American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-8, Issue-5, pp-115-120
www.ajer.org
Research Paper Open Access

Application of VES for Aquifer Characterisation in Ishiayi Community, Ahoada West Local Government Area of Rivers State, Southern Nigeria.

*Oki, O. A & Eteh, D. R
Department of Geology, Niger Delta University, Bayelsa State, Nigeria.
**Corresponding Author: ustin_oki@yahoo.com; +2349030277209*

ABTSRACT - *Vertical Electrical Sounding method was applied for the purpose of aquifer characterisation in Ishiayi Community in Ahoada West LGA of Rivers State to determine the best point to site borehole in a production complex and best depth range of the well to screen to avoid seasonal effect on the aquifer yield and high iron content associated with shallow aquiferous unit in the area. Results from 3 (three) VES points along a profile within the survey facility showed that 7 (seven) geoelectric layers existed to the depth of investigation, with a top to bottom sequence of sandstone > clay & sandstone > clay > sandstone (first aquifer) > clay > sandstone (second aquifer) > clay, the layers were laterally continuous across all VES points but varied in thicknesses. 2 (two) aquifers were delineated of which the interest was the second aquifer because literature from the area showed that the shallower aquifer yield was season dependent and mostly reported to have high iron content. The best drilling point (VES 2) with optimum aquifer yield was inferred from the information on maximum thickness and depth profile of the aquiferous zone across the survey area. The maximum thickness of the target aquifer along the profile is 13.6 m occurring beneath VES 2 with a resistivity of 635 Ωm consistent with freshwater bearing sandstones in the area.*

KEYWORDS:*Electrical Resistivity, Vertical Electrical Sounding, Aquifer Characterisation, Ahoada West LGA.*

Date of Submission: 25-04-2019 Date of acceptance: 05-05-2019

I. INTRODUCTION

One of the most important resource required for life to thrive is water. In most communities of the Niger Delta, accessibility to potable water is a major challenge, this is due to a rapid population growth in recent times which has not been matched with an increase or upgrade in water resource infrastructure by successive governments, poor maintenance of distributary and storage facilities of the oil and gas industry which has led to the reoccurrence of hydrocarbon spills, indiscriminate activities of oil pipeline vandals and poor waste management practices in most communities (Amadi et al., 2010, Nwankwoala et al, 2014; Egai and Douglas, 2015; Oki and Akana, 2016). Most of the activities mentioned have not only caused a devastation of the environment, they have also polluted and contaminated surface water bodies and in some cases shallow aquifers in the area. The logical alternative to source for potable water for domestic and industrial purpose is underground water. The Earth acts like a natural filter, as surface water seeps into the subsurface impurities are trapped or suspended within soil particles, as such, underground water is usually more potable and is not as easily contaminated as surface water.

Vertical Electrical Sounding is a non-invasive geophysical technique that has been successfully employed over the years for subsurface characterisation (Zohdy et al, 1974; Ekine and Osobonye, 1996; Olorunfemi et al, 1999; Oseji et al, 2006; Oborie and Nwankwoala, 2012; Oborie et al, 2014). It is also fast and relatively cheap. This method is employed in groundwater exploration to determine subsurface layer properties based on their resistance to flow of electric current. Results obtained by this method can be used to infer water bearing units and quality of water they hold when constrained with secondary information from the area (Ushie and Nwankwoala, 2011).

There have been a lot of reports of high iron content in groundwater from shallow boreholes in Ishiayi community in Ahoada West in Local Government Area of Rivers State and surrounding communities (Udom and Amah, 2006; Okiongbo and Ogobiri, 2011; Egai and Douglas, 2015). Deeper boreholes have also been reported to have negligible iron content in them. Since most boreholes in the area were drilled by quacks, there is very little drilling information obtainable from existing wells. This research was carried out to delineate shallow and deep aquiferous zones in the area. Based on aquifer properties determined, an informed recommendation was made on drilling point and range of screen depth for optimal yield and minimal iron content fit for domestic and industrial use.

