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ISSN: 2687-5993

International Journal of Earth Sciences Knowledge and Applications

RESEARCH ARTICLE

Hydrogeophysical Studies of Central Kwara State Basement Complex of Nigeria

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INFORMATION

Article history
Received 24 August 2020
Revised 10 September 2020
Accepted 11 September 2020
Available 15 October 2020

Keywords
Ground Magnetic
VLF-EM
Coefficient anisotropy
Longitudinal conductance
Transverse resistance
Groundwater yield

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ABSTRACT

The quest to meet the required groundwater need of citizens of Nigeria, especially Central Kwara State for both domestic and industrial application in the face of scarce water resources, occasioned by incessant borehole failure/low yield, has prompted researches for viable source of water. In this study, an integrated geophysical approach involving ground magnetic, Very Low Frequency Electromagnetic (VLF-EM) and Vertical Electrical Sounding (VES) has been employed to establish geologic features associated with groundwater occurrence in four (4) local government area of Central Kwara State. Twenty VLF-EM profiles, fifteen magnetic profiles and seventy-three VES were conducted in W-E orientation across the geologic strike within settlements in the area, with traverse length 500 to 3000 m and spread 200 to 650 m (AB). The ABEM Wadi VLF-EM and SAS 4000 terrameter equipments, and total field intensity magnetometer G19T were used to measure conductive/resistive variation and magnetic susceptibility of various lithologic units. The results from VES were used to determine the second order parameters such as total traverse resistance (T), longitudinal conductance (S) and coefficient of anisotropy (λ) while the product of coefficient of anisotropy and total traverse resistance were employed to determine the yield index The yield index ranged between 1to 3000 G.W.I with range of 32 to 350, 350 to 450, 450 to 850, 850 to 1750 and 1750 to 3000 and above representing dry/abortive, extremely low yield, low yield, medium yield and high yield respectively. From the results, it is concluded that the north-eastern and the central region of the area has the highest prospect while part of the north western, north central and the south eastern part has medium prospect and the rest of the area has prospect for low yield except for the south western end. Part of the south western and the middle part of the north eastern part has lean or least prospect for groundwater.

1. Introduction

Groundwater generally refer to water within the subsurface which can be abstracted by the construction of well or boreholes for the purpose of domestic, agricultural and industrial water usage and applications. Porosity and permeability are the most important properties governing the accumulation, migration and distribution of groundwater in aquifers (Kosinski and Kelly, 1981; Ilugbo et al., 2018; Adebo et al., 2018). If groundwater resource is to be tapped, it is essential that the project is to be conducted in a most efficient and cost-effective manner, consisting of near accurate delineation of the water bearing units and the probable depth of drilling (Bawallah et al., 2018). The crust of the earth is composed of solid rocks, when the rock is closely examined, they are found to be composed of discrete grains of different sizes, shapes, and colours. These grains are minerals, which are building blocks of all rocks (Murali and Patangay, 1998). In a typical Basement Complex Area such as Central Kwara, and its environs, the occurrence of groundwater in recoverable quantity is controlled by geological factors

(Olorunfemi and Fasuyi, 1993; Amadi and Olasehinde, 2010). The delineation of these geological factors or fissures i.e. faults, joints, fractures, and weathered materials is very essential for better understanding of the geology in terms of their groundwater potential. Therefore, to target potential bedrock aquifers that can give copious supply of groundwater, the mentioned geologic fissures must be identified through Geophysical Investigations and intercepted by boreholes (Adelusi et al., 2013; Okereke et al.,2012; Ilugbo and Adebiyi, 2017).

Considering the many cases of failed/abortive borehole that are common occurrence in this study Area, making majority of the inhabitants to depend on surface water from river, stream, and hand dug well for their daily survival. These sources of water are highly vulnerable to pollution, thereby making the people susceptible to water borne diseases. It therefore becomes a challenge to find a lasting solution to this predicament facing the Government and people of the Area. The delineation of these geologic fissures in low permeability rocks requires the necessary expertise and good understanding of geology in a complex geological environment as was the case in central Kwara. Therefore, ground magnetic, electromagnetic (EM) and Electrical resistivity methods were used in this research work in Central Kwara, which are underlain by rocks of the Precambrian Basement Complex of Nigeria with the aim of assessing its groundwater yield capacity.

2. Site Description and Geology of the Investigated Area

The investigated area lies within latitude $8^0 31' 0"$N to $8^0 43' 0"$N and longitude $4^0 28'00"$Nto$4^0 34' 0"$E, (Fig. 1). It is made of four local government areas, within the Central Kwara State in Nigeria. This includes Moro Local Government, Asa Local Government, Kwara West and Kwara East Local Government of the study area. The area is comprising of forty (40) Towns and Villages, which can be accessed through major and minor road networks. The topography is generally undulating with some areas characterized by hilly ridges and gentle steeps. The area enjoys a tropical climate with two distinct seasons, comprising of rainy season (April to October) and dry season (November to March) with the temperature ranging between 23^0C to 32^0C and dry season (Bawallah et al., 2018). The Central Kwara and it environ is located within Precambrian Basement Complex region. This is because of the tectonics and metamorphic changes that has occurred in the area (Olade, 1978). The following series of rock stands out in the Precambrian Basement rock of Central Kwara and it environ, older granite, younger granite, granite-gneiss, migmatite-gneiss and quartz and laterite. The study area is mainly of older granite undifferentiated of the basement complex rock (Fig. 2).

