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Groundwater Prospecting utilizing Vertical Electrical Sounding Technique in Obafemi-Owode Local Government Area South-West Nigeria

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Abstract

Investigation for groundwater resource potentials in terms of its hydrological variation and consequent impact on the subsurface water quality using electrical resistivity method was undertaken at Obafemi-Owode Local Government Area, South-West Nigeria with the principal aim of evaluating groundwater potentials and overburden units in the area. Twenty seven (27) vertical electrical sounding (VES) were carried out utilizing Schlumberger configuration with the maximum electrode spacing of 100m at each point using OMHEGA Allied Resistivity meter. The data were consequently interpreted using partial curve matching techniques and computer iteration program using WINRESIST. The geoelectric sections revealed three (3) to five (5) geoelectric layers. The weathered layer which comprises of Sandy Clay/Clayey Sand/Clay/Shale whose layer resistivity value ranges from 16.7Ωm in VESOB6 and VESOB8 with depths of 3.1m and 4.36m respectively to VESOB21 possesses the highest resistivity value of 5545.6 Ωm with a depth of 3.5m in VESOB24, underlying this layer are the fractured basement with the lowest resistivity value of 155.3Ωm in VESOB4 and the highest resistivity value of 1061.2Ωm in VESOB5. The fresh basement displayed resistivity values that range from 432.8Ωm in VESOB21 to 22,388.7Ωm in VESOB16; the corresponding depths are undetermined due to current termination. The reflection coefficient range is between 0.02 and 0.98 while groundwater potentials of the area were classified as high areas; high (overburden thickness >13m and reflection coefficient less than < 0.8); medium (overburden thickness ≥13m and with reflection coefficient ≥ 0.8) and low (overburden thickness < 13m and reflection coefficient ≥ or ≤ 0.8). The study has therefore identified favourable groundwater potentials of the area with < 1.5 coefficient of anisotropy values.

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INTRODUCTION

The significance and necessities of Groundwater exploration in Nigeria cannot be overemphasized owning to the ever increasing demand for water supplies, most obvious in areas with inadequate surface water supplies. Already, ten percent of the world's population is affected by chronic water scarcity and this is likely to rise to one-third by about 2025 (WHO, 1996; WHO, 2009; Ufuogbune *et al.,* 2001). The water scarcity experienced by the dwellers of Obafemi-Owode Local Government Area mostly in dry season, led to the continuous quest for subsurface water supply. Most surface water like rivers and streams are vulnerable to pollution both from internal and external contamination sources.

The option principally made available to man is groundwater, which may be defined as "water in the zone of saturation and from which wells, springs and underground run off are supplied" (Ufuogbune *et al.,* 2001). This water is trapped by geological formations (Ishola, 2019). The advantages of groundwater over other sources have been severely emphasized at different times and diverse locations in published literatures (Olorunfemi *et al.,* 1999; Bayewu *et al.,* 2018; Ishola *et al.,* 2016; Ishola *et al.,* 2021). High percentage of water users across the globe rely substantially on groundwater (Reilly *et al.,* 2008). Though, water has been and will continue to be a renewable resource, but its continuous and quality supply is decreasing gradually due to lack of proper adequate water management techniques and effect of poor waste water management especially in Nigeria and other developing and under developing countries of the globe. The demand for groundwater over the years has increased significantly throughout the world due to population growth, industrialization, socio-economic development, technological and climatic changes (Olayinka *et al.,* 1999; Alcano, 2007; Ishola *et al.,* 2016; Ishola, 2019). The urge to sustain groundwater need by people has inadvertently strengthened the application of appropriate geophysical and/or hydrogeological search (Olayinka *et al.,* 1999; Olorunfemi *et al.,* 1999; Lashkaripour, 2003; Batayneh, 2010; Omosuyi, 2010; Anudu *et al.,* 2011) in order to locate areas of high and reliable groundwater prospects or characterize seasonal changes in the near-surface aquifer (Webb *et al.,* 2011; Bayewu *et al.,* 2018). Studies show that high rate of urbanization, industrialization and other human activities have resulted into the release of toxic substances into the ground which consequently migrate its way as discharge materials and percolate through the subsurface with unprecedented impacts on the aquiferous zone (Bala and Ike, 2001; Ishola, 2019; Ishola *et al.,* 2021). Groundwater reservoir in the Precambrian Basement Complex usually occur at shallow depths and hence, are vulnerable to surface or near-surface contaminants (Rupert, 2001; Babiker *et al*., 2005).