Physiography and geology of study area

The study location is Ishiayi community in Ahoada West LGA in Rivers State, Nigeria. It is located within latitudes N05° 03’ 11” and N05° 03’ 46” and longitudes E006° 25’ 00” to E 006° 25’ 30” (Fig. 1). The topography in the area is generally low lying with an elevation of 15m above sea level. The survey area lies within the rain forest of the Niger Delta Sedimentary Basin. It is drained by tributaries and creeks of the Orashi River and River Nun, and traversed by two major roads (Mbiama - Yenagoa and East - West roads) and several minor roads. The major economic activities of the locals are farming, fishing and local sand dredging from creeks and rivers. The Niger Delta is located in the humid climatic region of the rain forest with characteristic seasonal torrential down pours. Rainfall in the Niger Delta is heavy due to the closeness of the delta region to the equator, annual rainfall gets as high as 4,000 mm close to the coast (Offodile, 2002) and to about 3,000 mm in Ahoada West.

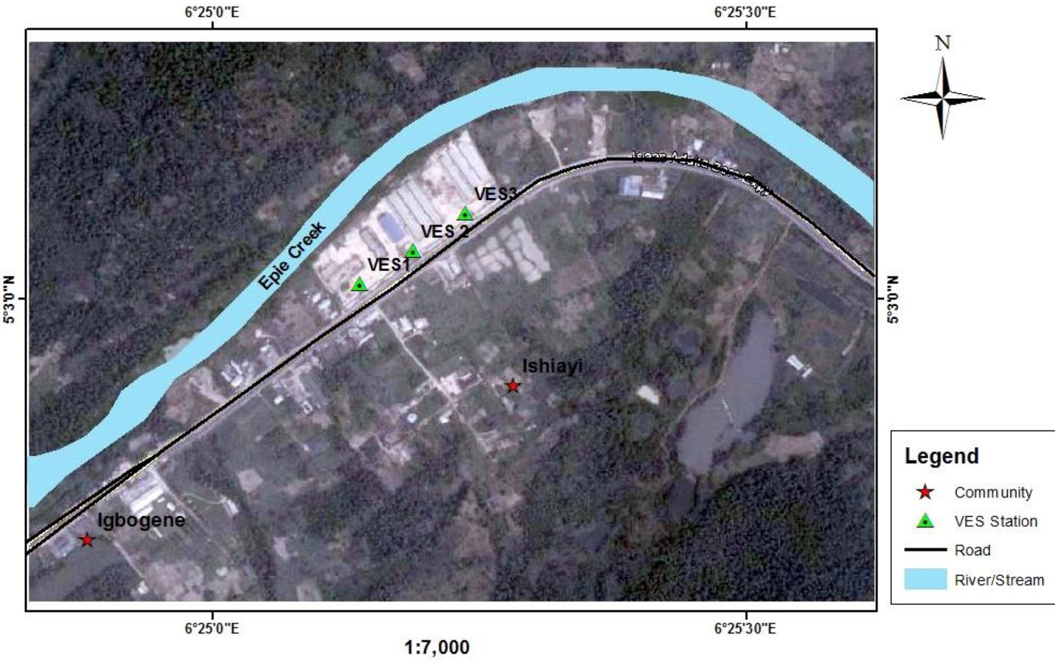

Fig. 1 Location map showing VES stations (Google Earth, 2018)

The Niger Delta Basin is a complex prolific Basin formed by an extensional rift system in the Niger Delta and the Gulf of Guinea on a passive continental margin near the west coast of Nigeria (Reijers et al, 1996). The major lithostratigraphic units observed on a well-section through the Niger Delta consist of an upper delta top facies, a middle delta front lithofacies and a lower prodelta lithofacies. The lithostratigraphic units correspond respectively with the uppermost Benin Formation aged Oligocene to recent, the Agbada Formation lies beneath the Benin Formation aged Eocene to recent and the lowest lying Akata Formation aged Paleocene to recent (Short and Stauble, 1967). The Akata Formation is composed mainly of marine shales with sandy and silty beds which are believed to have been laid down as turbidites and continental slope fills with an estimated thickness of 7,000 m. The Agbada Formation which the petroleum bearing unit in the Niger Delta, consists mostly of shore face and channel sands with minor shales in the upper parts and an intercalation of sands and shales in equal proportion in the lower parts, with a thickness of over 3,700 m (Doust and Omatsola, 1990). The Benin Formation consisting of continental sands and gravels is about 280 m thick and maybe up to 2,100 m in the region of maximum subsidence (Whiteman, 1982). The environment of deposition is partly lagoonal and fluviolacustrine/deltaic (Reyment, 1965), the Benin Formation is the aquiferous unit in the Niger Delta Basin

(Etu-Efeotor and Akpokodje, 1990; Offodile, 2002), the clayey intercalations of the Formation gives rise to a multi-aquifer system with the shallow unconfined aquifer occurring at depths ranging from 20 m to 40 m across the area (Etu-Efeotor, 1981; Edet, 1993; Udom and Amah, 2006). The main source of recharge is through direct precipitation owing to the relatively high annual rainfall, water infiltrates through the highly permeable sands of the Benin Formation to recharge the aquifers (Amajor and Ofoegbu, 1988; Udom and Amah, 2006).