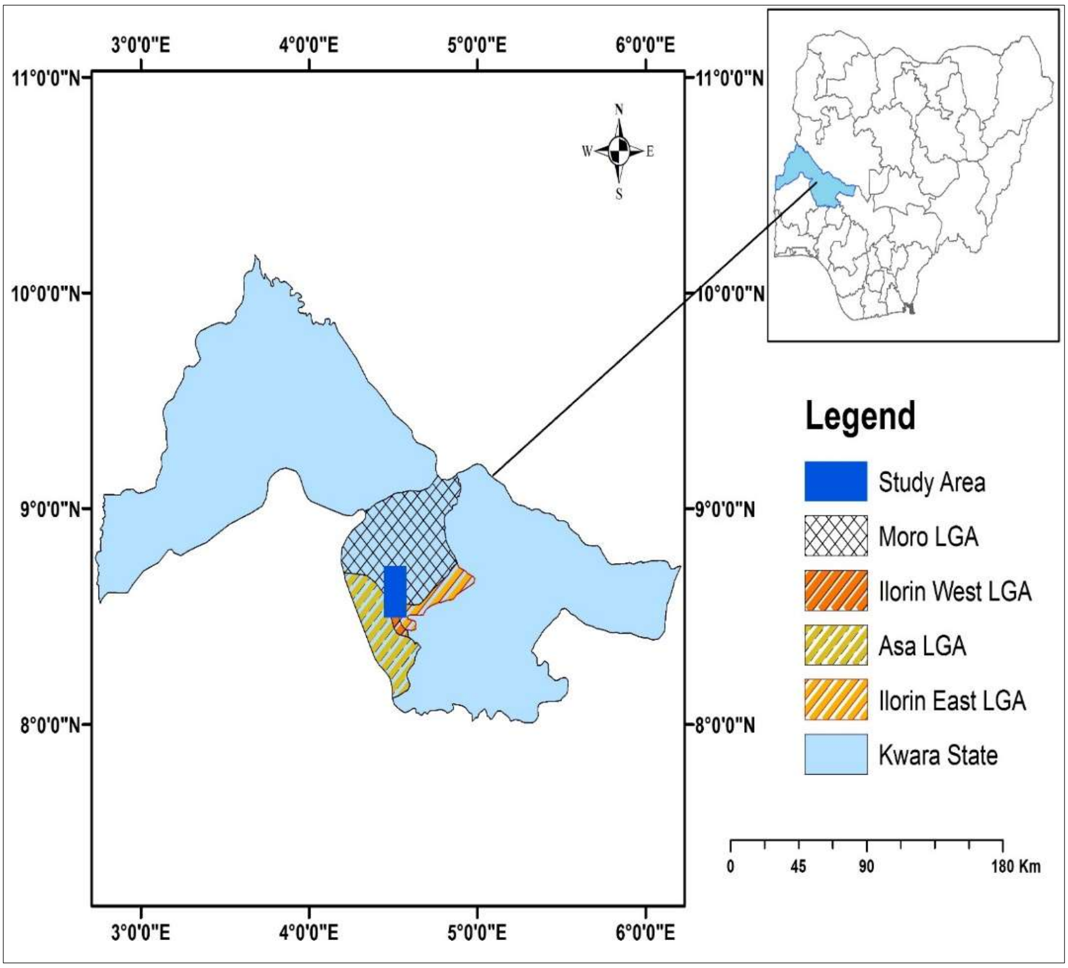

Fig. 1. Location map of study area

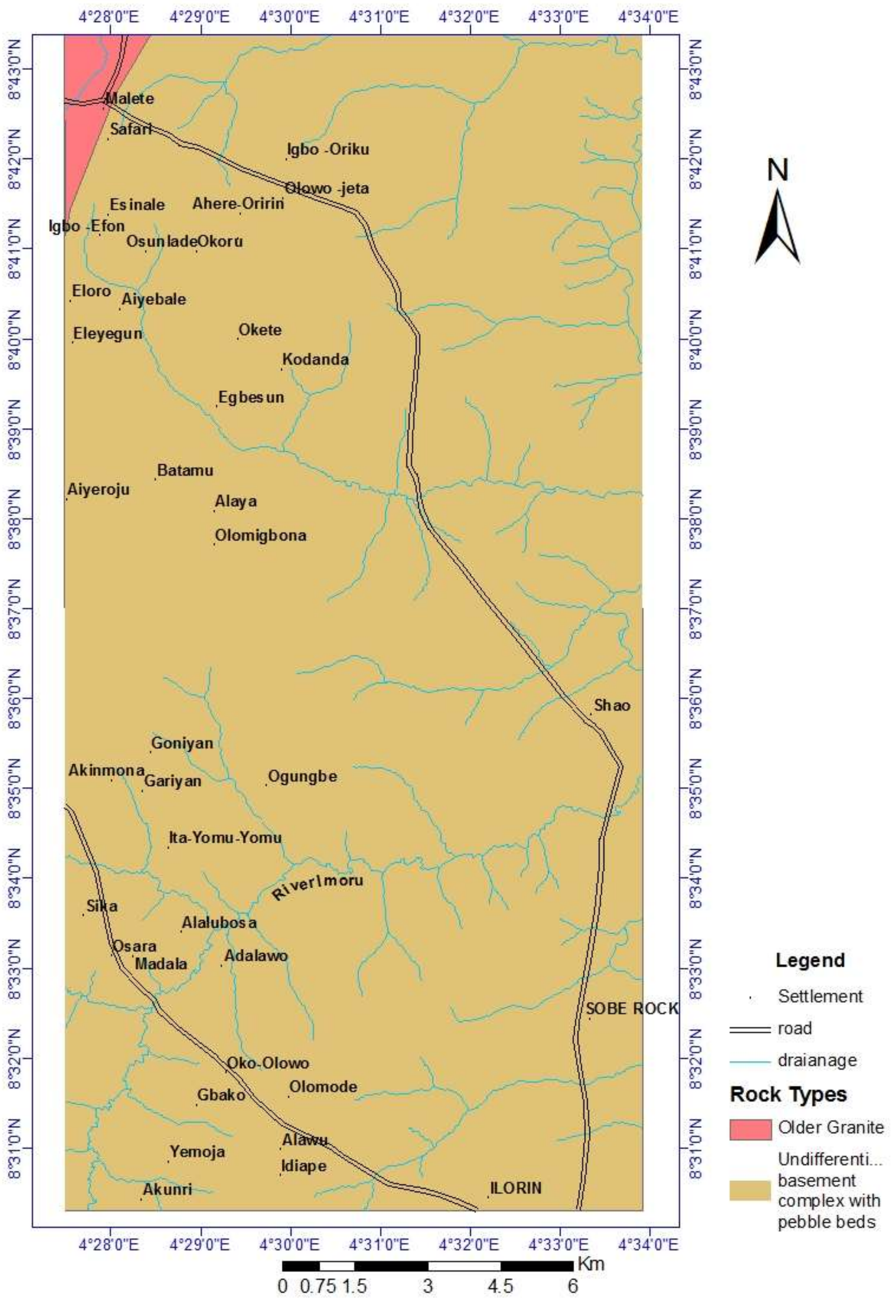

Fig. 2. Geological map of the study area (modified after Bawallah et al., 2018)

3. Research Methodology

The research involves acquisition of data collection where ground magnetic, electrical resistivity and VLF-EM. Electromagnetic profiles were carried out within the study area in East-West orientation, with measuring station interval of 20 m along the traverse length ranging between 500 m to 3 km (Fig. 3). The VLF-EM involves two orthogonal components of the magnetic field were measured, and normally the tilt angle and the elliptvicity of the vertical magnetic polarization ellipse are derived. real (in-phase) and imaginary (quadrature) are used in the Karous-hjelt Fraser filter (KHFILT) software programme. These components are based on the tilt angle and ellipticity as Re = tan (α) 100% and 1m = e 100%. The real and imaginary data values were first plotted using the Microsoft excel. Next was the plot using the karous-hjelt filter (Pirttijarvi, 2004) program to obtain the Fraser filtered pseudo-sections. The Fraser and karous–Hjelt filtering are the two methods widely used in processing VLF – EM data (Fraser, 1969; Karous and Hjelt, 1983). Ground magnetic data were corrected for diurnal variations and offset errors, and the data were subsequently presented as profiles. Points of low magnetic susceptibility were correlated with zones of high positive peak anomaly and these zones were considered for Vertical Electrical Sounding. The schlumberger electrode configuration was adopted for the vertical electrical sounding (VES) techniques which is a measure of vertical variations in the ground resistivity. A total of seventy-three vertical electrical soundings were conducted across the survey area. Each sounding involved stepwise expansion of current electrode separation (AB.2) from 1 to 650 m. The sounding data were presented as sounding curves, which are plots of apparent resistivity (ℓa) values against electrode separation (AB/2) on a bi-log graph. The interpretation of VES curves was done using curve matching of the sounding curves with the theoretical curves with the assistance of auxiliary curves (Keller and Frischnecht, 1966). The results were later enhanced by computer iteration Computer Resist version 1.0 (Vandar Velpan, 1988) to refined the geo-electric parameters obtained from the manual curve matching. The Dar-Zarrouk parameters are obtained from the first order parameters (geoelectric parameters) which are Total longitudinal unit conductance (S), Total transverse unit resistance (T), and coefficient of anisotropy (λ). The product of total transverse resistance and coefficient of anisotropy was used to determine the groundwater yield.

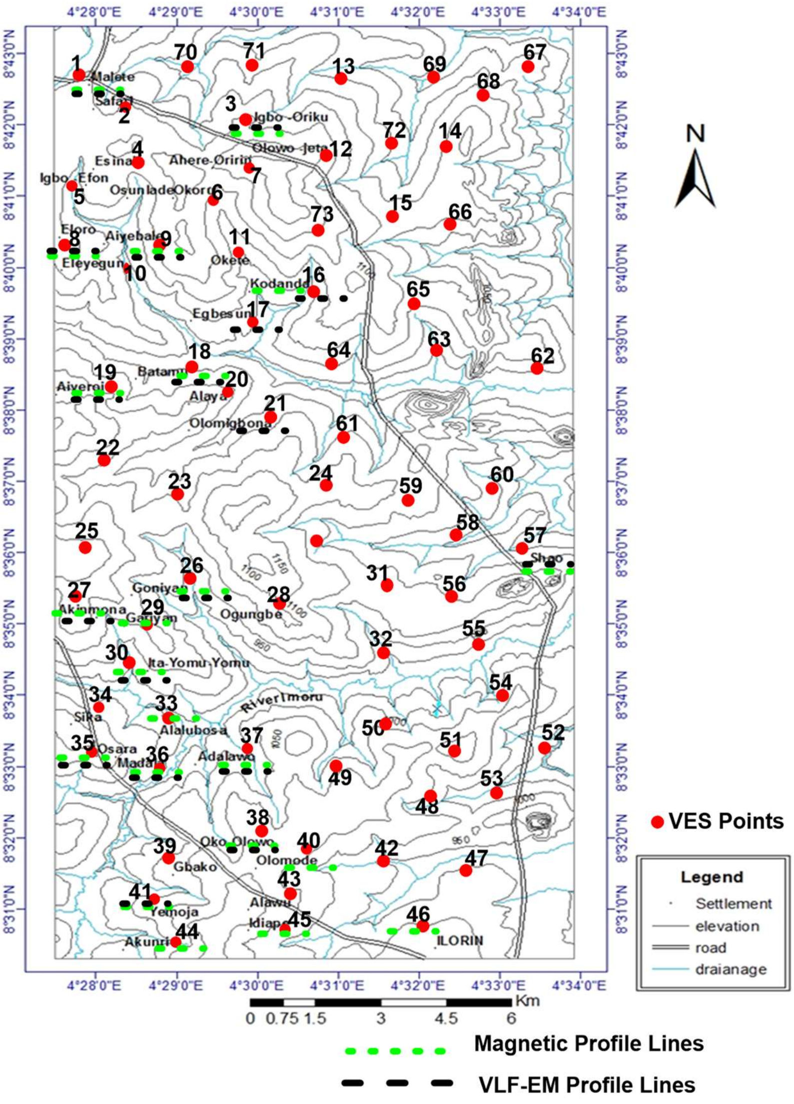

Fig. 3. Map of the Niger Delta Region of Nigeria (Short and Stauble, 1967)

4. Result and Discussions

4.1. VLF-EM

The areas of high current density correspond to positive values and low current density flow corresponds to negative values, resulting into positive peaks and negative troughs on each of the traverse. the positive peaks anomaly is indicative of conductive zones i.e. weak zones, that may be interpreted as fracture/fault, cracks joints or weathered basement rock materials; while the negative troughs are indicative of non-weak zone/resistive materials that may be interpreted as fresh basement rock materials that are neither fractured, faulted, cracked, jointed nor weathered. Therefore, the VLF-EM profiles consist of plots of raw real and filtered real against distances at each of the locations. The peak positive amplitude of the EM response suggests the presence of conductors which corresponds to probable fracture zones in the area. Fig. 4a-t displays the profile plot from profile one to twenty indicating zones of major anomaly/conductive zone with the area. In all an average of eighty (80) conductive zones were identified as diagnostic of fractured, fault, joint, cracks and highly weathered basement material throughout the entire study area. Along profile one (Fig. 4a), two major anomalous zone of interest were identified between 20 – 90 m and between 280-340 m with anomaly values of five to forty percentage (5-40%). Two major positive peaks anomaly of interest diagnose of a conductor were observed in profile two (Fig. 4b). This occurred between 200-340 m with anomaly values of two to ten percentage (2-10%). Two conductive zones were identified between 400-600 m and 800-1000 m along profile three with anomaly values of 3-18 % (Fig. 4c). One major positive peak anomaly occurred at 170 m with anomaly values of 3-10 % (Fig. 4d). Profile Five covered a distance of one kilometer (1 km) and exhibited three to four major anomaly zones at 480 m, 640 m, 820 m and 920 m with anomaly values of one to eighteen percentage (1-18%) (Fig. 4e). Five conductive zone of interest were observed along profile six (Fig. 4f) at a distance of 240 m. 480 m, 660 m, 740 m and 860 m with anomaly values ranging from 1-12%. Three conductive zones were observed at 90 m, 240 m and 440-480 m along profile seven (Fig. 4g), with anomaly values ranging from 0.1-18 %. Profile Eight was characterized by three conductive zones between 120-160 m, 240 m and 400 m to 440 m with anomaly values of 0.8% to 18% (Fig. 4h). Three to four conductive zones were observed on along profile nine with one major point of interest, occurring at 140-200 m with anomaly values varies from 3% to 13% (Fig. 4i). Four positive peak anomalies were at 20 m, 140 m, 280 m and 400 m with anomaly values of 0.5% to 3% along profile ten (Fig. 4j). This procedure was repeated for the remaining VLF-EM profiles (Fig. 4k-t) cutting across the entire study area from which Vertical Electrical Sounding (VES) points were identified for further studies.