Obafemi-Owode is a fast growing area in Ogun State coupled with its very close proximity to Abeokuta; the ancient administrative city and Capital of Ogun State, South-West Nigeria. It lies in the basement terrain and a decrease in water status in terms of quality and quantity has been its challenge. The daily increase in population and the accompanied infrastructural growth within Obafemi-Owode Local Government Area necessitated the quest for further emphasis for the development of a sustainable water supply network. Also, the physical, human and material resources being invested in the development and supply of public water system are quite demanding and higher when compared to harnessing groundwater sources (Ishola *et al.,* 2016). Therefore, much emphasis is placed on the development of subsurface water which is hopefully achievable within a short period of time (Ishola *et al.,* 2016). Groundwater exploration within the Basement Complex rocks of Nigeria is usually carried out with the use of Vertical Electrical Sounding (VES) (Omosuyi *et al.,* 2003; Olasehinde and Bayewu, 2011; Oloruntola and Adeyemi, 2014; Ishola *et al.,* 2016). Consequently, a reconnaissance and detailed geoelectric survey of the study area was undertaken to determine the geoelectric parameters (resistivities, thicknesses, number of layers) of subsurface layers and their hydrogeological properties.

Location, geology and hydrology of the Area

Obafemi-Owode is situated in Ogun State within the southwestern part of the Nigerian Precambrian basement complex rocks and lies within longitudes $3^{0}20.617'$ with $3^{0}45.236'$E and latitudes $7^{0}00.102'$ and $7^{0}11.897'$N . The map of surveyed and sampled locations for the study area is shown in (Fig. 3**).** The study area is accessible via Lagos-Abeokuta express road; two major roads, few minor roads and footpaths making conveyance and mobility accessible and convenient. The study areas fall within the humid tropical region which is characterized by two distinct seasons which characterized the tropics in the southern part of Nigeria namely; the wet and dry seasons (Ishola *et al*., 2016).

The physiography of the study area results from the geomorphic processes that have shaped the terrain (Akanni, 1992); the topography is undulating and ranges from high to low relief. The crystalline basement complex rocks of Nigeria are well represented in specified study areas of Ogun State (Kehinde-Phillips, 1990). These rocks belong to the youngest of the three major provinces of the West African Craton recognized by Hurley and Rank (1976). This source of water supply is not sufficient and therefore does not meet the demand of the populace. This surface water, which serves as the major source of water consumption in the identified locations of the study area, has a very low productivity during the dry season due to low evaporation rate and consequent lower precipitation than annual average. Though, most sachet water industries rely heavily on the supply from state water corporations; this has overtime increased the challenge of water scarcity due to the overriding higher demand for the water over the corresponding supply. Furthermore, some inhabitants use hand dug wells, but this also creates similar painful effect during dry season because the depth of the aquiferous zone is not being reached due to the nature of the terrain and the cost of drilling of standard borehole is capital intensive. For these reasons, groundwater stands to be the best considered option but there is a contesting challenge of delineating high productive aquiferous zones in different investigated locations.