II. MATERIALS AND METHOD

This investigation employed the Vertical Electrical Sounding (VES) method of Electrical Resistivity survey to characterise the vertical variation in the subsurface material to a depth of interest. The field procedure was carried out with a resistivity machine by applying current into the ground through two electrodes (A and B), then measuring the resultant potential difference (ΔV) between them using two potential electrodes (M and N). The centre point of the electrode array remained fixed but the spacing of the electrodes was systematically increased so as to obtain 1D georesistivity information (vertical variation in resistivity of Earth materials) of the midpoint of AB (for detailed explanation see Okiongbo and Ogobiri, 2011). The maximum lateral extent of AB was 300 m because secondary information obtained from the area showed that depth to target aquifer was expected to be less than 100 m. Three (3) survey stations along a profile within the survey property were occupied and data was acquired using the ABEM 3000 Resistivity meter, a self-averaging digital equipment. Data processing was done by computer aided modelling and Interpex inversion software from which information of layer parameters i.e. layer resistivity and thickness were obtained. Information of layer parameters was used to generate a 2-D geo-electric profile of the subsurface of the surveyed area from which the best drilling point for maximum aquifer yield was inferred.

III. RESULTS AND DISCUSSION

Results from the modelled data from the three VES stations occupied was presented in Table 1. It showed that seven distinct layers were delineated by all three geo-electric profiles carried out, also, all three VES were of the QHKHK type curve (Figs. 2, 3 and 4).

Table 1 Location points and geo-electric parameters.

Location	Co-ordinates	Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Curve type
VES 1		1	300	2.4	2.4	QHKHK
		2	85	3.7	6.1	
		3	18	3.9	10.0	
		4	315	5.8	15.8	
		5	75	11.2	27.0	
		6	480	8.8	35.8	
		7	47	∞	∞	
VES 2		1	220	2.1	2.1	QHKHK
		2	97	4.6	6.7	
		3	23	4.2	10.9	
		4	382	9.7	20.6	
		5	76	6.7	27.3	
		6	635	13.6	40.9	
		7	52	∞	∞	
VES 3		1	280	2.7	2.7	QHKHK
		2	83	5.8	8.5	
		3	15	3.3	11.8	
		4	287	7.0	18.8	
		5	24	7.9	26.7	
		6	515	10.6	37.3	
		7	67	∞	∞	

