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Groundwater Prospecting and Lithology Description in Kreigani Town, Southern Nigeria, Using Vertical Electrical Sounding

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Abstract
Electrical resistivity survey was carried out to determine the groundwater potentials and subsurface lithology in Kreigani town, Ogba/Egbema/Ndoni L.G.A of Rivers State. Vertical electrical sounding method with Schlumberger array using ABEM SAS 1000 Terrameter was employed to delineate the variation in the lithologic distribution and depths to aquiferous formations in the area. Five (5) vertical electrical sounding were carried out with a maximum spread of 300m. The VES raw data obtained from the field was improved with the use of WINRESIST computer software by converting the apparent resistivity values obtained from electrode spacing to apparent resistivity values as a function of the depth of each layer delineated. The geo-electrical data obtained from VES 1 revealed five (5) lithologic layers of curve type AAA with topsoil to a depth of 1.8m, 2nd layer; fine sand with strata thickness of 3.2m, 3rd layer; medium sand with thickness of 11.4m, 4th layer; coarse sand with thickness of 29.5m, 5th layer, coarse sand to an infinity depth. The 4th layer is observed to be aquiferous with resistivity of 568.3Wm and depth of 45.6m. VES 2 revealed five (5) lithologies of curve type AAA with topsoil to a depth of 1.8m, 2nd layer; fine sand with thickness of 3m, 3rd layer; medium sand with thickness of 12.0m, 4th layer; coarse sand with thickness of 28.0m, 5th layer coarse sand to infinity depth. The 4th layer is observed to be aquiferous with resistivity of 9871Wm at the depth of 45.2m. VES 3 revealed five (5) lithologies of curve type AAA with topsoil to a depth of 2.6m, 2nd layer; fine sand with thickness of 3.3m, 3rd layer; medium sand with thickness of 9.5m, 4th layer; coarse sand with thickness of 31.3m, 5th layer coarse sand to infinity depth. The 4th layer is observed to be aquiferous with resistivity of 1541Wm at the depth of 46.7m. VES 4 revealed six (6) lithologies of curve type QQHA with topsoil to a depth of 1.7m, 2nd layer; medium sand with thickness of 2.2m, 3rd layer; medium sand with thickness of 4.5m, 4th layer; fine sand with thickness of 11.7m, 5th layer coarse sand with thickness of 25.9m, 6th layer; coarse sand to infinity depth. The 5th layer is observed to be aquiferous with resistivity of 1026Wm at the depth of 46.3m. VES 5 revealed six (6) lithologies of curve type AAKH with topsoil to a depth of 1.7m, 2nd layer; fine sand with thickness of 2.2m, 3rd layer; medium sand with thickness of 3.9m, 4th layer; medium sand with thickness of 8.0m, 5th layer coarse sand with thickness of 30.5m, 6th layer; coarse sand to infinity depth. The 5th layer is observed to be aquiferous with resistivity of 1081Wm at the depth of 46.3m. A recommendation of an average depth of 46m is to be drilled for all boreholes in the study area to yield potable and less vulnerable groundwater.

Keywords: *Geoelectric layer. Resistivity survey. Lithology. Groundwater. Borehole.*

Background of Study

The improvement of technology has made the quest for water for all purpose in life to drift from ordinary search for surface water to the prospecting for steady and reliable subsurface water, groundwater, from boreholes. In Nigeria presently, boreholes have rescued the citizenry from acute shortage of water.

Groundwater is characterized by a certain number of parameters which are determined by geophysical methods such as electrical resistivity method, seismic method, magnetic method, gravity method among others. The use of electrical resistivity method in geophysical exploration for groundwater in a sedimentary environment has proven reliable (Emenike, 2001). Records show that the depths of aquifers differ from place to place because of variational in lithologic occurrence and distribution (Okwueze, 1996). Kreigani town in Ogba/Egbema/Ndoni local government area of Rivers State have witnessed increase in oil exploration activities. This is likely to have effect on ground water in the area. In order to determine if these activities have impacted groundwater in the areas in terms of pollution, this research was carried out. Electrical resistivity method was used for this study because of its relatively low cost compared to other geophysical methods. Electrical resistivity method is one of the most useful techniques in searching for underground water.