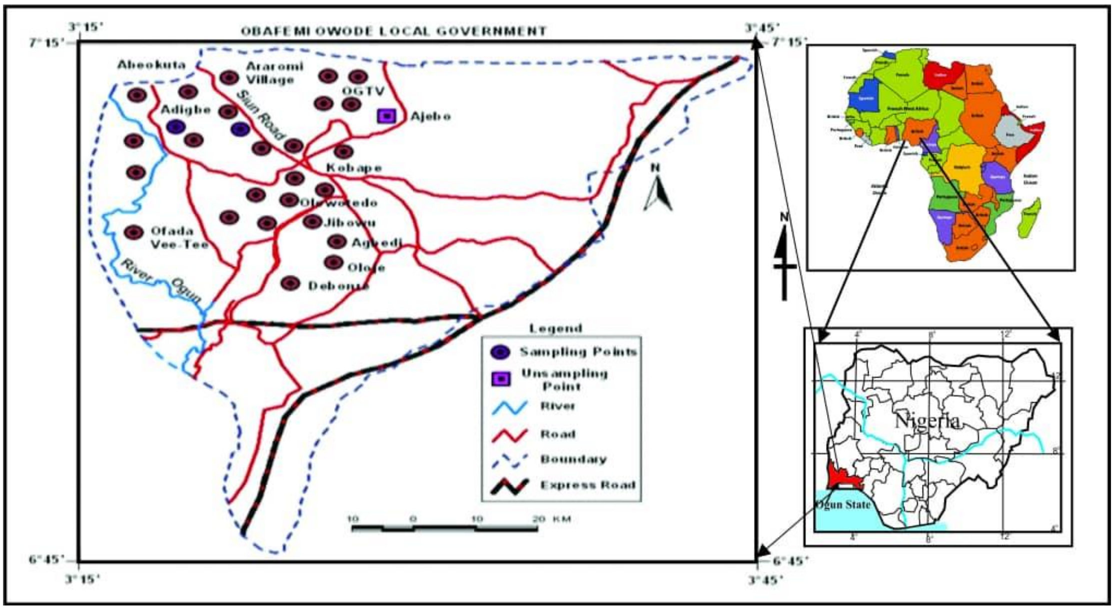

Fig. 3: Map showing the investigated location in Obafemi-Owode study area (Ishola et al., 2016)

DATA AND METHODOLOGY

The electrical resistivity of the subsurface geology of the study area was investigated using ALLIED OHMEGA resistivity meter (REV G0414) obtained from the Department of Geology, University of Ibadan. Schlumberger Configuration was adopted in undertaken a total of twenty-seven (27) Vertical Electrical Sounding (VES) with maximum current electrode ($\frac{AB}{2}$) spacing of 100m across the area while the coordinates of the locations were acquired using Global Positioning System (GPS 60, GARMIN) (Fig. 3). The field equipments used were geological map, electrodes, cable and reels, hammer, measuring tape, recording sheets and GPS. The current (AB) electrodes spacing was varied from 1 to maximum of 100m and the potential (MN) electrodes were changed from 0.25m to 5m respectively. The potential electrodes needed to be increased so as to measure the spacing in current electrodes with respect to depth. Consequently, the apparent resistivity (ρ_a) values were obtained as the product of the resistance read from the resistivity meter and its corresponding geometric factor calculated (Ariyo and Adeyemi, 2009; Ishola *et al.,* 2021). The extracted results were then plotted against their corresponding half current electrode spacing ($\frac{AB}{2}$) on a bi-logarithm paper. The plotted field curves were therefore interpreted manually by partial curve matching with suitable auxiliary charts using different master curves in consonance with basic local subsurface geology and hydrogeologic history of the study area (Bayewu *et al*., 2018; Ishola *et al.,* 2016; Ishola *et al.,* 2021). The acquired geoelectric parameters output from the partial curve matching qualitative interpretation then provided an input model for computer-assisted iteration of the Vander Velpen, (2004) utilizing WINRESIST version 1.0 program both for the iteration and presentation of the curves.