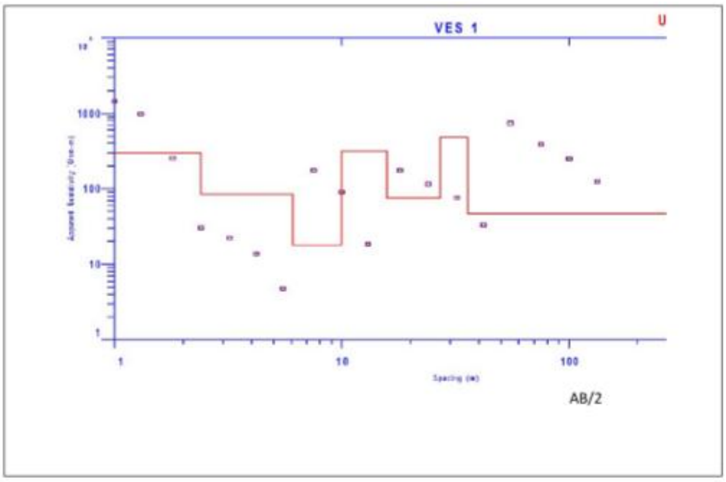

Fig. 2 VES 1 geo-electric curve

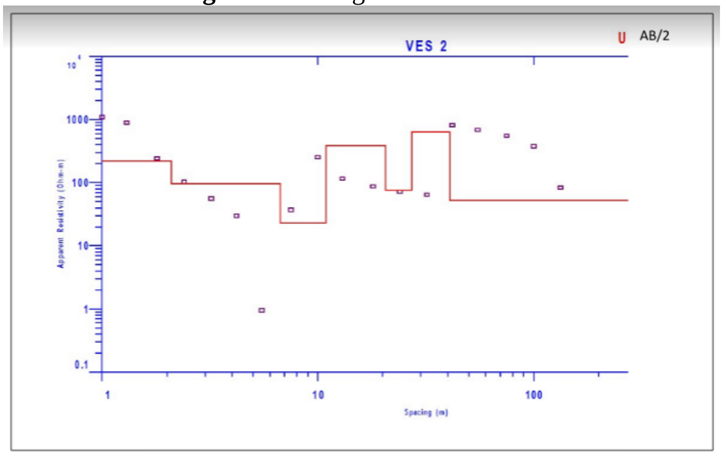

Fig. 3VES 2 geo-electric curve

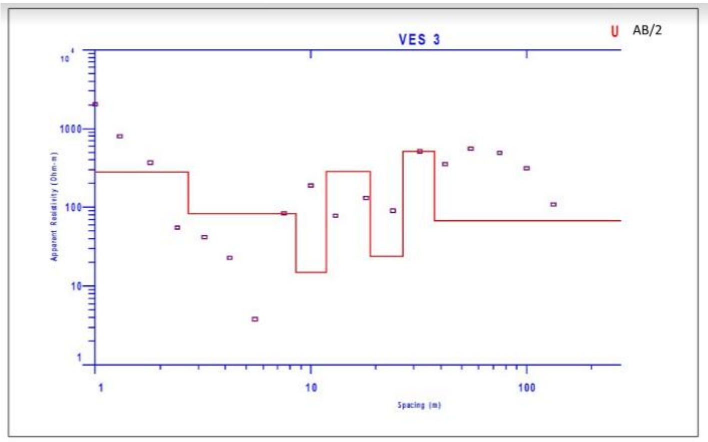

Fig. 4VES 3 geo-electric curve

On VES 1, the top soil had a resistivity of 300 Ωm consistent with sandstones, with a thickness of 2.4 m, the site had obviously been sand-filled and compacted in the recent past. A second layer 3.7 m thick, with a resistivity of 85 Ωm consistent with silty-clay was observed. Beneath this second layer, a distinct clayey third layer was delineated, it had a resistivity of 18 Ωm and a thickness of 3.9 m. The fourth layer had resistivity of 315 Ωm consistent with a freshwater coarse grained sandstone aquifers in the area, it had a thickness of 5.8 m. It was the first inferred aquifer delineated. The shallow aquifer is sealed at the base by a fifth layer with resistivity of 75 Ωm associated with clayey material having a thickness of 11.2 m. The sixth layer had a resistivity of 480 Ωm associated with freshwater bearing coarse grained sandstones, it had a thickness of 8.8 m, this is the second inferred aquifer delineated and it was sealed by a clayey seventh layer with resistivity of 47 Ωm. VES 2 had a compacted sandstone top soil with resistivity 220 Ωm and 2.1 m thick, underlain by a silty-clay layer with resistivity 97 Ωm and a thickness of 4.6 m. The third layer had a resistivity of 23 Ωm, consistent with clays that was 4.2 m thick. The fourth geo-electric layer had a resistivity of 382 Ωm consistent with freshwater bearing sandstones in the area, this layer was inferred as the shallow aquifer earlier delineated by VES 1. It had a thickness of 9.7 m. Beneath the fourth layer is a clayed layer with a resistivity of 76 Ωm and thickness 6.9 m, it acted as a bottom confining material for the shallow aquifer and a top seal for the deeper aquifer in the sixth layer, which had a resistivity of 635 Ωm consistent with the freshwater bearing sandstones in the area. The second aquifer had a thickness of 13.6 m and was underlain by a clayey seventh layer, which had a resistivity of 52 Ωm. The third station occupied (VES 3), like the first two also had an artificial top soil of compacted sandstones with a resistivity of 280 Ωm and thickness of 2.7 m. The second layer delineated by the 1D profile had a resistivity of 83 Ωm and thickness of 5.8 m associated with silty-clay soil, beneath is a clayey third layer with resistivity of 15 Ωm and thickness 3.3 m. The fourth layer was the shallow aquifer material with a resistivity of 287 Ωm and a thickness of 7.0 m, consistent with the shallow aquifer earlier delineated by the first two VES's. A fifth clayey layer existed beneath the shallow aquifer with a resistivity of 24 Ωm and a thickness of 7.0 m. The second aquifer material (coarse grained sandstones) with a resistivity of 515 Ωm and a thickness of 10. 6 m was delineated by the geo-electric profile as the sixth layer, which was underlain by a seventh layer with resistivity of 67 Ωm consistent with clay material.