Study Location

The study area is Kreigani Towns, located in Ogba/Egbema/Ndoni L.G.A., Rivers State (Fig.1). The area lies within Latitude $05^{o}\ 18^{I}\ 58.1^{II}$ N -- $05^{o}\ 19^{I}\ 24.1^{II}$ N and Longitude $006^{o}\ 38^{I}\ 16.0^{II}$ E -- $006^{o}\ 37^{I}\ 57.9^{II}$ E with elevation of 6m above sea level. The area is accessible through Port Harcourt – Omoku Road.

Brief Geology

Geologically, the study area lies within the Niger Delta and generally has a dry flatland surface and high water table level. The water table depth decreases seawards, varying from about 5m (inland) to 0.5m at the coast. The

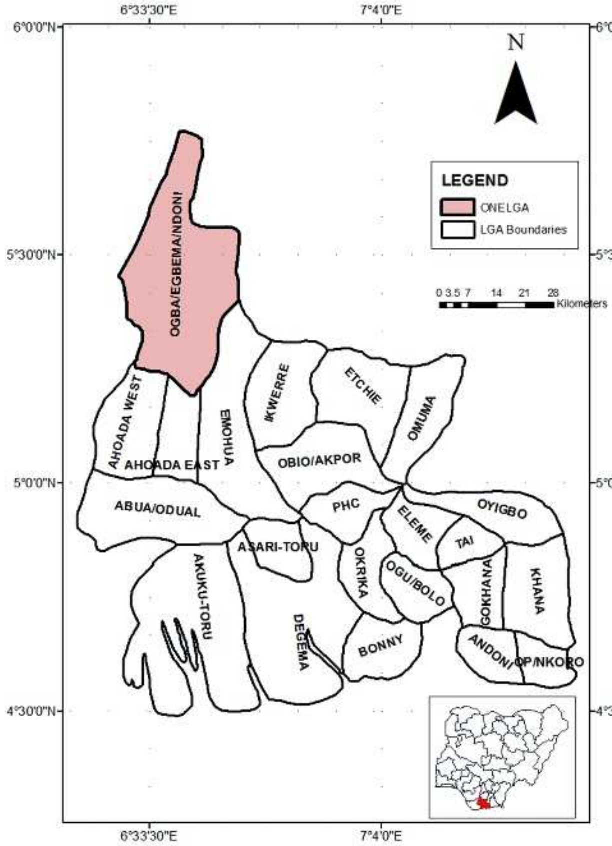

Fig. 1: Map of Rivers State showing Ogba/Egbema/Ndoni L.G.A.

high water table level in the Niger Delta is as a result of the high rainfall, general swampiness and flat topography of the area. These features of the Niger Delta also account for the higher moisture content of soil in the region, affecting the geotechnical properties of its soils negatively and causing serious drainage problem in the region. The three main depositional environments of most deltaic environment (marine, mixed and continental) are observed in the Niger Delta and termed the Akata, Agbada and Benin Formations. This have been confirmed by studies carried out by Nedeco (1959); Allen (1956); Reyment (1965); Short and Stauble (1967); Maron (1969); Weber (1971); Burke (1972); Kogbe (1989) and Etu-Efeotor (1997).

Geomorphologically, the Niger Delta has a flat land topography. Its terrain is drained and crisscrossed by numerous rivers, tributaries and creeks. Five major geomorphic units have been recognized in the Niger Delta (Akpokodje 2001) namely:

(i) Dry flatland and plains.
(ii) Sombreo Warn deltaic plains with abundant fresh water back swamps.
(iii) Fresh water swamps, meander belts and alluvial swamps.
(iv) Salt water or mangrove swamps.
(v) Active/abandoned coastal ridges.