Effect of Anisotropy on Resistivity

In any given geological environment, layering and fracturing is an indispensable parameters affecting resistivity measurement. Thus, there is no uniformity in the flow of electric current (Bayewu *et al*., 2018).

Anisotropy coefficient is a measure of inhomogeneity of a medium (Olorunfemi *et al*., 1999); it increases linearly with increase in groundwater yield. In stratified conductors, identifiable parameters are of basic importance for the understanding and consequent interpretation of the geoelectrical model of stratified conductors. These parameters are related to different combinations of the thickness and resistivity of each geoelectrical layer in the model. The integration of the thickness and resistivity of the geoelectric layers into single variables; the Dar-Zarouk parameters of Transverse unit resistance (R) and Longitudinal unit conductance (S), can be efficiently utilized as a basis for the evaluation of aquifer properties such as transmissivity (T) and protective capacity (Pc) of the overburden rock materials in the course of geo-electrical section with a unit crossectional area.

For a geologic layer that is horizontal, homogenous and isotropic, the Dar-Zarouk parameters of transverse unit resistance and longitudinal unit conductance can be expressed as:

$S_i = \sum_{i=1}^{n} h_{i/\rho_i}$ and $T = \sum \rho_i h_i$ ……………………………………………………..(1)

The Anisotropic coefficient (λ) = $\sqrt{\rho_t/\rho_l}$ (Ishola *et al*., 2016).

$$(\lambda) = \sqrt{\frac{T}{H} \cdot \frac{S}{H}} \quad \text{......} \quad (2)$$

T and S are known as Dar-Zarrouk parameters (Ishola *et al.,* 2016).
For an isotropic medium

$\rho_t = \rho_l$ such that $\lambda = 1$
For an anisotropic medium
$\rho_t > \rho_l$ such that $\lambda > 1$
Equation (2) is used for layered rocks such as sedimentary rocks and it is also applicable to basement complex rocks that shows layered structured (Olayinka, 1996; Ishola, 2019; Ishol *et al*., 2016). This was calculated using method of Bhattacharya and Patra (1968); Olayinka (1996). The reflection coefficient between the sub-basement and basement layer was calculated which is an indication that the fracture within the bedrocks are filled with water.

$$K_n = \frac{\rho_n - \rho_n - 1}{\rho_n + \rho_n - 1} \qquad (3)$$

Where Kn is the reflection coefficient
n is the no of layers
ρ_n *is the layer resistivity of the* nth layer
$\rho_n - 1$ is the layer resistivity overlying the nth layer.
where ρ_i and h_i are the layer resistivity and thickness of the ith layer. The aquifer transmissivity (T) can therefore be expressed as the multiplication of the hydraulic conductivity (k) and the layer thickness (h) of the geological formation (Ishola *et al*., 2016).

$$T = Kh \qquad (4)$$

When saturated aquifers are clean and their natural fluid characteristics are fairly constant (signifying lack or low impact on the general subsurface water quality by contaminants loads migrating from the surface), the hydraulic conductivity is proportional to the resistivity of the aquifer. This implies that in the absence of a pumping test data, the aquifer hydraulic conductivity K can be approximated to the true resistivity of the aquifer derived from geoelectric investigation (Olorunfemi and Okhue, 1992; Hubbard and Robin, 2002). Therefore

$$T = Kh = \rho h \qquad (5)$$

But the product of the resistivity to its thickness is the transverse resistance (R), which is numerically equal to the transmissivity, T (Hubbard and Robin, 2002).

$$T = R \qquad (6)$$

The aquifer parameters in this study were calculated from the Geometric computations of Dar-Zarrouk parameter for each location from the output of the analysis in the study area.