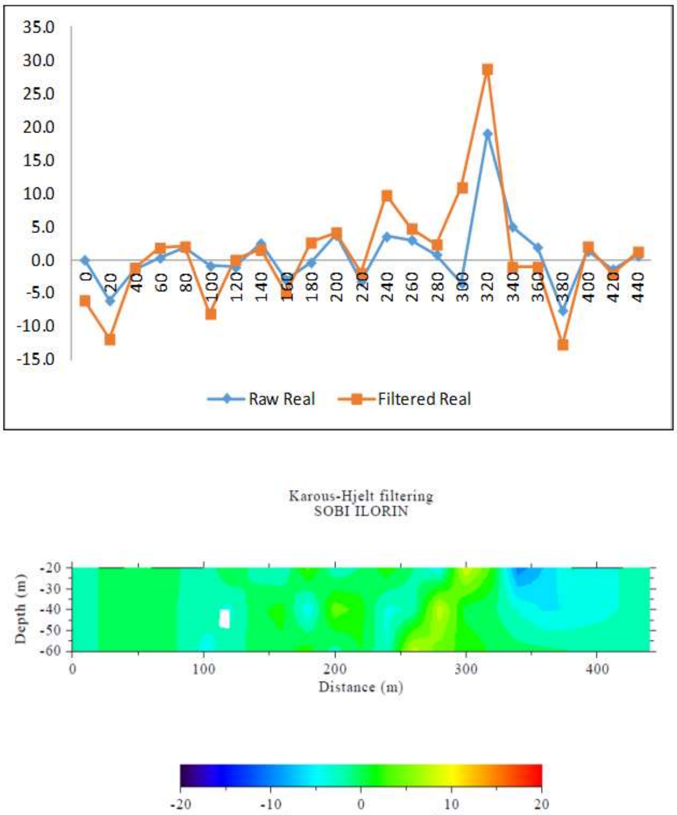

Fig. 4b. Sobi Ilorin Profile

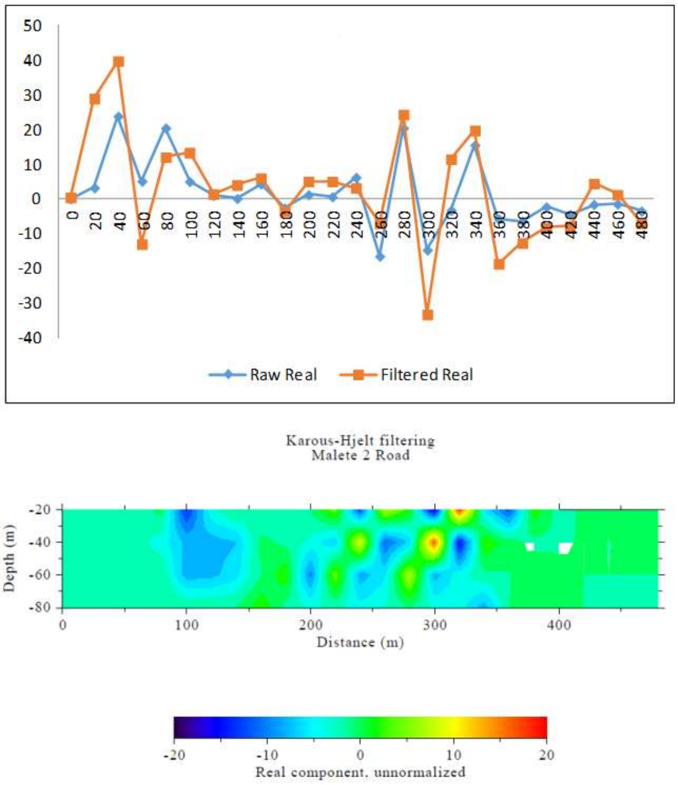

Fig. 4a. Malete 2 Road Profile

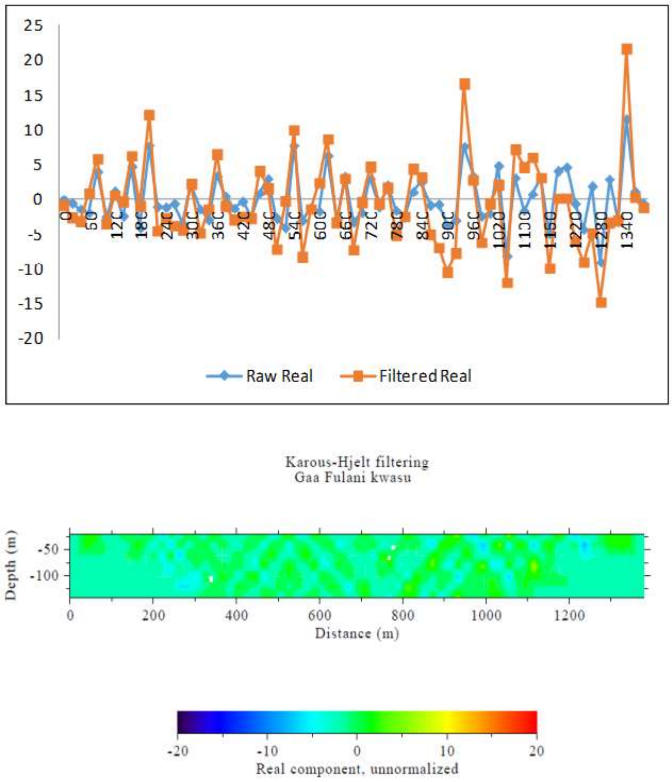

Fig. 4c. Gaa Fulani Kwasu Profile

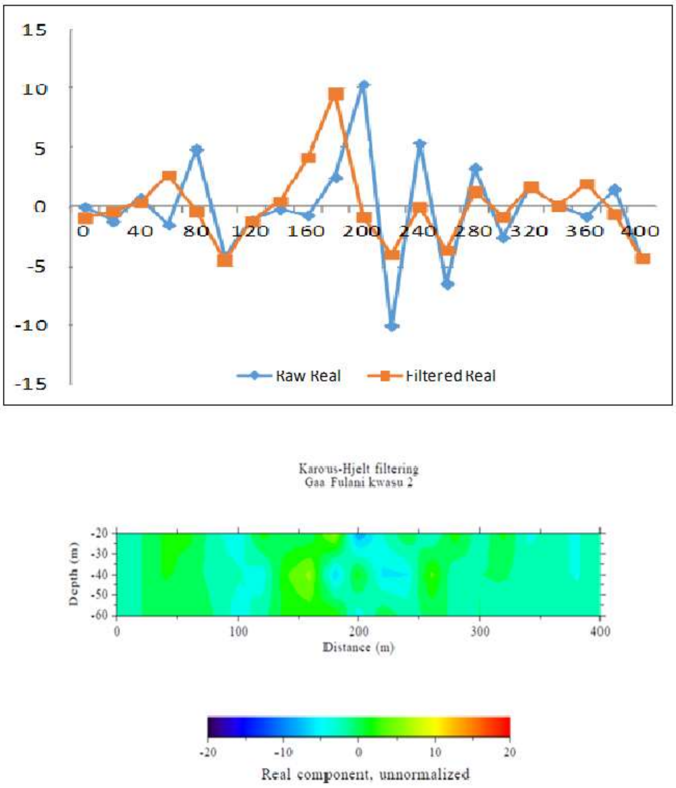

Fig. 4d. Gaa Fulani Kwaa 2 Profile

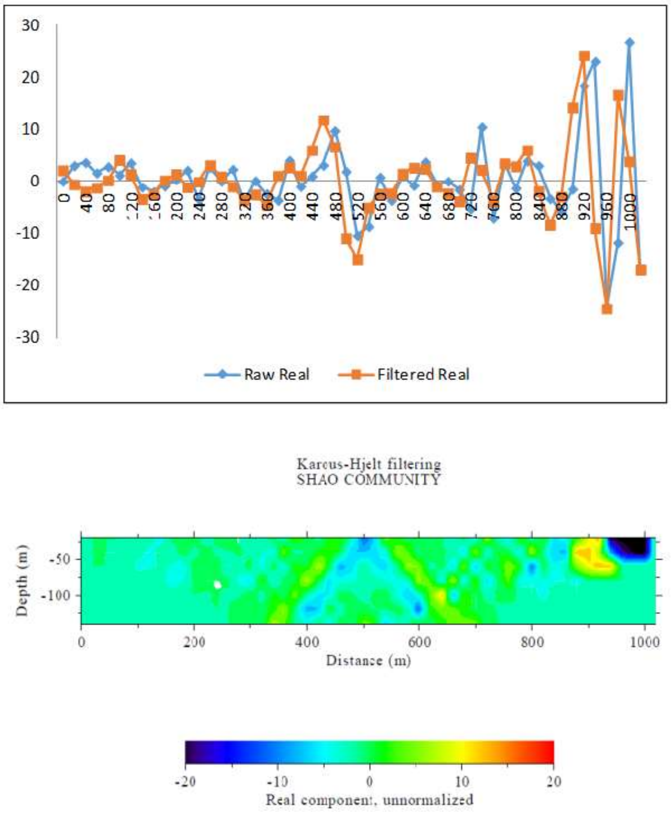

Fig. 4f. Shao Community Profile

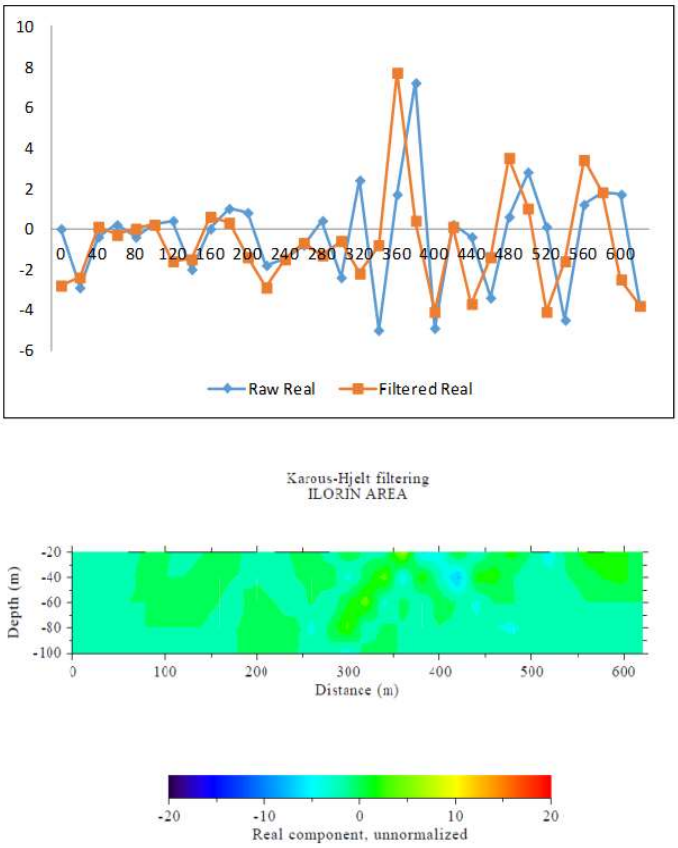

Fig. 4e. Ilorin Area Profile

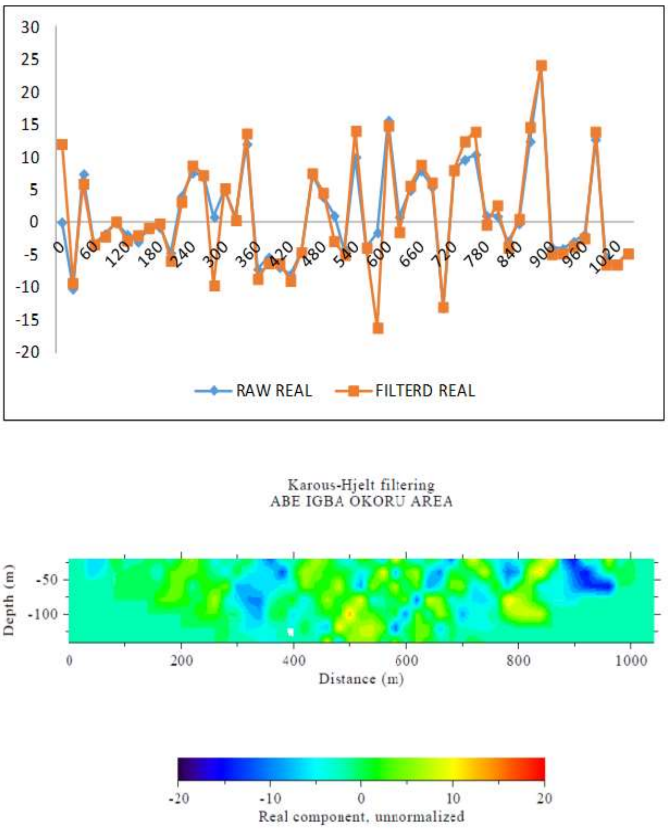

Fig. 4g. Abe Igba Okoru Area Profile

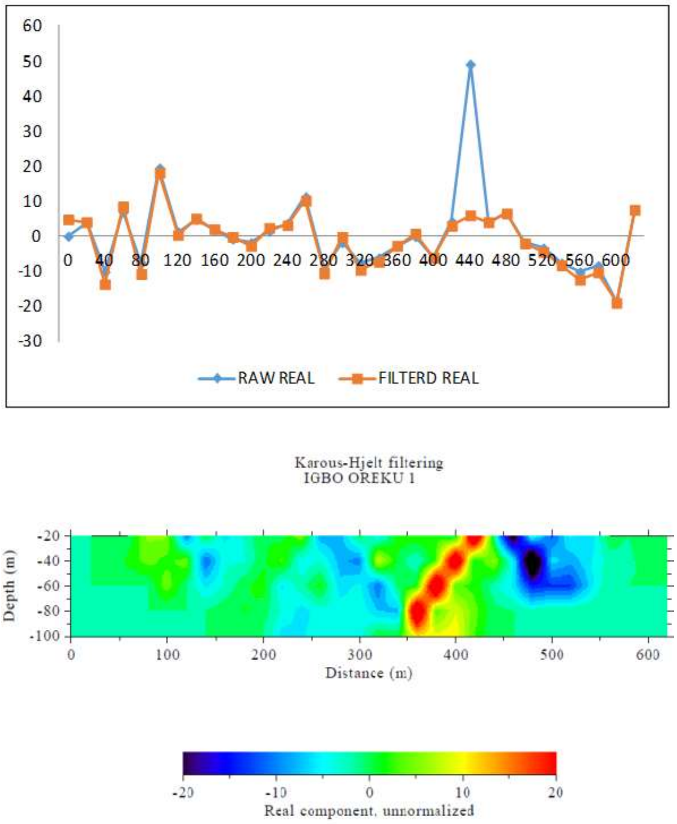

Fig. 4h. Igbo Oreku 1 Profile

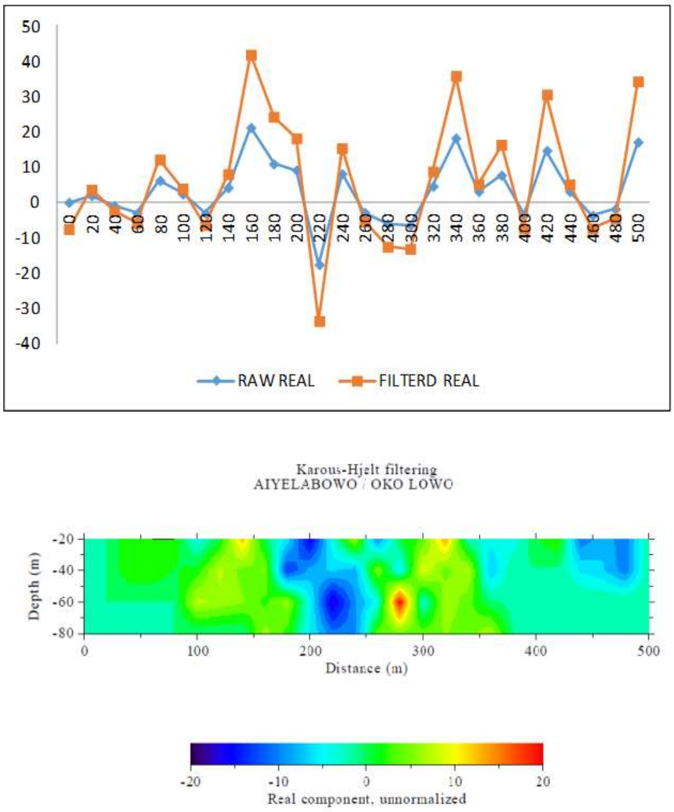

Fig. 4j. Aiyelabowo/ Oko Lowo Profile

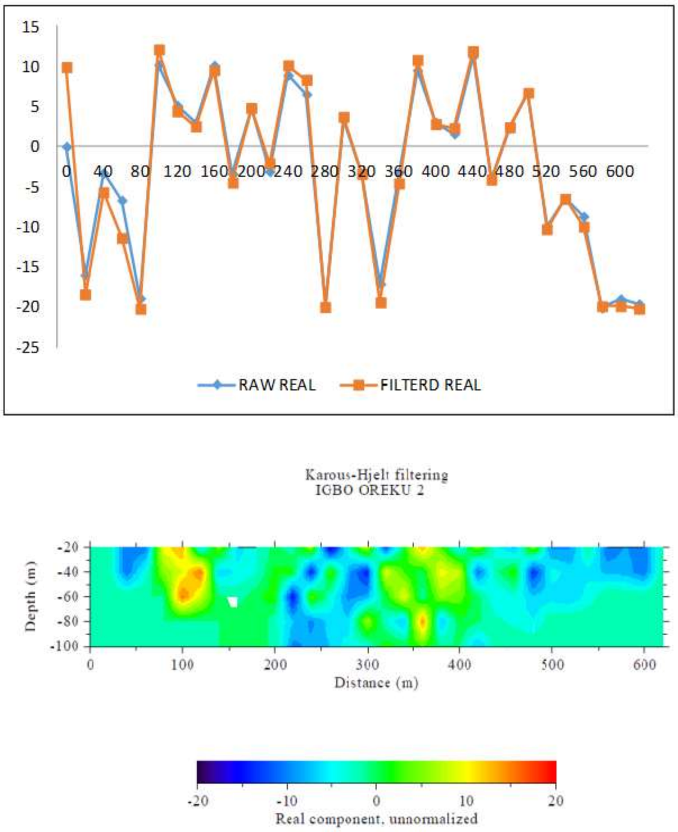

Fig. 4i. Igbo Oreku 2 Profile

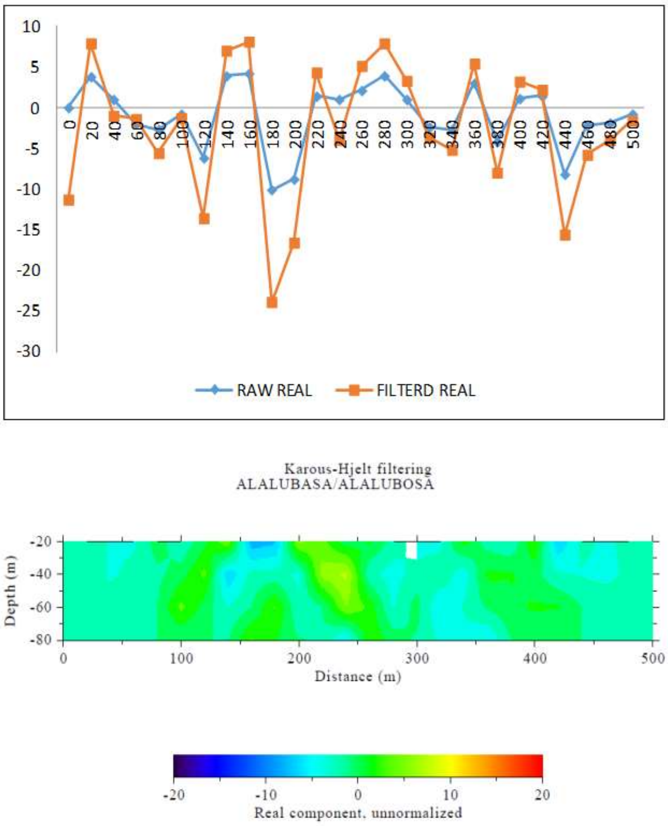

Fig. 4k. Alalubasa Profile

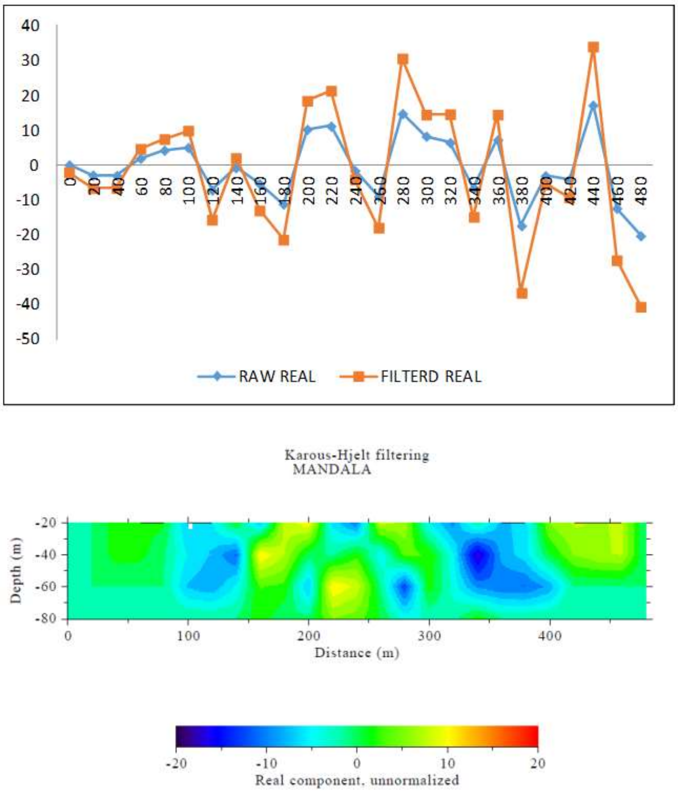

Fig. 4l. Mandala Profile

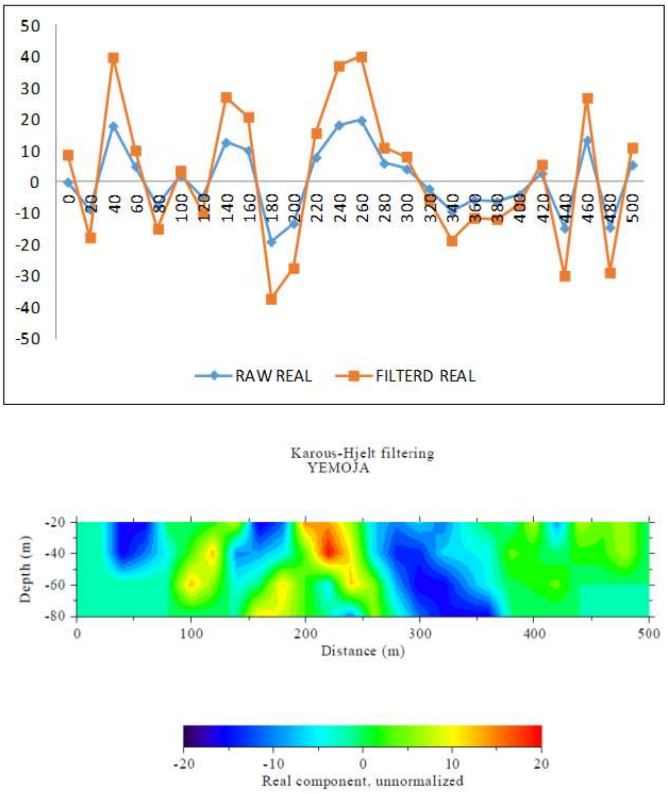

Fig. 4n. Yemoja Profile

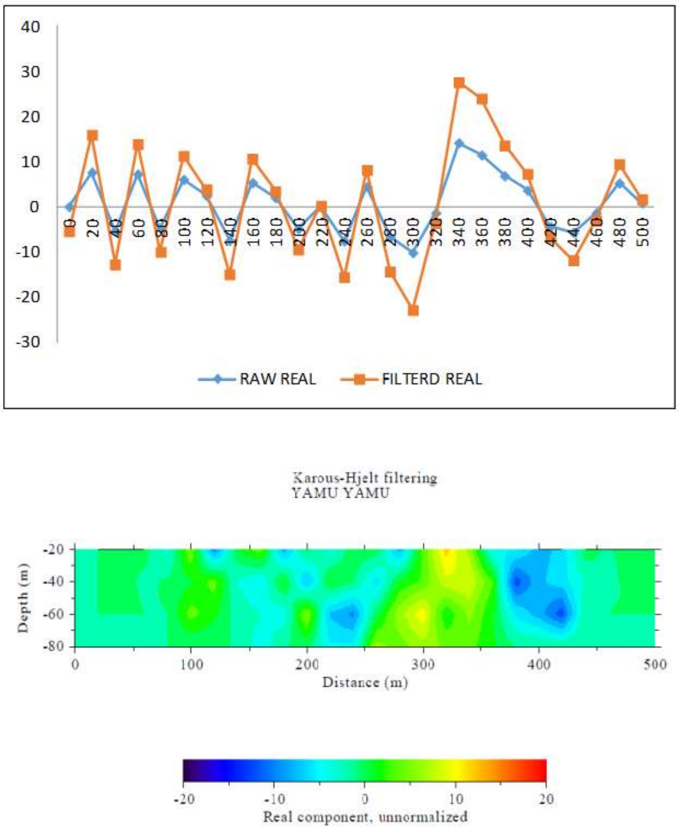

Fig. 4m. Yamu Yamu Profile

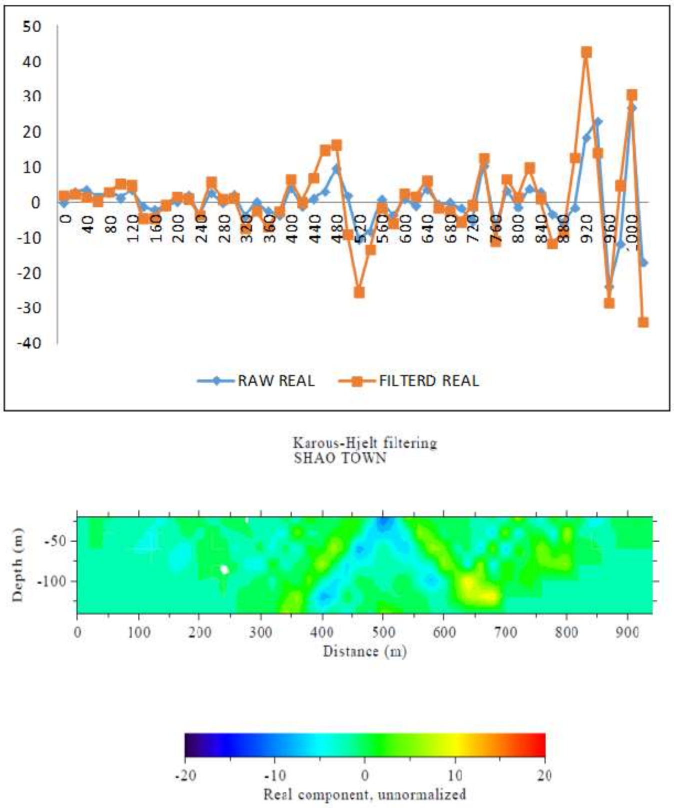

Fig. 4o. Shao Profile

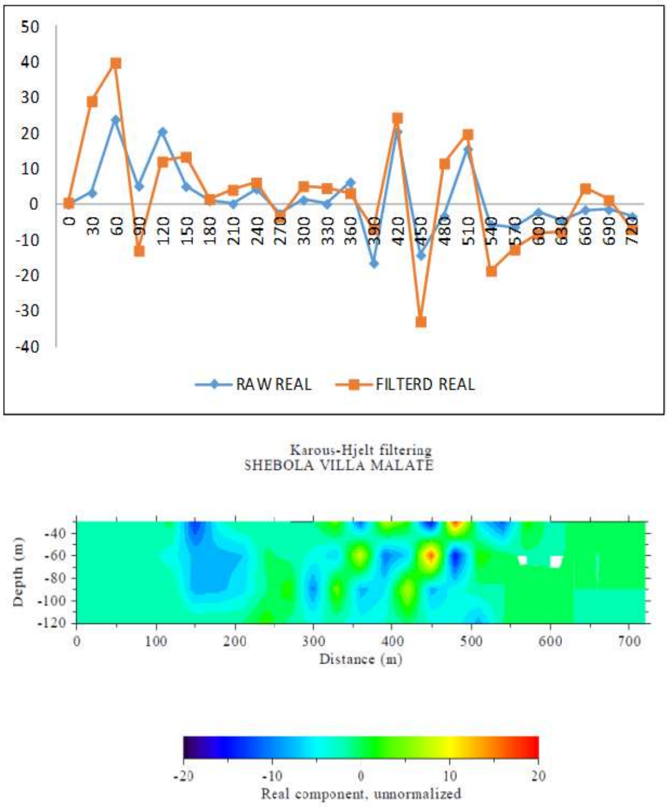

Fig. 4p. Shebola Villa Profile

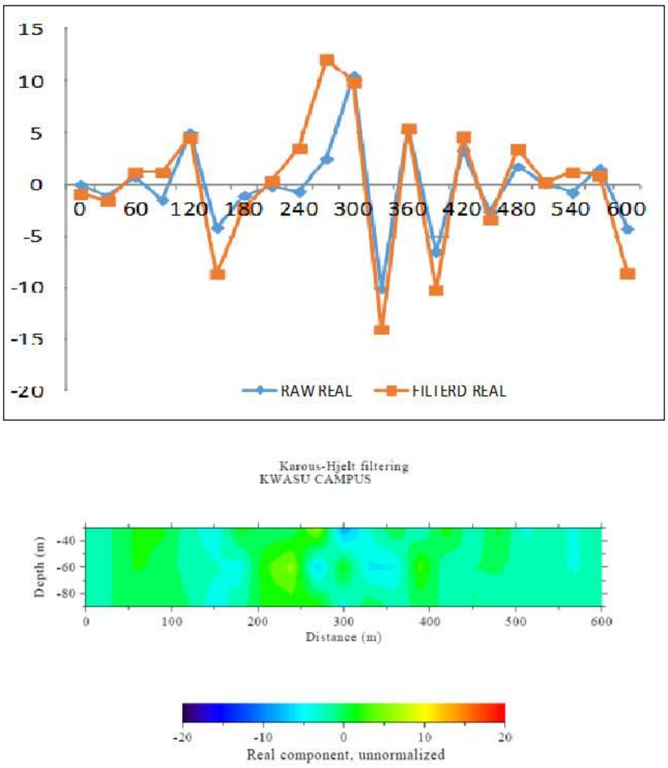

Fig. 4r. Kwasu Campus Profile

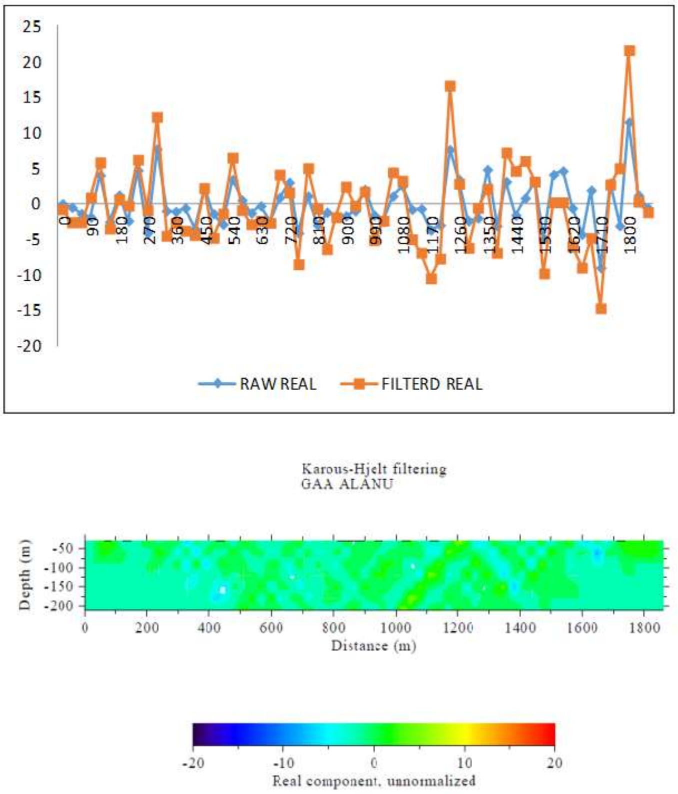

Fig. 4q. Gaa Alanu Profile

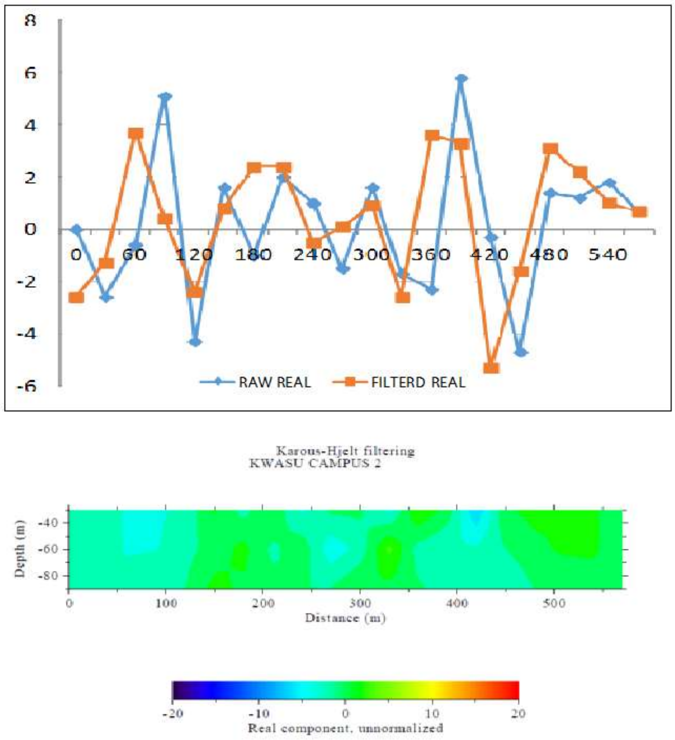

