 30" E, with an elevation of about 8.4m. Ibusa is in the northern part of Delta State, it is located between Longitude 6°32'E and 6°34'E and Latitude 6°32'N and 6°28'N, with an elevation of about 113m above sea level. Ekpoma is in Esan LGA in the central part of Edo State, it is located within latitude 6° 44' 10" N and longitude 6° 10' 13.9" E. Its elevation is about 345m above sea level. The map of Niger Delta States showing the study areas is displayed in Figure 1.

### **Geology and hydrogeology of the study area**

The Niger Delta Region is a geologic area in West Africa also known as the Niger Delta basin. The Niger Delta province is in Southern Nigeria, a delta is an accumulation of sediments which originates at the mouth of a river where it enters a lake or the sea in more than one mouth (Igben, 2016). It is usually developed only where there is no tidal or current action capable of removing the sediment as soon as it is formed, hence the delta progresses from the coastline (Opute, 2016).

The stratigraphic columns of the Niger Delta from top to bottom are Benin, Agbada and Akata formations. Benin Formation is the primary aquifer unit. The aquifer in the Benin formation is largely phreatic, these formations are overlain by different types of

quaternary deposits made up of topsoil, red laterite, clay, fine sand, medium sand and coarse sand in the form of pebbles. The stratigraphic geologic unit of the Niger Delta is shown in Table 1.

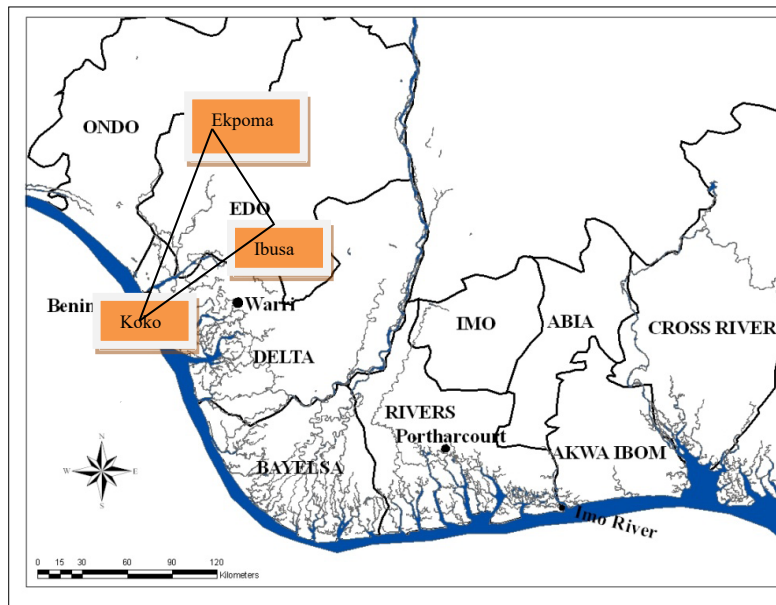


Figure 1. Map of Niger Delta showing the study areas (After GAMERS 2017).

Table 1. Geologic Units of the Niger Delta (Doust and Omatsola, 1990)

Geologic Unit	Lithology	Age
Alluvium (General) Freshwater Backswamp and meander belt Mangrove and salt water / backswamps Sombreiro – warri deltaic plain	Gravel, sand, clay, silt Sand, clay, some silt and gravel Medium – fine sand, clay and some silt Sand, clay and some silt	Quaternary
Benin Formation (coastal plain sand)	Coarse to medium sand with subordinate silt and clay lenses	Miocene
Agbada Formation	Mixture of sand, clay and silt	Eocene
Akata Formation	Shale	Paleocene

## 2. MATERIALS AND METHODS

### Research Design

The design adopted for this study is an admixture of comparative experimental and survey research. While the former was done to determine and compare the depth of the water table in the selected settlements, the later was used to determine the distance to the points of portable water collection by a sample of households. These techniques were adopted as recommended by Kothari and Garg, (2019).

### Data Collection

Earth resistance meter (Petrozenith Terametter) was used in the survey to obtain Vertical Electrical Sounding (VES) data at the three locations; namely, Koko, Ibusa and Ekpoma. Schlumberger array was employed because of its good vertical resolution. A total spread (L) of 600m distances in each location was covered. The apparent resistivity  $\rho_a$  was calculated using the relation

$$\rho_a = KR$$

$$K = \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \pi$$

where  $AB = L$  ..... Current electrode spacing in meter

$MN = a$  ..... potential electrode spacing in meter

$\pi = 3.14$

for  $L \geq a$

$$K = \frac{\pi L^2}{2a}$$

Therefore, apparent resistivity  $\rho_a = KR$

Tables 2, 3 and 4 are VES data for Koko, Ibusa and Ekpoma respectively.