RESULTS AND DISCUSSION

The salient features of the acquired field data from the electrical resistivity soundings were interpreted quantitatively with the inferred lithologies from the geoelectric interpretation shown in Table 1. The resistivity of the top Soil ranges from 14.4**Ω**m in VESOB26 with a thickness of 6.2m alongside 15.5**Ω**m in VESOB24 with a thickness of 0.3m to VESOB15 which has the highest resistivity value of 7959.2**Ω**m with a thickness of 0.6m. The weathered layer which comprises of Sandy Clay/Clayey Sand/Clay/Shale whose layer resistivity value ranges from 16.7**Ω**m in VESOB6 and VESOB8 with depths of 3.1m and 4.36m respectively to VESOB21 possesses the highest resistivity value of 5545.6 **Ω**m with a depth of 3.5m in VESOB24, underlying this layer are the fractured basement with the lowest resistivity value of 155.3**Ω**m in VESOB4 whose depth could not be determined due to current termination and the highest resistivity value of 1061.2**Ω**m in VESOB5. The fresh basement displayed resistivity values which range from 432.8**Ω**m in VESOB21 to 22,388.7**Ω**m in VESOB16; the corresponding depths are undetermined due to current termination. It is worthy of note that the nature of the basement is not dependent on the absolute resistivity values but rather dependent on its reflection coefficient values which measures the competency of the rock (Olayinka 1996;

Olorunfemi et al., 2005; Ishola *et al.,* 2016). The lower reflection coefficient values (< 0.8) were observed in all the investigated locations except in five locations namely; VESOB18 (0.97 with a resistivity value of its fresh basement as 17710.9 **Ω**m with the overburden thickness of 45m); VESOB19 (0.93 with a resistivity value of its fresh basement as 12037.3 **Ω**m with the overburden thickness of 33.2m); VESOB20 (0.89 with a resistivity value of its fresh basement as 12495.8**Ω**m with the overburden thickness of 41.06m); VESOB25 (0.99 with a resistivity value of its fresh basement as 8834.9**Ω**m with the overburden thickness of 35.1m) and VESOB26 (1.0 with a resistivity value of its fresh basement as 5289 **Ω**m with the overburden thickness of 32.6m). This suggests that the other areas with lower values of reflection coefficient (< 0.8) have less competent underlying basement. Thus, they are therefore referred to as the fractured basement.

Table 1: Geoelectric Interpretation and Inferred Lithologies of the Study Area

VES Points	No of Layers	Resistivity (ohm-m)	Thickness (m)	Depth (m)	Reflection Coefficient	Inferred Lithology	Aquifer Type
VESOB1	1	278.4	0.9	0.9	0.3509	Lateritic Top Soil	Confined
	2	45.0	2.5	3.4		Sandy Clay	
	3	101.1	7.85	11.25		Clayey Sand	
	4	673.0	–	–		Fractured Basement	
VESOB2	1	567.8	0.5	0.5	0.1438	Lateritic Top Soil	Confined
	2	1033	1.3	1.8		Sandy Clay	
	3	139.8	6.5	8.3		Clayey sand	
	4	2138.3	–	–		Fresh Basement	
VESOB3	1	488.7	2.7	2.7	0.1869	Lateritic Top Soil	Unconfined
	2	55.6	10.8	20.6		Sandy Clay	
	3	372.9	–	–		Fractured Basement	
VESOB4	1	207.8	1.8	1.8	0.1983	Lateritic Top Soil	Unconfined
	2	24.3	13.7	15.5		Sandy Clay	
	3	155.3	–	–		Fractured Basement	
VESOB5	1	1081.2	1.1	1.1	0.0296	Lateritic Top Soil	Unconfined
	2	44.8	11.3	12.4		Sandy Clay	
	3	1061.2	–	–		Fractured Basement	
VESOB6	1	570.1	1.0	1.0	0.0875	Lateritic Top Soil	Unconfined
	2	452.2	1.6	2.6		Sandy Clay	
	3	16.7	3.1	5.7		Clayey sand	
	4	1301.8	–	–		Fresh Basement	
VESOB7	1	347	1.0	1.0	0.2225	Lateritic Top Soil	Unconfined
	2	295.2	1.8	2.8		Sandy Clay	
	3	36.5	15.3	18.1		Clayey sand	
	4	408.4	–	–		Fractured Basement	
VESOB8	1	60.6	0.31	0.31	0.3682	Lateritic Top Soil	Unconfined
	2	16.71	4.36	4.67		Sandy Clay	
	3	840.58	29.3	33.97		Clayey sand	