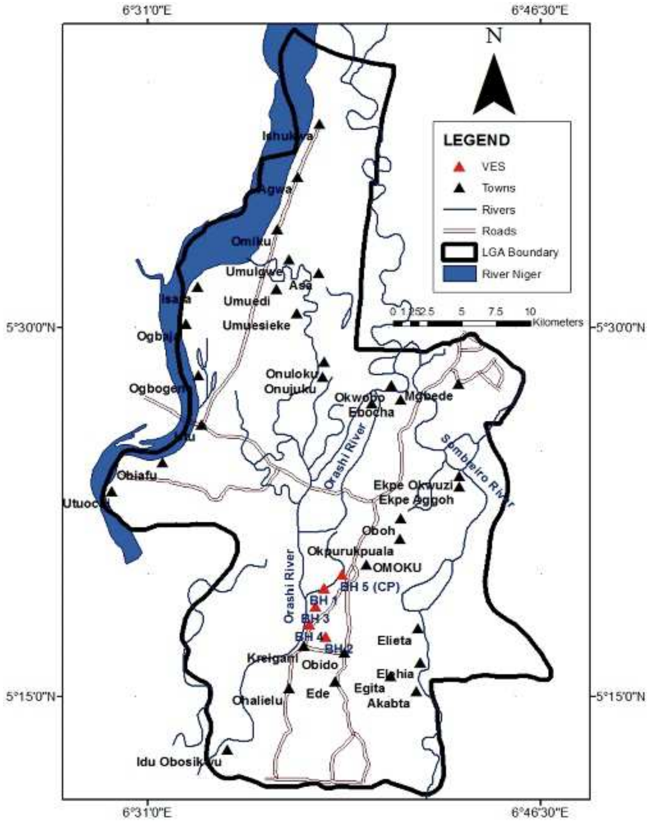

Fig. 2: Map of Study Location showing VES lines

Method of Study

Vertical Electrical Sounding (VES) technique of electrical resistivity method in geophysical exploration was employed for this study using the Schlumberger electrode configuration. Five (5) lines of VES were carried out cutting across the study area.

The equipment used was Abem Terrameter SAS 1000C. While sounding, the four (4) electrodes were arranged along a straight line with the potential electrodes placed between the current electrodes and all four were on a straight line, disposed with respect to the center of the configuration at each spreading. The current electrode spacing was constant on either side by AB/2 (horizontal distance between the two electrodes).

Electrical current (I) was applied to A and B electrodes and potential was measured between M and N electrodes. The geometric factor (K) can be obtained for four electrode arrays of AMNB configuration as:

$\mathbf{K = [(AB/2)2 - (MN/2)2/MN]^{\pi}}$ ………. (1) (geometric

factor)
where AB/2= half current electrode spacing MN/2= half potential electrode spacing.

The VES array consists of the series of the electrode combinations AMNB with gradually increasing distances among the electrodes for consequent combinations.

The depth of sounding increases with distance between A and B electrodes. The K factor for the combinations is calculated with Equation 1 above. From this field work, five (5) VES sounding were done on the field. The plots obtained from the resistivity data were examined and their character noted in terms of the pattern of resistivity with depths of VES or laterally in profile data. The areas of high resistivity were noted, described and attributed to the presence or absence of conducting bodies below the surface at the point or area of the observation of the anomalies.