Fig. 4s. Kwasu Campus Profile

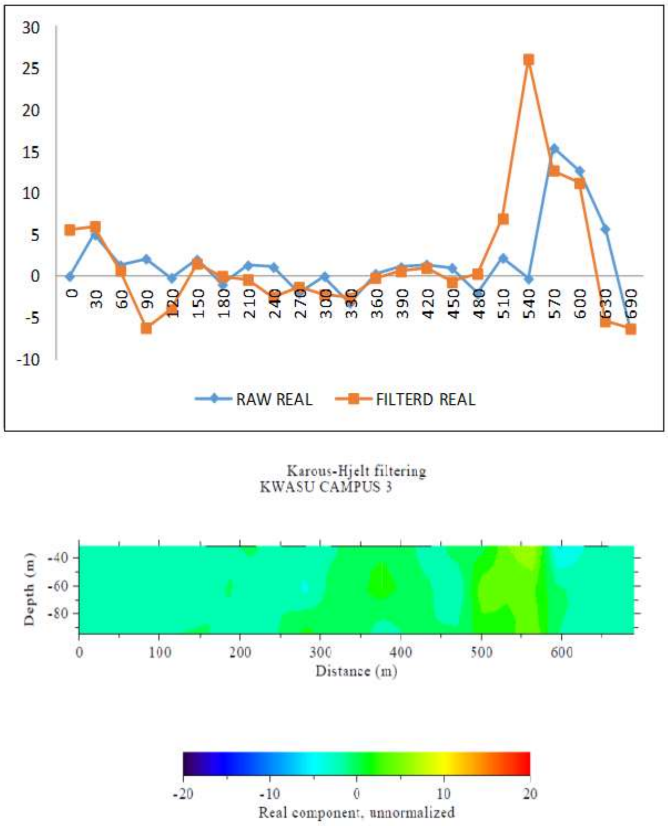

Fig. 4t. Kwasu Campus 3 Profile

4.2. Magnetic Survey Profile

The magnetic profile is a plot of the relative magnetic intensity (nT) against the distance in meters. The relief of the anomaly characterized by magnetic lows and high will provide information about the subsurface conductor response. Two zones of magnetic lows were observed between 220-280 m and 500-550 m along Malete profile one (Fig. 5a). These were correlated with the VLF-EM profile taken concurrently along with the magnetic profile. The two zones were identified for further investigation to determine the nature and the depth extent of the anomaly. This operation was similarly repeated in all the magnetic profiles. Igbo Efon magnetic profile has two low magnetic susceptibility zones at zero to 120 m and 200-300 m (Fig. 5b). Sefari magnetic profile displays two points of low magnetic susceptibility at 30 m and 150 m (Fig. 5c).

The entire profile was characterized by magnetic highs except at 160 m where a magnetic low was observed along Okoru magnetic profile (Fig. 5d). Alaaya magnetic profile indicates three points of magnetic lows at 120 m, 400 m and 580 m (Fig. 5e). Tegbesun magnetic profile has three major low magnetic susceptibility zones at 90 m, 360 m and 460 m (Fig. 5f). The entire profile was