**Table 2.** VES data of Koko

AB/2 (L) (m)	MN/2 (a)(m)	R (Ω)	k (m)	$\rho_a$ (Ωm)
1	0.5	32.9700	2.3562	77.684
2	0.5	7.7400	11.781	91.185
7	0.5	1.0500	153.15	160.81
10	1	1.0100	155.51	157.07
14	1	0.8740	306.31	267.72
17	1	0.2734	452.39	123.7
21	1	0.1414	691.15	97.708
32	5	0.0707	313.85	22.18
47	5	0.4243	686.12	29.112
70	5	0.0623	1532	95.398
100	5	0.0482	3134	150.96
150	10	0.5538	3519	1949
200	10	0.0576	6267	361.36
250	10	0.0463	9802	454.32

**Table 3.** VES data of Ibusa

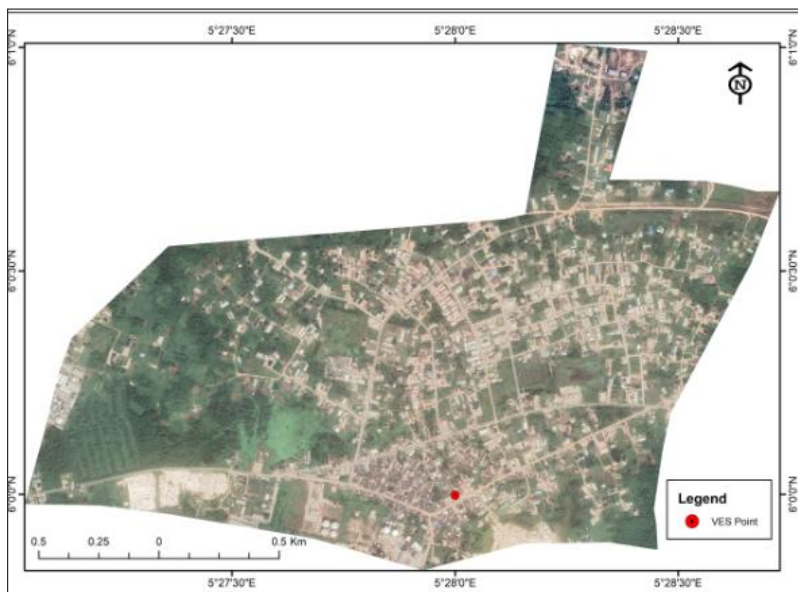
AB/2 = L (m)	MN/2 = a (m)	MN	R (Ω)	K (m)	$\rho_a$ (Ωm)
1	0.5	1	68.98	2.3562	162.5307
3	0.5	1	3.24	27.489	89.06436
5	0.5	1	0.77475	77.754	60.23991
10	0.5	1	0.07384	313.37	23.13924
10	2	4	0.47586	75.398	35.87889
17	2	4	0.34084	223.84	76.29363
21	2	4	0.31609	343.22	108.4884
32	2	4	0.21936	801.11	175.7315
47	2	4	0.13095	1732	226.8054
70	5	10	0.29705	1532	455.0806
100	5	10	0.13824	3134	433.2442

150	10	20	0.56805	3519	1998.968
200	10	20	0.21837	6267	1368.525
250	10	20	0.10879	9802	1066.36
250	15	30	0.24822	6521	1618.643
300	15	30	0.07396	9401	695.298

**Table 4.** VES data of Ekpoma

AB/2	MN/2	MN	R( $\Omega$ )	K(m)	$\rho_a$ ( $\Omega$ m)
1	0.5	1	573.06	2.3562	1350.244
2	0.5	1	141.45	11.781	1666.422
3	0.5	1	78.89	27.489	2168.607
5	0.5	1	39.33	77.754	3058.065
10	0.5	1	8.58	313.37	2688.715
17	0.5	1	2.99	907.13	2712.319
21	0.5	1	1.74	1385	2409.9
32	0.5	1	0.645	3216	2074.32
47	1	2	0.45643	3468	1582.899
70	1	2	0.20766	7695	1597.944
100	1	2	0.13593	15706	2134.917
100	3	6	0.55489	5231	2902.63
150	3	6	0.31163	11776	3669.755
200	3	6	0.25239	20939	5284.794
250	5	10	0.20168	19627	3958.373
250	10	20	0.3346	9802	3279.749
300	10	20	0.26522	14121	3745.172

The base maps showing the VES points and other features in Koko, Ibusa and Ekpoma are displayed in Figures 2, 3 and 4 respectively.