	4	35.7	–	–		Fractured Basement	
VESOB9	1	118.7	3.3	3.3	0.7666	Lateritic Top Soil	Confined
	2	161.7	4.6	7.9		Sandy Clay	
	3	168.9	9.36	17.26		Clayey sand	
	4	2122.3	–	–		Fresh Basement	
VESOB10	1	553.2	0.9	0.9	0.0303	Lateritic Top Soil	Confined
	2	984.7	2.1	3.0		Sandy Clay	
	3	1282.5	12.3	15.5		Coarse Sand	
	4	685.5	69.3	84.7		Clayey sand	
	5	1634	–	–		Fresh Basement	
VESOB11	1	453.2	0.7	0.7	0.0736	Sandy Top Soil	Confined
	2	958.5	9.8	10.5		Sand	
	3	271.4	86.4	96.8		Clayey sand	
	4	1635.9	–	–		Fresh Basement	
VESOB12	1	285.7	0.4	0.4	0.6542	Sandy Top Soil	Confined
	2	2236.7	1.4	1.8		Sand	
	3	422	7.8	9.6		Sandy Clay	
	4	55.5	39.55	49.15		Clayey sand	
	5	527	–	–		Fresh Basement	
VESOB13	1	331.1	0.7	0.7	0.2225	Lateritic Top Soil	Confined
	2	697.9	6.4	7.1		Sandy Clay	
	3	39.6	83.8	90.8		Clayey sand	
	4	654.4	–	–		Fresh Basement	
VESOB14	1	1019.9	0.6	0.6	0.2378	Lateritic Top Soil	Confined
	2	4543.7	2.1	2.7		Sandy Clay	
	3	113.9	7.5	10.2		Shale/Clay	
	4	10876.2	–	–		Fresh Basement	
VESOB15	1	7959.2	0.6	0.6	0.4355	Lateritic Top Soil	Confined
	2	2161.9	1.9	2.5		Sandy Clay	
	3	274.3	14.5	17.0		Shale/Clay	
	4	11627.9	–	–		Fresh Basement	
VESOB16	1	1647.3	1.0	1.0	0.5427	Lateritic Top Soil	Confined
	2	4989.5	2.2	3.2		Sandy Clay	
	3	181.4	23.0	26.2		Shale/Clay	
	4	22388.7	–	–		Fresh Basement	
VESOB17	1	1035.2	1.1	1.1	0.3179	Lateritic Top Soil	Unconfined
	2	281.9	11.7	14.3		Sandy Clay	
	3	2733.3	–	–		Fresh Basement	
VESOB18	1	24.6	1.2	1.2	0.9682	Lateritic Top Soil	Confined
	2	261.6	1.4	2.6		Sandy Clay	
	3	437.97	19.2	21.8		Clayey Sand	
	4	492.8	23.5	45.3		Shale/Clay	
	5	17710.9	–	–		Fresh Basement	
VESOB19	1	48.0	1.9	1.9	0.9280	Lateritic Top Soil	Confined
	2	401.8	2.1	4.0		Sandy Clay	
	3	396.13	29.2	33.2		Shale/Clay	
	4	12037.3	–	–		Fresh Basement	