For VES, the types of curve (Fig.3) obtained were noted in terms of:

A - Type: Continuous increase of resistivity with depth i.e. p1<p2<p3
Q - Type: Continuous decrease of resistivity with depth i.e. p1>p2>p3
H - Type: 3 layers in which p1>p2<p3
K - Type: 3 layers in which p1<p2<p3

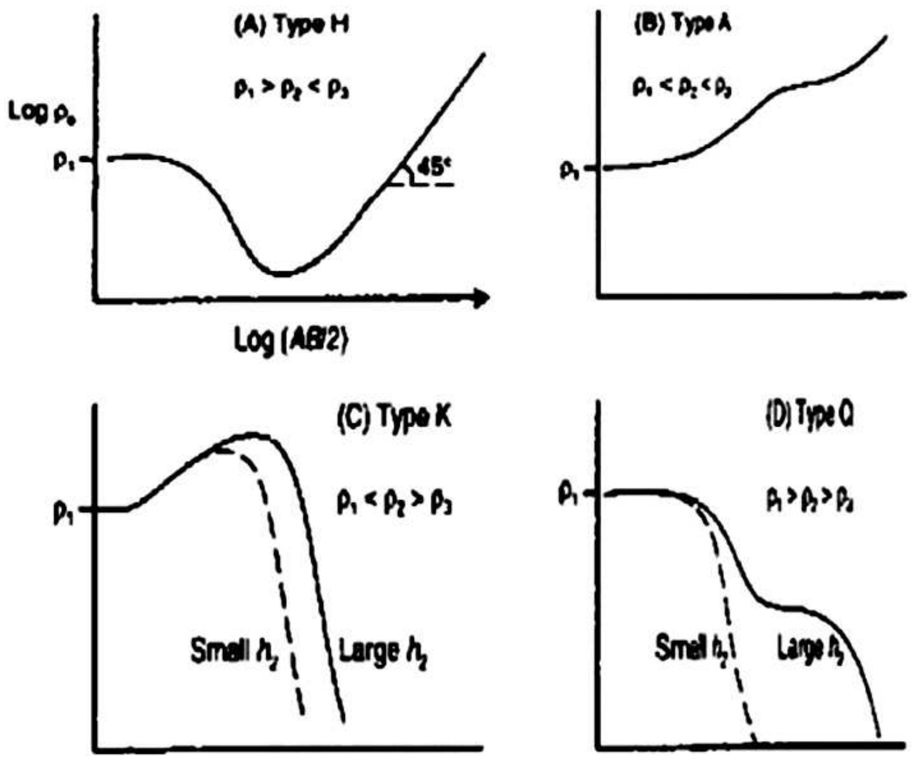

Fig. 3: Graphical representation of VES curve types, (USEPA, archive, 2016)

Results and Discussions

The geo-electrical data obtained from VES 1 (Fig. 4) revealed that the depth delineated is composed five (5) lithologic secession of curve type AAA with topsoil to a depth of 1.8m, 2nd layer; fine sand with strata thickness of 3.2m, 3rd layer; medium sand with thickness of 11.4m, 4th layer; coarse sand with thickness of 29.5m, 5th layer, coarse sand to an infinity depth. The 4th layer is observed to be the first aquifer with resistivity of 568.3Wm and depth of 45.6m (Table 1). VES 2 revealed five (5) lithologies of curve type AAA (Fig. 5) with topsoil to a depth of 1.8m, 2nd layer; fine sand with thickness of 3m, 3rd layer; medium sand with thickness of 12m, 4th layer; coarse sand with thickness of 28m, 5th layer coarse sand to infinity depth. The 4th layer is observed to be the first aquifer with resistivity of 9871Wm at the depth of 45.2m (Table 2). VES 3 revealed five (5) lithologies of curve type AAA (Fig. 6) with topsoil to a depth of 2.6m, 2nd layer; fine sand with thickness of 3.3m, 3rd layer; medium sand with thickness of 9.5m, 4th layer; coarse sand with thickness of 31.3m, 5th layer coarse sand to infinity depth. The 4th layer is observed to be the first aquifer with resistivity of 1541Wm at the depth of 46.7m (Table 3). VES 4 revealed six (6) lithologies of curve type QQHA (Fig. 7) with topsoil to a depth of 1.7m, 2nd layer; medium sand with thickness of 2.2m, 3rd layer; medium sand with thickness of 4.5m, 4th layer; fine sand with thickness of 11.7m, 5th layer coarse sand with thickness of 25.9m, 6th layer; coarse sand to infinity depth. The 5th layer is observed to be the first aquifer with resistivity of 1026Wm at the depth of 46.3m (Table 4). VES 5 revealed six (6) lithologies of curve type AAKH (Fig. 8) with topsoil to a depth of 1.7m, 2nd layer; fine sand with thickness of 2.2m, 3rd layer; medium sand with thickness of 3.9m, 4th layer; medium sand with thickness of 8m, 5th layer coarse sand with thickness of 30.5m, 6th layer; coarse sand to infinity depth. The 5th layer is observed to be the first aquifer with resistivity of 1081Wm at the depth of 46.3m (Table 5).