**Figure 2.** Google image of the study area in Koko showing the VES point.

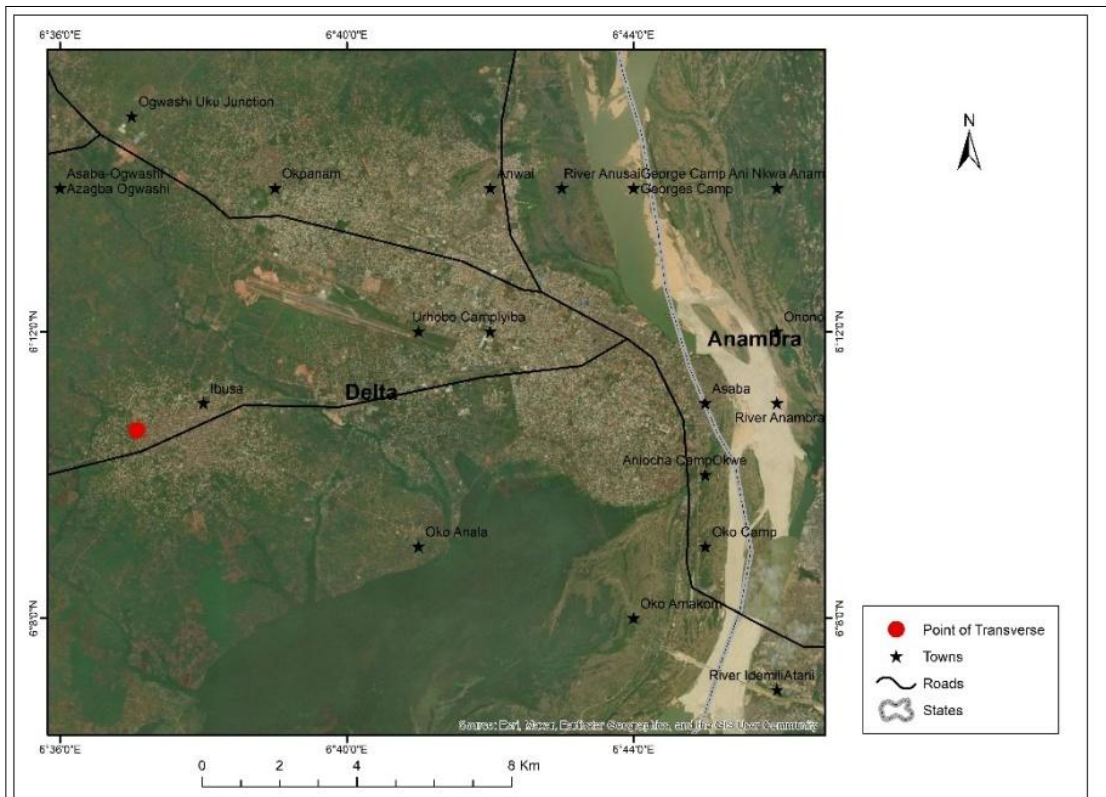


Figure 3. Google image of the study area in Ibusa showing the VES point.