VESOB20	1	103.2	1.1	1.1	0.8914	Lateritic Top Soil	Confined
	2	614.27	6.03	7.13		Sandy Clay	
	3	346.53	11.43	18.56		Clayey Sand	
	4	1003.2	22.5	41.06		Shale/Clay	
	5	12495.8	–	–		Fresh Basement	
VESOB21	1	112.5	2.0	2.0	0.4370	Lateritic Top Soil	Confined
	2	57.08	6.1	8.3		Sandy Clay	
	3	199.43	9.13	17.43		Shale/Clay	
	4	432.8	–	–		Fresh Basement	
VESOB22	1	238.7	1.7	1.7	0.1725	Lateritic Top Soil	Confined
	2	4084.2	11.53	32.3		Sandy Clay	
	3	309.8	14.17	46.47		Shale/Clay	
	4	6125.6	–	–		Fresh Basement	
VESOB23	1	83.5	1.3	1.3	0.4544	Lateritic Top Soil	Unconfined
	2	464.7	1.8	3.1		Clayey Sand	
	3	1281	24.3	27.4		Clay	
	4	205.1	46.0	73.4		Shale/Clay	
	5	686.2	–	–		Fractured Basement	
VESOB24	1	15.5	0.3	0.3	0.5644	Lateritic Top Soil	Confined
	2	5545.6	3.5	3.8		Sandy Clay	
	3	202.63	20.7	24.5		Shale/Clay	
	4	1548.6	–	–		Fresh Basement	
VESOB25	1	54.3	7.2	7.2	0.9878	Lateritic Top Soil	Unconfined
	2	350.0	27.9	35.1		Sandy Clay	
	3	8834.9	–	–		Fresh Basement	
VESOB26	1	14.4	6.2	6.2	0.9946	Lateritic Top Soil	Unconfined
	2	180.2	26.4	32.6		Sandy Clay	
	3	5289	–	–		Fresh Basement	
VESOB27	1	161.5	2.3	2.3	0.1027	Lateritic Top Soil	Unconfined
	2	474.5	9	11.3		Sandy Clay	
	3	1742.5	19.9	31.2		Clayey Sand	
	4	134	29.8	61.0		Shale/Clay	
	5	781.6	–	–		Fresh Basement	

Low to moderate range of resistivity values were identified between 16Ωm and 84Ωm. it is observed that VES 0B3, 0B4, 0B5, 0B7 and 0B13 have much higher groundwater potential values since the layer resistivity is between 0 and 100**Ω**m. High values of *T* can be associated with the zones of high transmissivity. Hence, these zones are suggested for the installation of monitoring wells for the unconfined aquifer. In Obafemi-Owode, the highest transverse unit resistance was recorded for VES 0B16 (808005.38) while lowest transverse unit resistance was recorded for VES 0B4 (6043.44). Higher values from 3000 to 9000**Ω**m^2 are mostly seen in the area where there is presence of hard rock at shallow depth. The range of transverse unit resistance values from 600**Ω**m^2 to 1200**Ω**m^2 is also considered as a criterion for identification of aquiferous zone (Jagadeeswara et al, 2003). Also these values of transverse unit resistance in the study areas are > 400**Ω**m^2 and correspond to zones where the thicknesses and resistivities of the aquifer are large. As conductance increases the resistivity naturally decreases pointing towards groundwater potential aquifer (Gowd, 2004). Values of S > 1.0

siemens would indicate zones in which the confined aquifer would be protected in comparisons, values of S <1.0 Siemens would indicate zones of probable risks of contamination. Generally, the coefficient of anisotropy (λ) is 1 and does not exceed 2 in most of the geological conditions (Zohdy Eaton and Mabey 1974).
Compact rock at shallow depth increases the coefficient of Anisotropy (Ishola, 2016). More than 2 coefficient of Anisotropy value (λ) indicates very hard porphyritic granite gneiss and garnet biotite genesis terrain of the geological environment. In Obafemi-Owode, the coefficient of Anisotropy ranges from 0.9 to 1.0 as shown in Table 2 with the variation from each VES station displayed in Fig. 4; areas with VES 0B2, 0B3, 0B4, 0B5, 0B14, 0B15, 0B18, 0B21 and 0B22 have lower coefficient of Anisotropy compared to other VES stations (Table 1). Also, areas with less than 1.5 coefficient of anisotropy values are considered as potential aquifers for groundwater exploitation. Alluvial aquifers, fractured zones and valley fills with anisotropy value around 1 are recognized as good groundwater potential zones(Oborie and Nwankoala, 2012; Ishola, 2016).