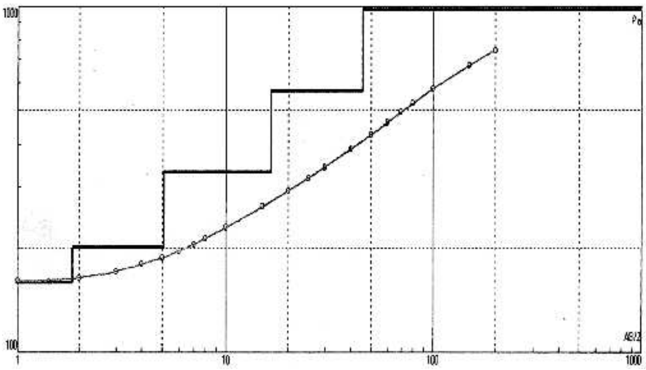

Fig. 4: VES curve for Station 1.

Table 1: Geoelectric Parameters and Layer Interpretation for VES 1.

Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Geological Interpretation
1	159.40	1.84	1.84	Top soil
2	201.20	3.24	5.07	Sand
3	332.30	11.44	16.51	Sand
4	568.30	29.15	45.66	Sand pressure aquifer
5	979.00	Infinity	Infinity	Aquifer

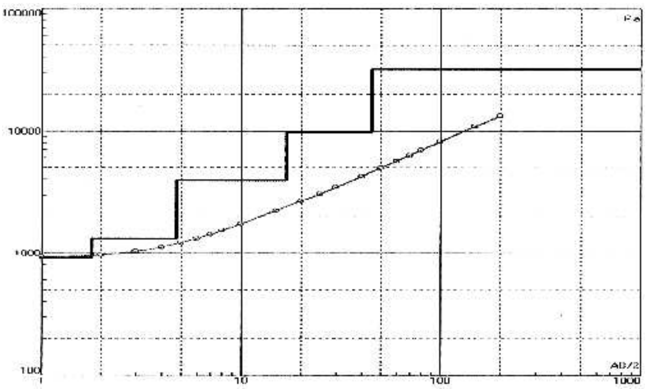

Fig. 5: VES curve for Station 2

Table 2: Geoelectric Parameters and Layer Interpretation for VES 2

Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Geological Interpretation
1	913.00	1.79	1.79	Top soil
2	1314.00	2.97	4.76	Sand
3	3971.00	12.07	16.83	Sand
4	9871.00	28.39	45.22	Sand (pressure aquifer
5	32247.00	Infinity	Infinity	Sand (aquifer)