characterized by magnetic lows with a value ranging between -10nT to -150nT. With the highest observed towards the west end of the traverse with a value of -150nT and towards the eastern end of the profile with a value of about -100nT i.e. at zero station and at five hundred meters at Abe Igba magnetic profile (Fig. 5g). Igbo Ereku magnetic profile (Fig. 5h) was also characterized by almost a complete magnetic low with values ranging from -10nT to -100nT except for 150 m and 170 m where the values were about +100nT and +140nT. Igbo Ereku 2 magnetic profile (Fig. 5i), the magnetic response here is nearly opposite of the magnetic trend in Igbo Ereku 1 where the entire magnetic profile was characterized with magnetic highs, expect at 90-110 m where magnetic lows was observed. Korede magnetic profile (Fig. 5j), the first half of this profile was characterized by magnetic lows of value ranging between -1nT to -230nT between zero to 100 m while the rest of the profile was characterized by magnetic highs from 150 m to the end of the profile with a magnetic value ranging from +1nT to +100nT.

Magnetic profile along Okoolowo (Fig. 5k), the entire profile was characterized by magnetic lows with a few spikes of high with a value varies between -50nT to -250nT while the few high spikes have value ranging to +200nT. Alalubosa magnetic profile (Fig. 5l) was characterized by magnetic lows, with a value ranging between -50nT to -90nT. Mandala magnetic profile (Fig. 5m) was characterized by low magnetic susceptibility with value ranging between -1nT to -350nT and positive high anomaly being at 130 m. Yanmu Yanmu magnetic profile (Fig. 5n) was characterized by three low magnetic susceptibility zones; these were observed at 20 m, 40 m and 60-110 m, with a value ranging between -10nT and -700nT. Yemoja magnetic profile (Fig. 5o) was characterized by magnetic lows with a value ranging between -50nT to -350nT. Except at 180 m where a spike of positive high with a value of +350 nT, between 250 - 300 m along the profile. Any points within the low magnetic susceptibility were considered for further investigation in order to determine the nature and the depth extent of the magnetic anomaly using the vertical electrical sounding (VES).

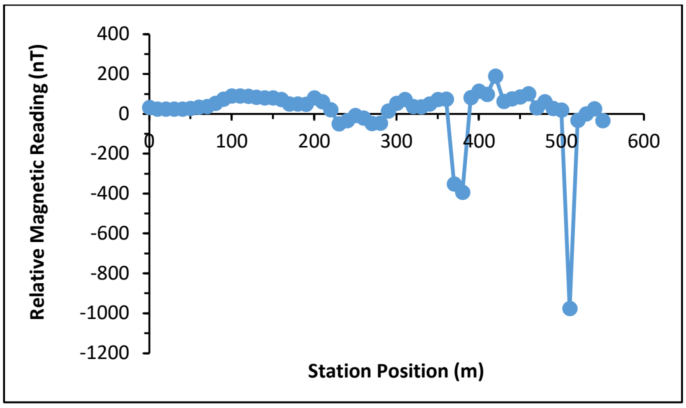

Fig. 5a. Magnetic survey profile (Malete profile)

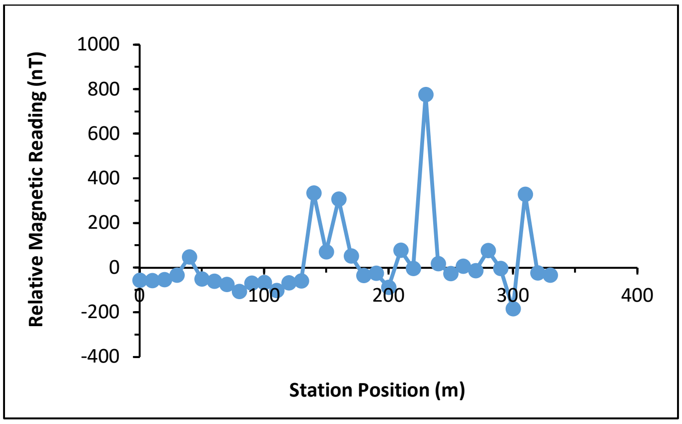

Fig. 5b. Magnetic survey profile (Igbo Efon profile)

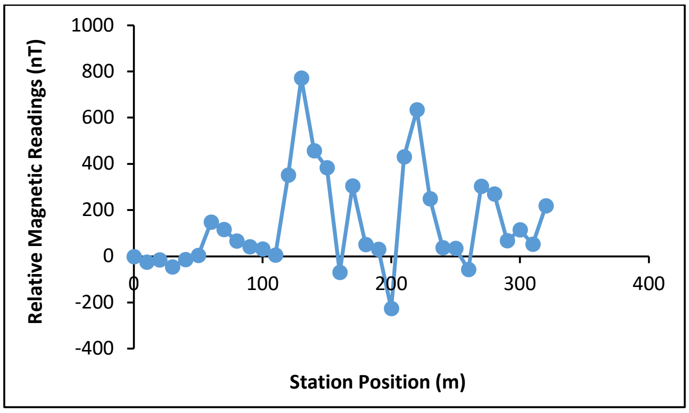

Fig. 5c. Magnetic survey profile (Sefari profile)

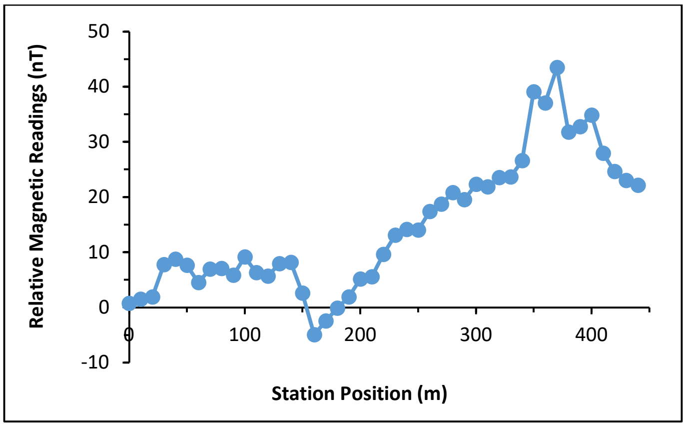

Fig. 5d. Magnetic survey profile (Okoru profile)

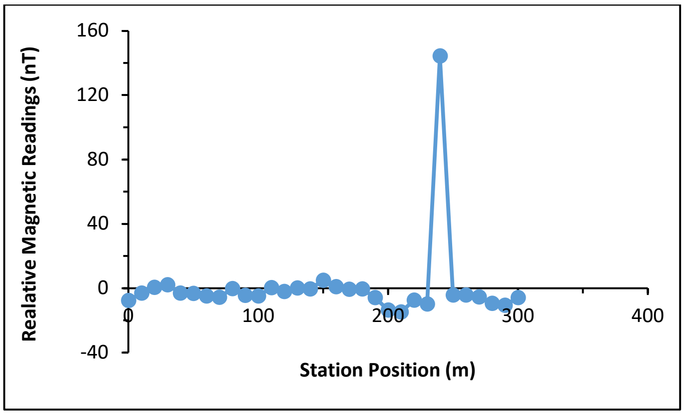

Fig. 5e. Magnetic survey profile (Alaaya profile)