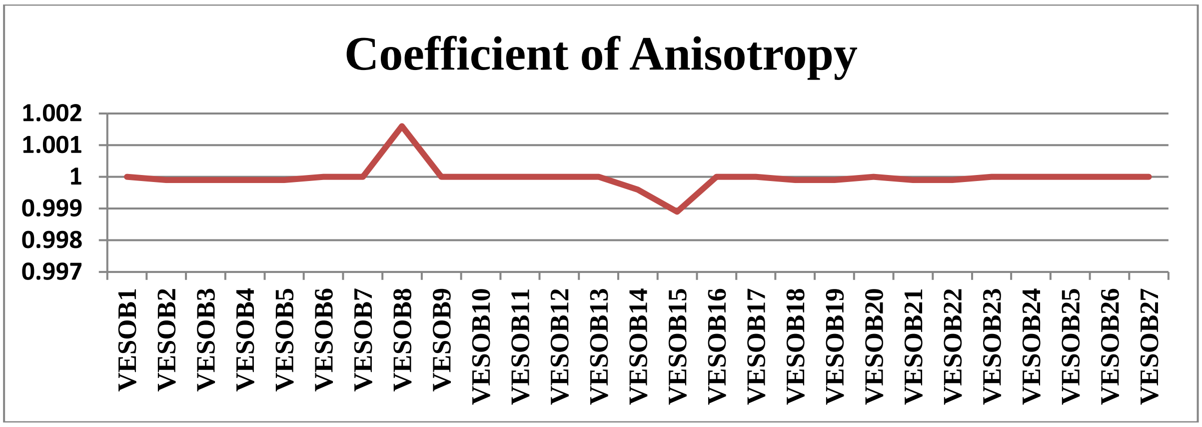

Fig. 4: Variation of Coefficient of Anisotropy with VES stations

CONCLUSION

The qualitative and quantitative data interpretation of the study area revealed that 63% of the investigated locations possess high groundwater potentials in terms of the analyzed aquifer properties of the study area, 18% have moderate or medium investigated and 19% have low groundwater potentials in terms of yield. The lower reflection coefficient values (< 0.8) were observed in all the investigated locations except in five locations namely; VESOB18 (0.97 with a resistivity value of its fresh basement as 17710.9 **Ω**m with the overburden thickness of 45m); VESOB19 (0.93 with a resistivity value of its fresh basement as 12037.3 **Ω**m with the overburden thickness of 33.2m); VESOB20 (0.89 with a resistivity value of its fresh basement as 12495.8**Ω**m with the overburden thickness of 41.06m); VESOB25 (0.99 with a resistivity value of its fresh basement as 8834.9**Ω**m with the overburden thickness of 35.1m) and VESOB26 (1.0) with a resistivity value of its fresh basement as 5289 **Ω**m with the overburden thickness of 32.6m); this suggests that the other areas with lower values of reflection coefficient (< 0.8) have less competent underlying basement; they are referred to as the fractured basement. The Coefficient of Anisotropy ranges from 0.9 to 1.0 while VES 0B2, 0B3, 0B4, 0B5, 0B14, 0B15, 0B18, 0B21 and 0B22 have lower coefficient of Anisotropy compared to other VES stations (Table 2) with locations less than 1.5 coefficient of anisotropy values considered as potential aquifers for groundwater exploitation. Therefore, prospecting for groundwater in the study area is very promising nevertheless the revelations in the study area are possible indications that the groundwater quality may have been impaired which necessitated the need for borehole water to be randomly sampled for contaminant loads based on these prospective analyses.

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