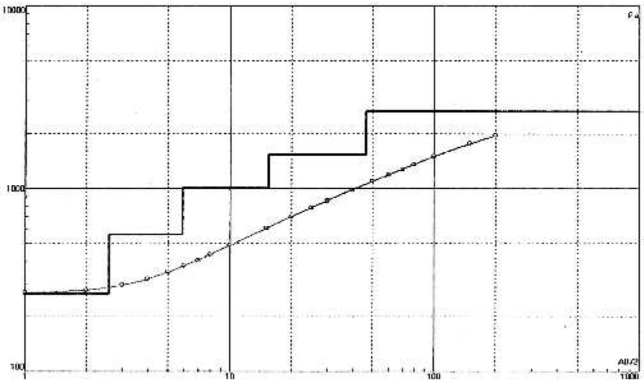

Fig. 6: VES curve for Station 3

Table 3: Geoelectric Parameters and Layer Interpretation for VES 3

Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Geological Interpretation
1	268.60	2.59	2.59	Top soil
2	557.70	3.30	5.89	Sand (dry)
3	1005.00	9.53	15.42	Sand
4	1541.00	31.27	46.69	Sand (pressure aquifer)
5	2641.00	Infinity	Infinity	Sand (Aquifer)

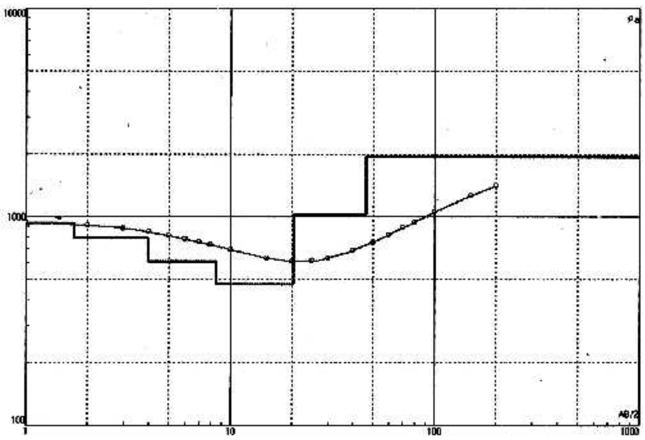

Fig. 7: VES curve for Station 4

Table 4: Geoelectric Parameters and Layer Interpretation for VES 4

Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Geological Interpretation
1	933.10	1.72	1.72	Top soil
2	791.60	2.24	3.96	Sand
3	610.50	4.52	8.48	Sand
4	475.00	11.86	20.34	Sand and clay
5	1026.00	25.94	46.28	Sand (pressure aquifer)
6	1948.00	Infinity	Infinity	Sand (Aquifer)

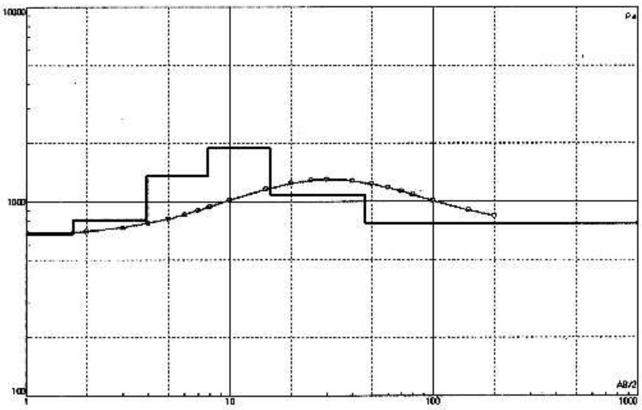

Fig. 8: VES curve for Station 5

Table 5: Geoelectric Parameters and Layer Interpretation for VES 5

Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Geological Interpretation
1	683.30	1.71	1.71	Top soil
2	805.40	2.21	3.92	Sand
3	1354.00	3.86	7.78	Sand
4	1881.00	8.04	15.82	Sand
5	1081.00	30.46	46.28	Sand (pressure aquifer)
6	771.30	Infinity	Infinity	Sand