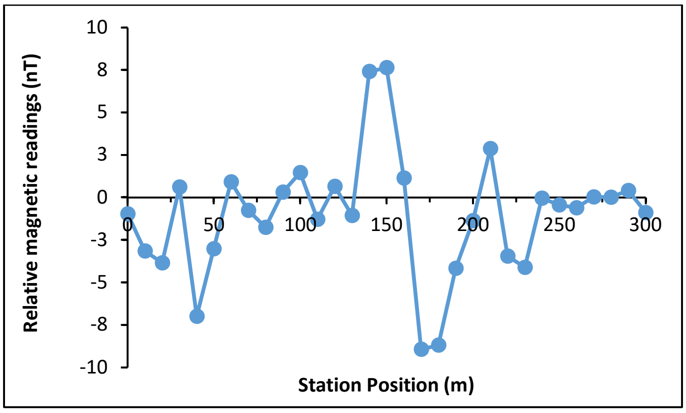

Fig. 5f. Magnetic survey profile (Tegbesun profile)

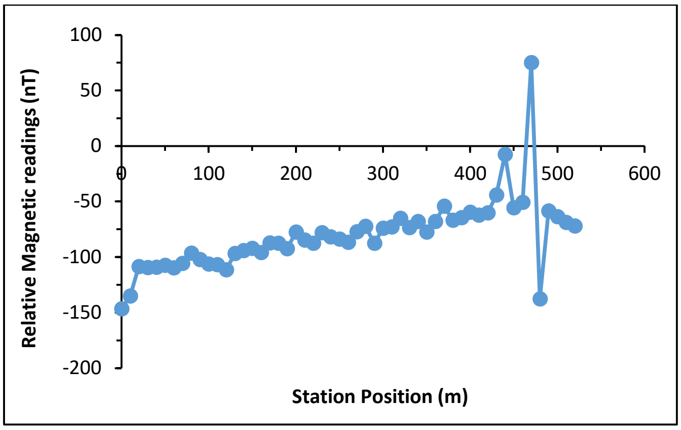

Fig. 5g. Magnetic survey profile (Abe Igba profile)

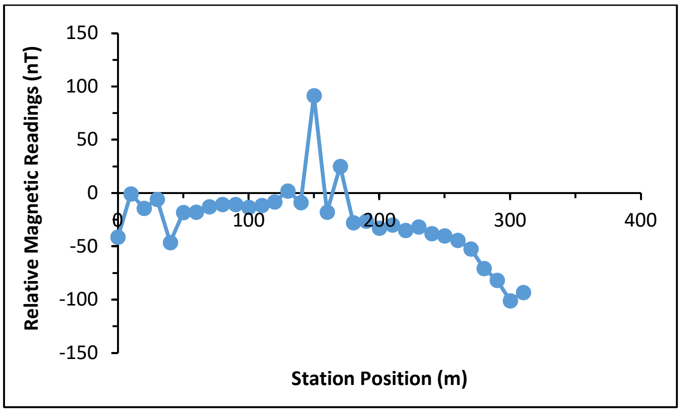

Fig. 5h. Magnetic survey profile (Igbo Ereku 1 profile)

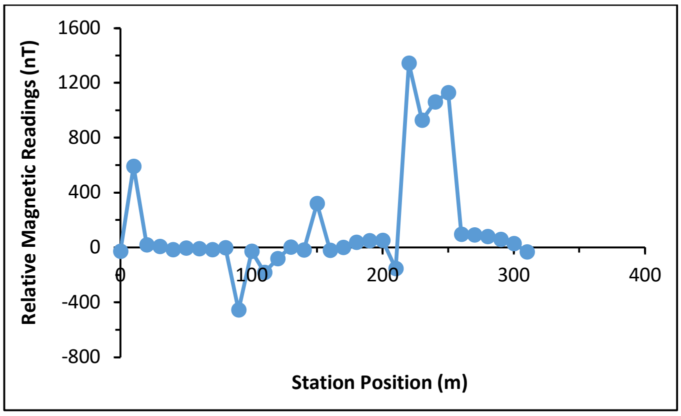

Fig. 5i. Magnetic survey profile (Igbo Ereku 2 profile)

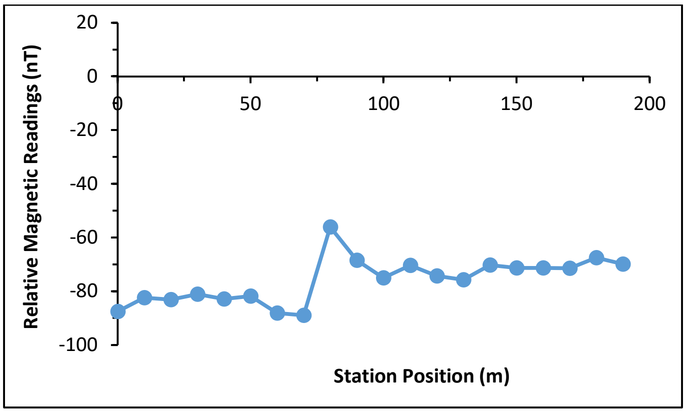

Fig. 5l. Magnetic survey profile (Alalubosa profile)

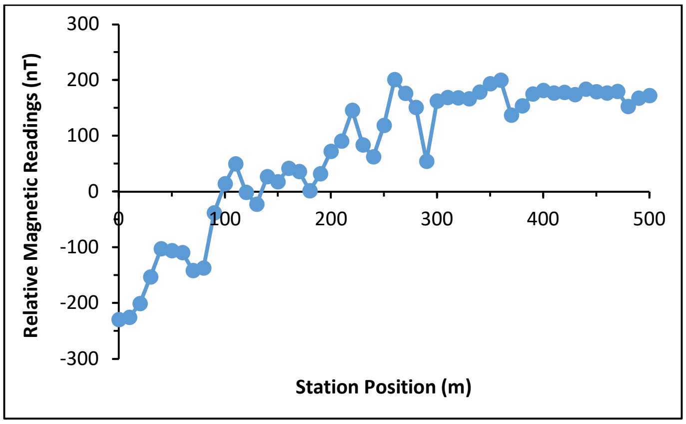

Fig. 5j. Magnetic survey profile (Korede profile)

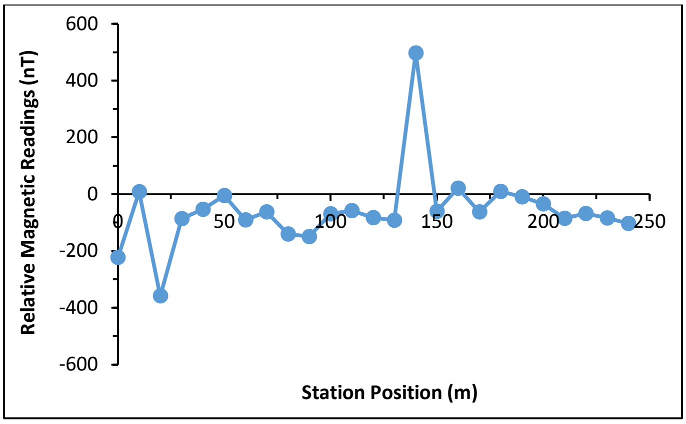

Fig. 5m. Magnetic survey profile (Mandala profile)

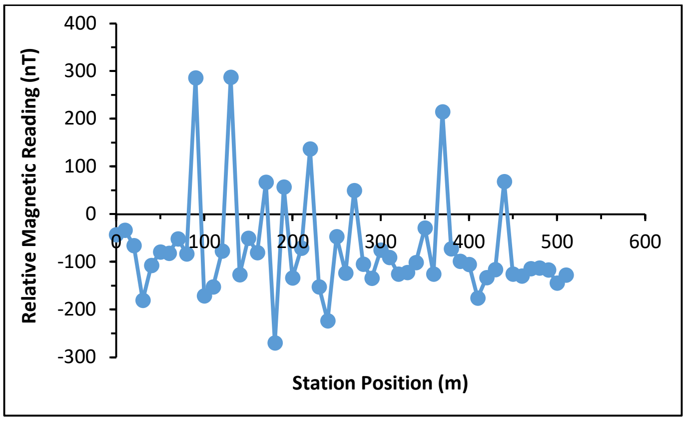

Fig. 5k. Magnetic survey profile (Okoolowo profile)

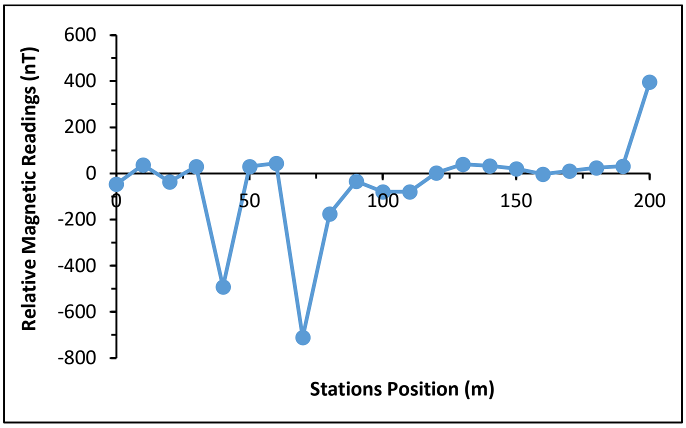

Fig. 5n. Magnetic survey profile (Yanmu Yanmu profile)

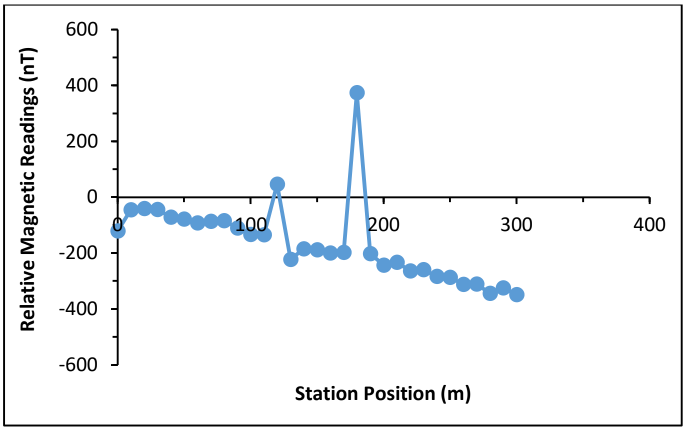

Fig. 5o. Magnetic survey profile (Yemoja profile)

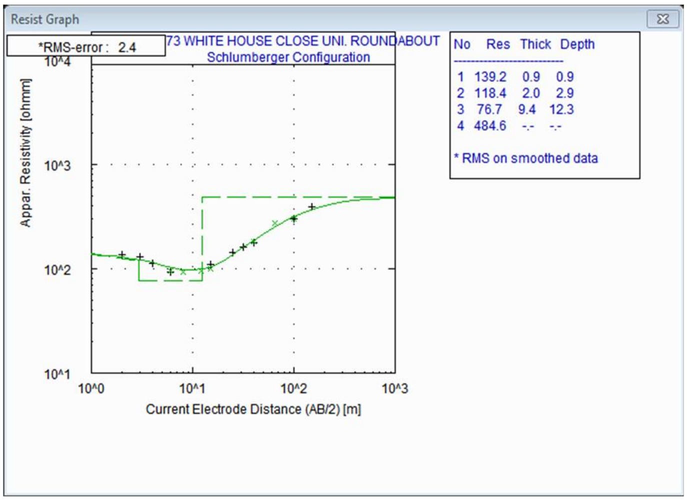

Fig. 6b. Typical HA sounding curve

4.3. Electrical Resistivity Method

Curves types identified ranges from H, HA, HK and HKH varying between three to four geo-electric layers. The H curve type predominating. Typical curve types in the area are as shown in Fig. 6a-d.