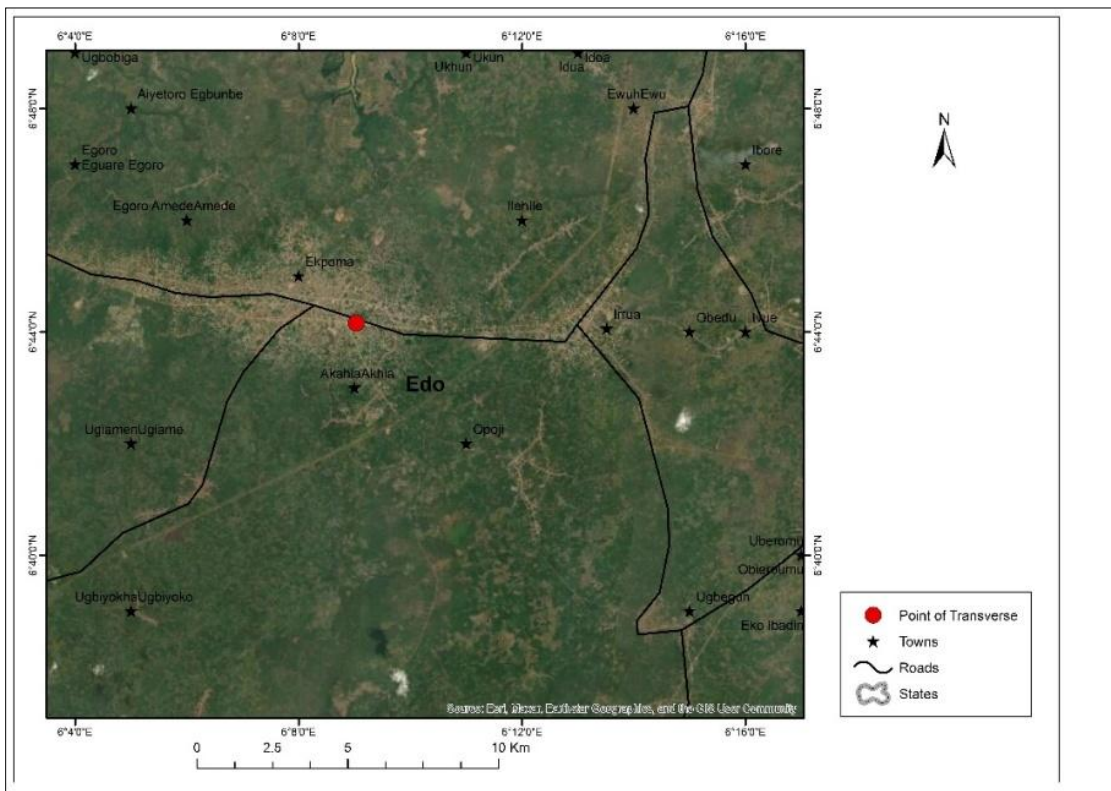


Figure 4. Google image of the study area in Ekpoma showing the VES point.

**Population and Sample**

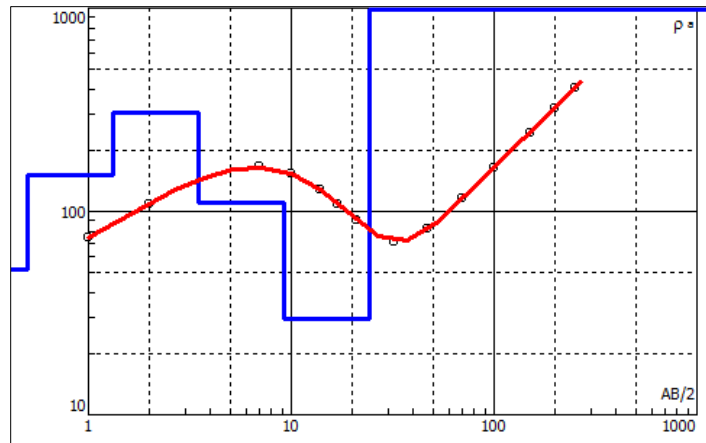
The population for the study includes all persons, male and female, who are resident in the study area. A purposive sampling procedure was used in the selection of settlements. The selected settlements are Koko, Ibusa, and Ekpoma. In each of the chosen settlement, fifty (50) households were randomly chosen. In all, 150 household heads or their representatives were interviewed for the study. The questionnaire covers the population’s accessibility to portable water, particularly the physical distance traversed by households.

**Data Analysis**

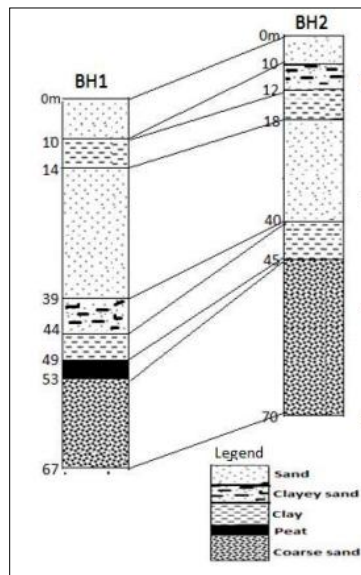
Information obtained from the questionnaire were analysed by descriptive statistics. Furthermore, the null hypothesis that there is no significant variation in the distance to points of portable water was tested by One-way Analysis of Variance (ANOVA). The Statistical Package for Social Sciences SPSS version 23 was used to facilitate the process of data analysis.

**3. RESULTS AND DISCUSSION**

The results of the resistivity data are presented as curves, figures and tables. The resistivity curve of VES in Koko is shown in Figure 5 and the geoelectric table in Table 5. The lithostratigraphy column of two boreholes (BH1 and BH2) of Koko shown in Figure 6 was used to compare the results obtained.