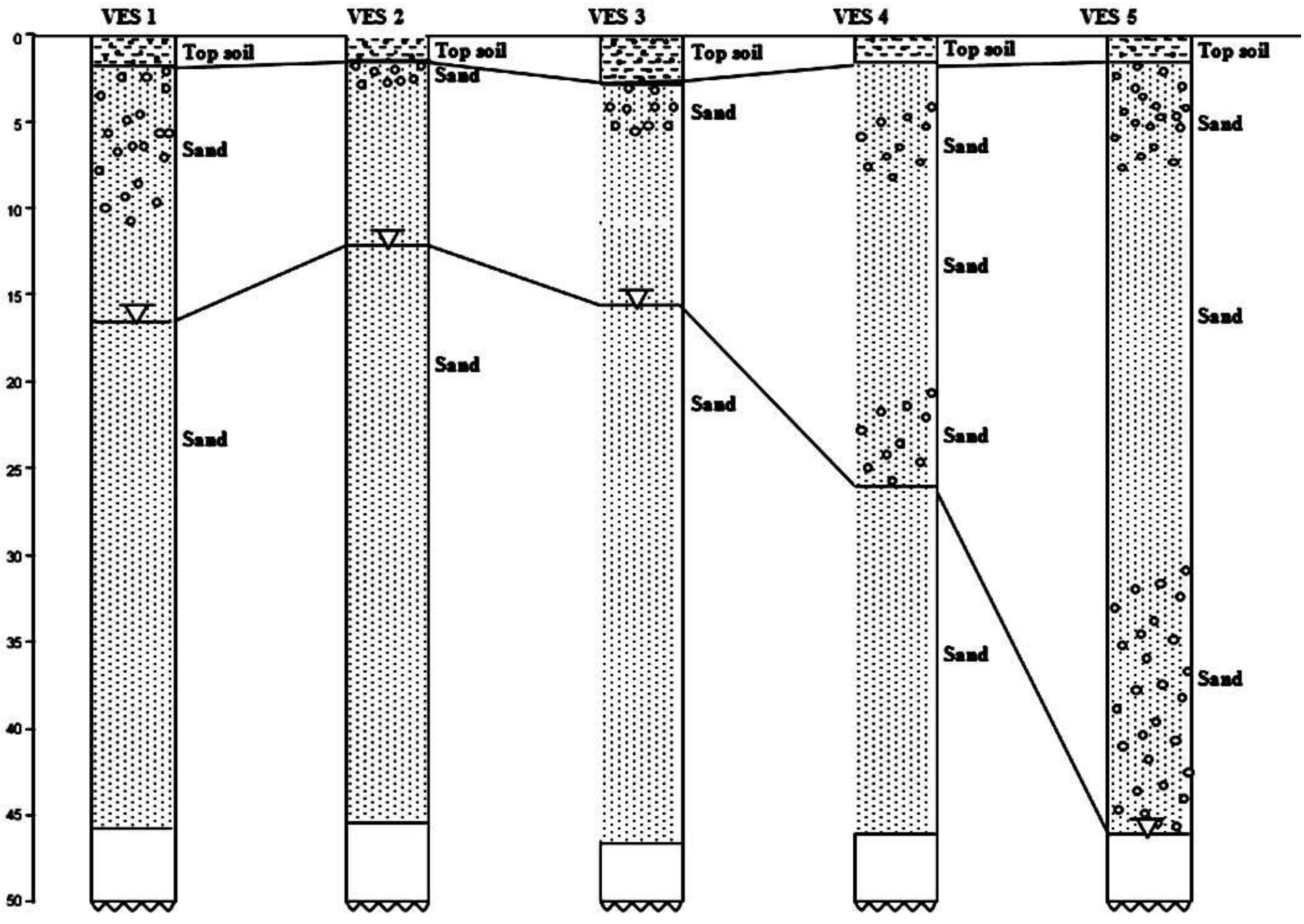

Fig. 9: Lithologic correlation of the study area

Conclusion

The electrical resistivity survey carried out in the study area revealed that the lithology is a typical representation of Benin formation in the Niger Delta with lithologies ranging from fine sand to medium sand and coarse sand. The coarse sand formation in all the locations delineated has the capacity to transmit water sufficiently and therefore represents good aquifers. A recommendation of an average depth 46m is to be drilled for all boreholes in the study area to sustainably yield potable and less vulnerable groundwater.

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