Using information of layer parameters obtained from the three VES points occupied a 2D cross-section profile across the survey stations was then generated, this was used to predict the drilling point and screen depth range that would have the best aquifer yield in the area based on the aquifer thickness and depth of occurrence with respect to the other points along the profile (Fig. 5).

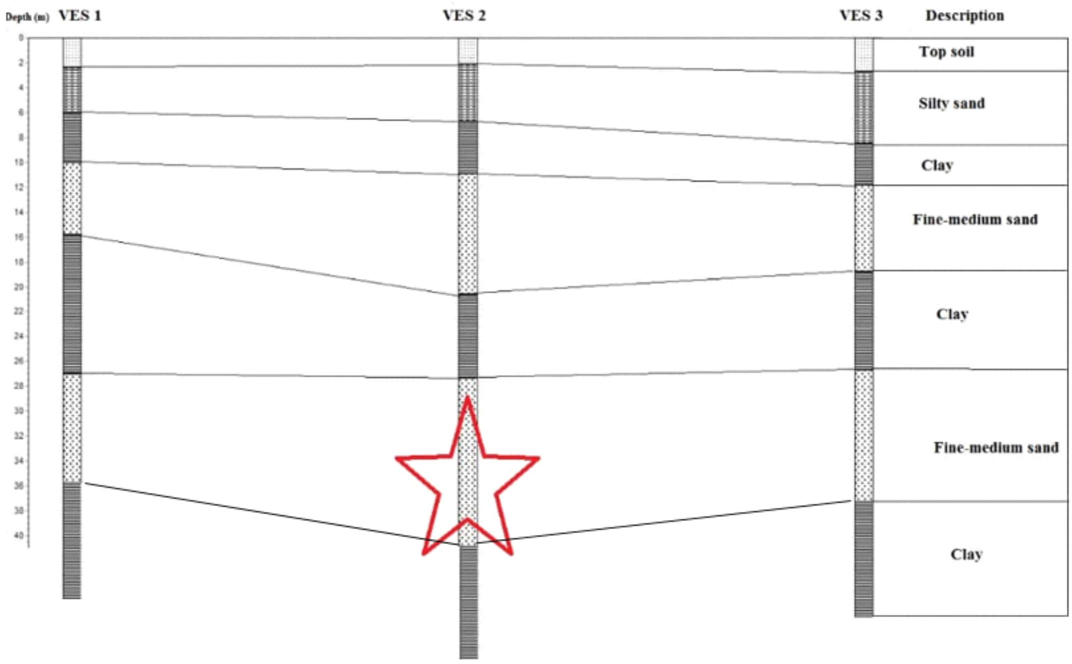

Fig. 52D geo-electric cross-section over sampled area showing recommended drilling target

IV. SUMMARY AND CONCLUSION

A successful attempt was made to characterise the aquifer system in Ishiayi community of Ahoada West LGA of Rivers state using Vertical Electrical Sounding method. Results obtained showed that although most subsurface layers where laterally continuous, they varied in thickness. The shallow unconfined aquifer in the area is documented to have a higher iron content than the second aquifer in the multi-aquifer system that exits in the area, based on this knowledge the second aquifer was of primary interest in this investigation. The second aquifer beneath VES 2 was recommended as the best drilling point, this was because it was thicker than that beneath both VES's 1 & 2.

ACKNOWLEDGEMENTS:

The authors are very grateful for the full sponsorship of this research by Ovidav Technologies International, also the numerous critical reviewers whose suggestions greatly improved the quality of the manuscript.

REFERENCES

Amadi AN, Olasehinde PI, Okosun EA, Yisa J. 2010. Assessment of the Water Quality Index of Otamiri and Oramiruikwa Rivers. Physics International. Vol. 1(2): 116 – 123.

Amajor LC, Ofoegbu CO. 1988. Determination of polluted aquifers by stratigraphically controlled biochemical mapping; Example from the Eastern Niger Delta, Nigeria. Groundwater and Mineral Resources of Nigeria. Pp. 62 – 73.

Ayebawari OE, Reward KD. 2015. Aspects of Geophysical Survey using Vertical Electrical Sounding (VES) for groundwater exploration in parts of Ahoada West LGA, Rivers State, Southern Nigeria. Geosciences. Vol. 5(1): 31 – 38.