**Figure 5.** Apparent Resistivity graph of Koko VES

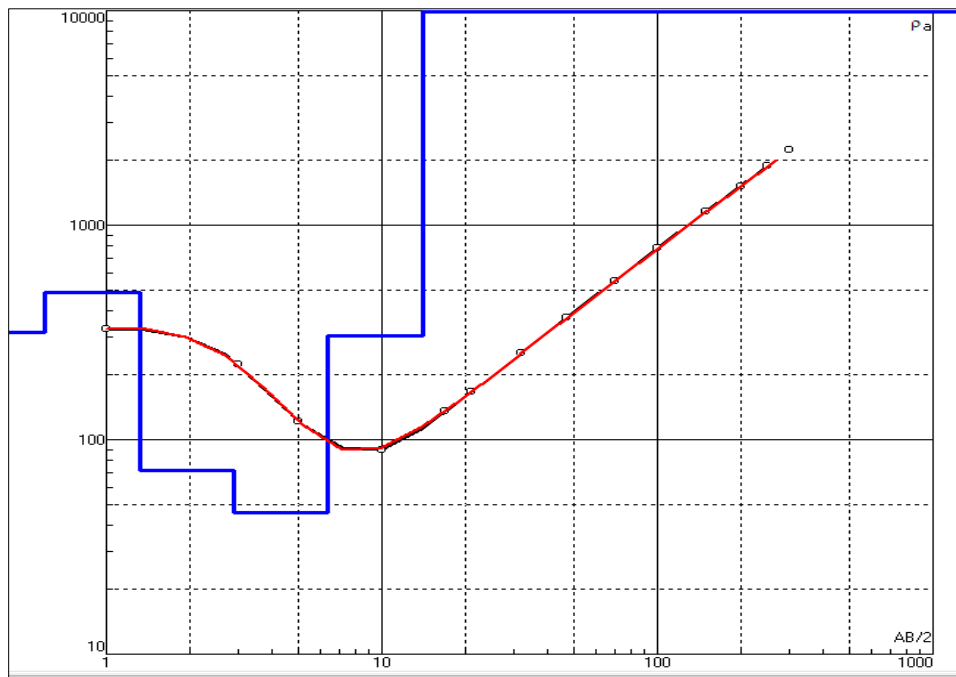


**Figure 6.** Lithostratigraphy of Koko for BH 1 and BH 2 (Modified after Ohwoghene-Asuma et al., 2019)

**Table 5.** Geoelectric table of Koko VES

Ves No	Layers	Resistivity ( $\Omega\text{m}$ )	Thickness (M)	Depth (M)	Curve Type Kh	Lithology
1	1	69.3	0.7	0.7	$Q_1 < Q_2 > Q_3 < Q_4$	Topsoil
	2	196.9	5.9	6.6		Sand
	3	66.8	38.7	45.3		Sandy clay
	4	341.7	---	---		Coarse sand

Apparent resistivity graph of Ibusa and the geoelectric table are shown in Figure 7 and Table 6.



**Figure 7.** Apparent Resistivity graph of IbusaVES

**Table 6.** Geoelectric table of IbusaVES

LAYER	RESISTIVITY	THICKNESS	DEPTH	LITHOLOGY
1	223.1	0.7	0.7	Sandy topsoil
2	69.2	2.3	3.0	Sandy clay
3	33.9	7.5	10.5	Clayey sand
4	174.5	52.5	62.9	Coarse sand
5.	621.3	---	-- ---	

Apparent resistivity graph of Ekpoma VES is shown in Figure 8 while the geoelectric table is depicted in Table 7. The topsoil in Koko is characterized by a resistivity value of 69.3 Ohm-m and a layer thickness of 0.7m (Table 5). While the top soil in Ibusa has a thickness of about 0.7m and it is composed of sandy soil with resistivity of 223.1  $\Omega\text{m}$  (Table 6). Ekpoma’s top soil has resistivity of 1325 $\Omega\text{m}$  with thickness of about 0.93m (Table 7). The soils in these layers are highly weathered due to its nearness to the surface and long exposure to weather changes.

The second identified layer is compose of sand with a resistivity of 196.9 Ohm-m and a thickness value of 5.9 m in Koko, being a sedimentary terrain, groundwater can be exploited here, though may not be portable due to its nearness to the surface and the thickness is thin. This is the depth at which most shallow boreholes reach and there is the possibility of wells being dry during dry seasons. The third layer is sandy clay with a resistivity of 66.8 Ohm-m and thickness of 38.7m, this is an aquitard and water here

cannot be transmitted easily because of the size of the pores as it is a sandy clay environment. The amount of clay mixed with sand tends to be high.

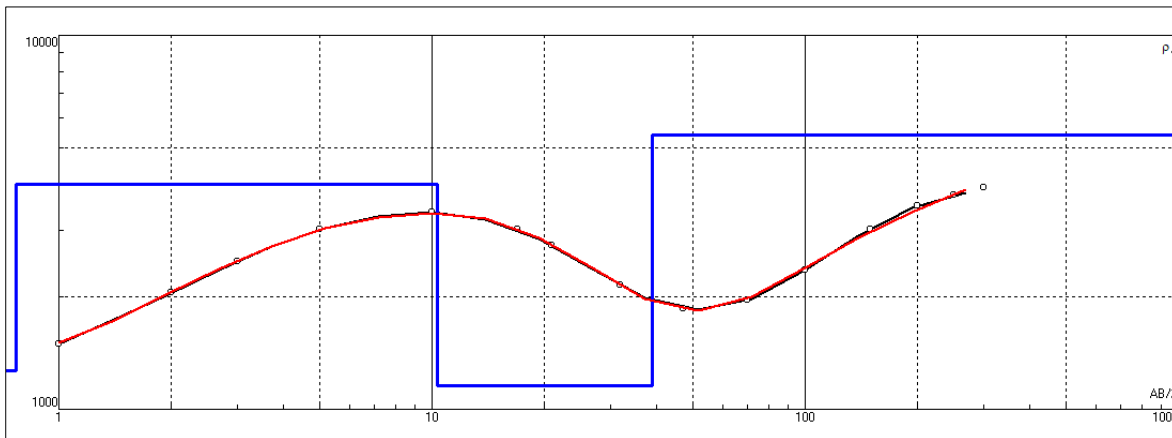


Figure 8. Apparent Resistivity graph of Ekpoma VES

Table 7. Geoelectric table of Ekpoma VES

LAYER	THICKNESS	DEPTH	RESISTIVITY	LITHOLOGY
1.	0.9278	0.9278	1325	Sandy topsoil
2.	3.41	4.338	4807	Clayey sand subsoil
3.	12.76	17.1	2726	Sandstone
4.	16.95	34.05	669.1	Sandy layer
5.	157.9	192.0	8308	Sandstone layer
6.	96.4	288.4	458.9	Sandy layer (Prospective)
7.	Undefined	Undefined	352.48	Sandy layer (Prospective)

The fourth substratum is composed of coarse sand having a resistivity value of 341.7 Ohm-m but the layer thickness could not be determined because the current terminated within this horizon. The coarse sand in this zone represents a confined aquifer unit where groundwater could be tapped with the assurance of getting water in wet and dry seasons because of the thickness of the layer. It is in agreement with the litho-stratigraphic column of Koko (Figure 6) used in comparing the result. In Ibusa, at the depth of about 63m and beyond with resistivity of 174.3Ωm and thickness of about 52m is composed of coarse sand. This is where groundwater can be exploited because of its fairly good permeability and porosity. It is in agreement with the findings of Okolie, (2010) in Ibusa and environs, confined aquifer were reported at the depth of about 40m and beyond. However, it depends on the location in the area.

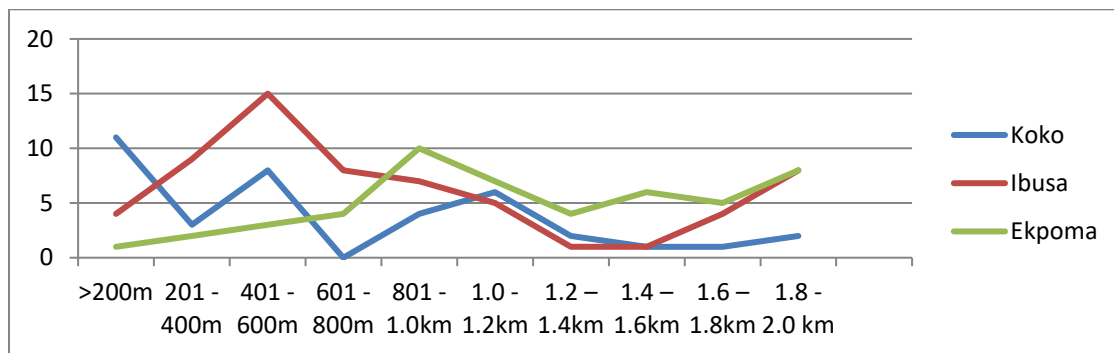
Water can be exploited at the depth of about 288m with resistivity of about 460Ωm in Ekpoma. This layer is composed of sand saturated with water. This is the depth where water can be exploited in wet and dry seasons known as confined aquifer. In summary, the three locations have different depths of aquifer units where groundwater can be exploited as a result of different topography, varied elevation and other geologic factors; which determine the physical distance to points of portable water.