Doust H, Omatsola E. 1990. Niger Delta: In Edwards, J. D and Santogrossi (Eds) divergent/passive margin basins. American Association of Petroleum Geologists Memoir. Vol. 48: 201 – 236.

Edet AE. 1993. Groundwater Quality Assessment in parts of Eastern Niger Delta, Nigeria. Environmental Geology. Vol. 22(1): 41 - 46.

Ekine AS, Osobonye GT. 1996. Surface geoelectric sounding for the determination of aquifer characteristics in parts of Bonny Local Government Area of Rivers State. Nigerian Journal of Physics. Vol. 85: 93 - 97.

Etu-Efeotor JO, Akpokogje EG. 1990. Aquifer systems of the Niger Delta. Journal of Mining and Geology. Vol. 26 (2): 279 – 285.

Etu-Efeotor JO. 1981. Preliminary Hydrogeochemical investigations of Sub-Surface waters in parts of the Niger Delta. Nigerian Journal of Mining and Geology. Vol. 18(1): 103 - 105.

Nwankwoala HO, Amadi AN, Oborie E, Ushie FA. 2014. Hydrochemical factors and correlation analysis in Groundwater quality in Yenagoa, Bayelsa State, Nigeria. Applied Ecology and Environmental Services. Vol. 2(4): 100 – 105.

Oborie E, Nwankwoala HO. 2012. Relationship between geoelectrical and groundwater parameters in parts of Ogbia, Bayelsa State, Central Niger Delta. Continental Journal of Earth Sciences. Vol. 7(1): 29 – 39.

Oborie E, Udom GJ, Nwankwoala HO. 2014. Characterization of aquifers in Yenagoa and Ogbia areas of Bayelsa State, Nigeria: A geoelectrical approach. Advanced Journal of Physical Sciences. Vol. 3(2): 31 – 39.

Offodile ME. 2002. Groundwater study and development in Nigeria. Mecon Engineering Services Ltd, Jos, Nigeria. Pp. 239 – 345.

Oki AO, Akana TS. 2016. Quality assessment of groundwater in Yenagoa, Niger Delta, Nigeria. Geosciences. Vol. 6(1): 1 – 12.

Okiongbo KS, Ogobiri G. 2011. Geoelectric investigation of Groundwater Resources in parts of Bayelsa State, Nigeria. Research Journal of Environmental and Earth Sciences. Vol. 3(6): 20 – 624.

Olorunfemi MO, Ojo JS, Akintude OM. 1999. Hydrogeophysical Evaluation of Ground Water Potentials of Akure Metropolis, Southwestern Nigeria. Journal of Mining and Geology. Vol. 35, 207 - 228.

Oseji JO, Asokhia MB, Okolie EC. 2006. Determination of groundwater potential in Obiaruku and environs using surface geoelectric sounding. Environmentalist. Vol. 26: 301 - 308.

Reijers TJA, Petters SW, Nwajide CS. 1996. The Niger Delta Basin, in: Reijers TJA (Eds), selected chapters on geology: SPDC Corporate Reprographic Services, Warri, Nigeria. Pp. 103 – 144.

Reyment RA. 1965. Aspects of the geology of Nigeria: the stratigraphy of the Cretaceous and Cenozoic deposits. 1st Edition, Ibadan University Press, California. Pp: 144.

Short KC, Stauble AJ. 1967. Outline of geology of Niger Delta: American association of petroleum geologist bulletin. Vol. 51(5): 764 – 772.

Udom GJ, Amah EA. 2006. Quality status of groundwater in Yenagoa and its environs, Bayelsa State. Nigerian Journal of Science and Industrial Studies. Vol. 4(1): 45 – 51.

Ushie FA, Nwankwoala HO. 2011. A preliminary geo-electrical appraisal for groundwater in Yalla, Southern Benue Trough, South-East, Nigeria. Middle East Journal of Scientific Research. Vol. 9(1): 1 - 7.

Whiteman A. 1982. Nigeria: Its petroleum geology, resources and potential. Graham and Trotman L.T.D. Vol. 1: 114 – 131.

Zohdy AAA, Eaton GP, Mabey DR. 1974. Application of Surface Geophysics to Groundwater Investigations. US Geology Survey.

*Oki, O. A & Eteh, D. R" Application of VES for Aquifer Characterisation in Ishiayi Community, Ahoada West Local Government Area of Rivers State, Southern Nigeria."American Journal of Engineering Research (AJER), vol.8, no.05, 2019, pp.115-120