**Distance to Points of Portable Water Collection**

Table 8 shows the distance respondents traversed to fetch portable water for use. It shows that a total of 12 respondents representing traversed over 1km to fetch water in Koko with a water table depth of 46m. While 17 respondents move the same distance in Ibusa, with a water table depth of 63m and above, 29 respondents traversed over 1km in Ekpoma with a depth of 288m. Only 15 respondents (Koko 11; Ibusa 3 and Ekpoma 1) traversed less than 200m. The rest of the respondents moved more than 200m. This finding is in contrast to the Nigerian National Water Sanitation Policy (FMWR, 2013), which stipulates the maximum distance of 250 meter-radius for end users of water. The linear distance traversed by respondents to point of water collection is shown graphically in Figure 9.

**Table 8.** Distance to Points of Portable Water Collection

Distance to points of portable water	Frequency	Frequency	Frequency
	Koko	Ibusa	Ekpoma
> 200m	11	4	1
201 – 400m	3	9	2
401 – 600m	8	15	3
601 – 800km	0	8	4
801 – 1.0km	4	7	10
1.0 – 1.2 km	6	5	7
1.2 – 1.4km	2	1	4
1.4 – 1.6km	1	1	6
1.6 – 1.8km	1	4	5
1.8 - 2.0 km	2	8	8



**Figure 9.** Distance traversed by Respondents.

To test the null hypothesis that there is no significant variation in the distance to points of portable water among the selected settlements, the One-way Analysis of Variance (ANOVA) was used. The result shows an F value of 1.267 and 2.067 for Koko and Ibusa and 0.671 and 6.850 for Koko and Ekpoma. These values are significant at 0.05 level of confidence. Therefore, there is variation among the three settlements in respect to the distance to points of portable water. The one-way Analysis of Variation (ANOVA) of the study area is shown in Table 9.

**Table 9.** One-way Analysis of Variation (ANOVA) of the study area.

		Sum of Squares	Df	Mean Square	F	Sig.
Koko	Between Groups	128.600	7	18.371	1.267	0.509
	Within Groups	29.000	2	14.500		
	Total	157.600	9			
Ibusa	Between Groups	61.500	7	8.786	2.067	0.364
	Within Groups	8.500	2	4.250		
	Total	70.000	9			

Koko	Between Groups	133.100	8	16.638	0.671	0.740
	Within Groups	24.500	1	24.500		
	Total	157.600	9			
Ekpoma	Between Groups	109.600	8	13.700	6.850	0.288
	Within Groups	2.000	1	2.000		
	Total	111.600	9			

#### 4. CONCLUSION

This study analysed depth of aquifers or water table in relation to accessibility of portable water by the residents of three selected settlements; namely, Koko and Ibusa in Delta, and Ekpoma in Edo States in Western Niger delta region. It assessed the physical distance traversed by the population to points of portable water as a measure of accessibility. Data were obtained from both comparative experimental and survey research. Earth resistance meter (Petrozenith Terametter) was used in the study to obtain Vertical Electrical Sounding (VES) data at the three settlements. Also, questionnaires were randomly administered on fifty (50) households to ascertain the population's accessibility to portable water, particularly the physical distance traversed by households. Data were analysed using descriptive statistics and one-way Analysis of Variance (ANOVA). The study reveals that water table depths of 46m, 63m .and 288m for Koko, Ibusa and Ekpoma respectively had indirect impact on households' accessibility to portable water. To test the null hypothesis that there is no significant variation in the distance to points of portable water among the selected settlements, the One-way Analysis of Variance (ANOVA) was used. The result shows an F value of 1.267 and 2.067 for Koko and Ibusa and 0.671 and 6.850 for Koko and Ekpoma. These values are significant at 0.05 level of confidence. Hence the variation among the three settlements in respect to the distance to points of portable water. The study recommends infrastructural development in areas where the water table is deeper. This is to facilitate the supply of water to areas of deficiency. Moreover, efforts should be made to harness and purify surface water for human consumption.

#### Acknowledgement

The authors have no acknowledgments to disclose.

#### Author Contributions

Okezie Uchegbulam: Geophysical data acquisition, processing, interpretation and original draft.

Jomata Lucky Igben: Administering of questionnaire, data analysis, editing, review and validation.

#### Informed consent

Not applicable.

#### Ethical approval

Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

#### Conflicts of interests

The authors declare that they have no conflicts of interests, competing financial interests or personal relationships that could have influenced the work reported in this paper.

#### Funding

This research did not receive any external funding like specific grant from funding agencies in the public, commercial, or nonprofit sectors.

**Data and materials availability**

All data associated with this study are present in the paper.

**REFERENCES AND NOTES**

- Akoteyon IS. Factors affecting household access to water supply in residential areas in part of Lagos Metropolis. *Bulletin of Geography* 2019; Socio-economic Series; 7-24.
- Akpoborie IA, Nfor AA, Etobro I, Odagwe S. Aspects of the Geology and Groundwater Conditions of Asaba, Nigeria". *Archives of Applied Science Research* 2011;3(2):537- 550.
- Chimezie C, Iwuala I, Agwu N, Amadi I, Obinna G, Udujih I, Helen I, Okereke SN. A Study on Sources, Availability and Accessibility of Potable Water in Imo State, Nigeria. *World J of Social Science Research* 2020; 7(1):1-8.
- Domènech L. Rethinking Water Management: from centralized to decentralized water supply and sanitation models' *Doc.d'Analisi Geogr\_africa* 2011;57(2):293-310
- Doust H, Omatsola E. Niger-Delta, in Edwards JD, Santogrossi PA (ed), *Divergent/passive margin Basins*, AAPG Memoir 48: Tulsa, American Association of Petroleum Geologist 1990;239-248.
- Fashae O, Akanle O, Olusola A, Orekoya S, Ola-Lawson DO, Olaniyan OI. Household access to portable water and consumption pattern in Ibadan Metropolis, Oyo State, Nigeria. *Ibadan J of Sociology* 2024;15(1):49-58.
- Federal Ministry of Water Resources (FMWR) Project for the Review and Update of Nigerian National Water Resources Master Plan; Japan International Agency, Abuja. 2013; Vols 1 and 6.
- GAMERS. Geospatial Analysis Mapping and Environmental Research Solutions. url: [www.gamers.com.ng](http://www.gamers.com.ng). 2017; (Accessed 10 Feb 2025).
- Igben JL. A profile of African river deltas. In Asagba AO, Omoweh DA (ed) *Perspectives on the development of the Niger Delta*. Institute of Delta Studies, Western Delta University, Oghara, Nigeria. IDS REPORT 1, 2016;53-61.
- Igben JL. Environmental Dynamics and Labour Input of the Rural Population in Delta State, Nigeria. *J of Environmental Management and Safety* 2012;3(5):15-26.
- Kothari CR, Garg G. *Research methodology: methods and techniques*. London, New Age International publishers, 2019.
- Ohwoghene-Asuma O, Aweto KE, Ugbe FC. Lithofacies Identification and Multivariate Analysis of Groundwater Chemistry in Coastal Aquifers in Koko Area of the Western Niger Delta. *Hydrology* 2019;6;31; doi: 10.3390/hydrology6020031.
- Okoh O, Miner C, Ode GN, Zoakah AI. Assessment of household water anagement practices of drinking water in two selected rural communities in Plateau State. *J of Community medicine and Primary Health Care* 2021;33(2):35-51.
- Okolie EC. Geophysical investigation of effects of topographic complexities on groundwater potential 268 in Ibusa, Delta State Nigeria. *Scholars Research Library Archives of Physics Research* 2010;1(3):62-71
- Oloye AO, Ilesanmi OA, Alababan BA, Omofunmi OE, Oni KO, Ebong MT. Assessment of portable water accessibilty in Ikole-Ekiti, Nigeria. *Nigerian J of Technology (NIJOTECH)* 2022; 41(6):1031-1035. doi.org/10.4314/njt.v41i6.14
- Opute FI. Limnology of the Niger Delta; In Asagba AO, Omoweh DA. (ed) *Perspectives on the development of the Niger Delta*. Institute of Delta Studies, Western Delta University, Oghara, Nigeria. IDS REPORT 1, 2016; 31-47.
- Solihu H, Bilewu SO. Availability, coverage and access to the portable water supply in Oyo State Nigeria. *Environmental challeges* 2021;5;100335. doi:10.1016/envc2021.100335.
- Uchegbulam O, Eruotor M. Groundwater prospect using electrical resistivity method in Koko Area, Western Niger Delta, Nigeria. *J of Science, Technology, and Education (JSTE)* 2024;7(4): 46-55.