The Dar-Zarrouk parameters are obtained from the first order parameters (geoelectric parameters) which are Total longitudinal unit conductance (S), Total transverse unit resistance (T), and coefficient of anisotropy (λ). The product of total transverse resistance and coefficient of anisotropy was used to determine the groundwater yield capacity index value (Table 1).

4.3.1. Total Longitudinal Conductance

Fig. 7 revealed that clay remains a dominant feature especially from the near surface to a reasonable depth which ultimately will affect the groundwater potential and yield of the investigated area. Since this are contributing factors to the low productivity and rechargeability. The thickness of the weathered layer beyond this horizon becomes a major deciding factor in groundwater productivity.

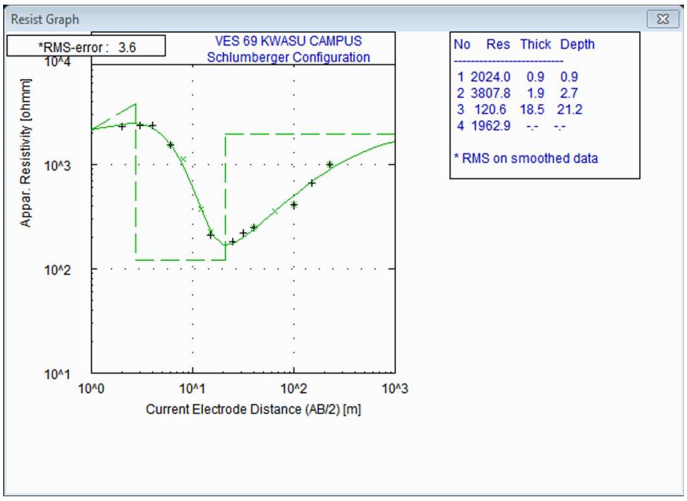

Fig. 6c. Typical kH sounding curve

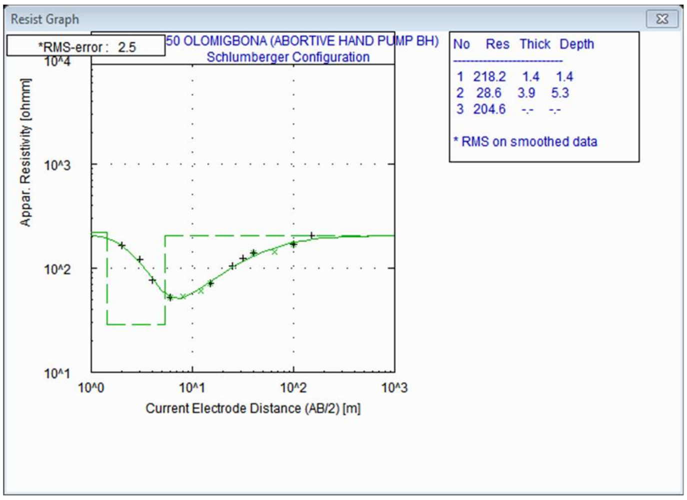

Fig. 6a. Typical H sounding curve

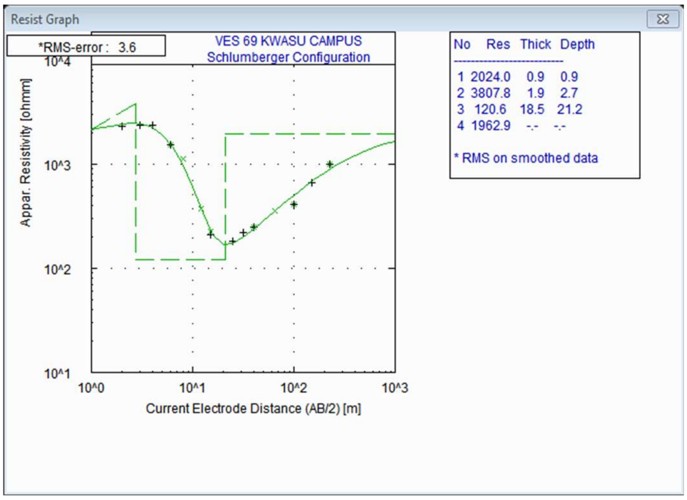

Fig. 6d. Typical HKH sounding curve

Expect for a pocket within the centre of the investigated area with a value ranging between 0.07-0.15, indicative of a thin clayey layer, the rest is characterized by very high longitudinal conductance with value ranging from 0.18-0.66. It implies that the study area exhibits a clayey material which was the probable major reason for the very low groundwater potential and yield.

4.3.2. Total Transverse Resistance

Fig. 8 displays that the area was moderately high with a value ranging from 576-2629 Ωm reflecting moderate to low permeability function, while a little pocket in the northwestern, eastern central and two other pocket points towards the southern parts with value ranging from 2,629-11,287.52 Ωm which implies high porosity and permeability.

This area constitutes less than 25% of the entire investigated area while about 75% was characterized by low porosity and permeability which was the major reasons for the low groundwater potential and yield.

4.3.3. Coefficient of Anisotropy

Fig. 9 can be further categorized into two zones of groundwater regime with 75% of the study area having a value ranging from 0.19-0.61, indicative of moderate to low groundwater potential. While the remaining 25% from the northwestern part, toward the centre, and a little pocket at the southern end has a value ranging from 0.61-1.96 which was indicative of moderate to high groundwater potential. Therefore, the information obtained exhibits that the groundwater potential and yield of the entire area is moderately low/low.

4.3.4. Groundwater Yield Capacity Map

Fig. 10 illustrates groundwater yield capacity of the entire Kwara Central which was categorized into six groundwater yield regime which are extremely poor, very low, low, moderate, high and very high with value ranging from 32-350, 250-450, 450-850, 850-1750, 1750-3000 and 3000-5945.59.

It shows that more than 70% of the entire area was characterized by moderate groundwater yield while the remaining 30% reveal pockets of varying groundwater yield regime, which justified the probable reason for low/moderate groundwater yield.

Table 1. Dar-Zarrouk Parameters and Groundwater Yield Capacity Index Value

Ves Location	Total Transverse Resistance (T) (h1*ℓ1)+hn*ℓn	Longitudinal Conductance (S) h1/ℓ1+hn/ℓn	Longitudinal Resistivity (ρl) (H/S)	Transverse Resistivity (ρt) (T/H)	Coefficient of Anisotropy (λ) (ρl/ρt)	Groundwater Yield Capacity Index Value (YC) =ʎ*T
VES 1 SHAO	464.08	0.39	13.84	103.13	0.37	
VES 2 SHAO	487.02	0.43	18.85	60.13	0.56	
VES 3 SHAO	295.58	0.59	11.50	43.47	0.51	152.0071159
VES 4 IYANA JOGODO	5184.04	0.16	95.00	338.83	0.53	2745.1
VES 5 OPONDA	2828.69	0.31	44.98	200.62	0.47	1339.4
VES 6 ABILUDE	8206.68	0.13	70.19	892.03	0.28	2302
VES 7 NEAR IGBO OREKU	4203.36	0.31	30.11	456.89	0.26	95.9
VES 8 ABE IGBA	2246.25	0.57	28.77	136.97	0.46	1029.5
VES 9 OKORU	1330.29	0.30	44.01	99.28	0.20	267.3
VES 10 OLD OKETE	1108.078	0.20	54.63	99.83	0.74	820
VES 11	480.9	0.35	21.85	62.35	0.59	284.2
VES 12 IKONDO	770.57	0.50	29.75	51.37	0.76	586.4
VES 13 AIYEKALE	919.07	0.27	51.44	67.09	0.88	205
VES 14 OLOWONIJATA	798.1	0.41	14.35	135.27	0.33	260
VES 15 ELEMERE	3069.64	0.39	20.26	388.71	0.23	705.4

VES 16 OGBA GBA	1569.44	0.37	53.26	80.48	0.81	1240.3
VES 17 ORE ASOMU	838.45	0.37	33.10	66.17	0.70	584.3
VES 18	1022.22	0.33	44.83	69.54	0.80	821
VES 19 KWASU CAMPUS	601.37	0.38	22.44	70.75	0.56	399
VES 20 KWASU FARM	227.74	0.27	15.41	55.55	0.53	120
VES 21 NW OF KWASU	269.87	0.19	41.08	350.37	0.12	316.3
VES 22 CENTRE KWASU	617.33	0.23	43.48	62.36	0.84	515.5
VES 23 MALETE	2231.14	0.35	58.37	108.32	0.73	1638
VES 24 SAFARI MALETE	1876.37	0.41	23.67	191.47	0.35	660
VES 25 IGBO	1794.39	0.44	40.90	99.14	0.64	1153
VES 26 AIYEKALE	785.01	0.23	45.40	74.76	0.78	612
VES 27 AIYEKALE 3	407.76	0.51	14.22	55.86	0.50	206
VES 28 AIYEKALE 4	2950.7	0.57	45.64	112.29	0.64	1868.4
VES 29 ALAYA	2642.36	0.66	38.62	104.03	0.61	1610
VES 30 ALAAGE 2	1673.48	0.44	27.05	140.63	0.44	734
VES 31 OLOFERE ALAAGA 3	2736.05	0.31	65.52	134.78	0.70	1908
VES 32 GAA ABU SAFARI AREA	1272.89	0.44	24.79	120.08	0.45	578.3
VES 33 AJAGBE	2561.26	0.19	98.53	137.70	0.84	2167
VES 34 ABEIKA	197.15	0.46	40.29	105.82	0.62	1201.4
VES 35 GAA DAUDA SAFARI	1627.56	0.46	33.80	105.00	0.57	923.3
VES 36 OWODE MALETE AREA	8743.52	0.27	120.91	264.16	0.68	5916
VES 37 IYANA OWODE	5007.77	0.14	95.11	370.95	0.51	2536
VES 38 GAA ALAPO	1228.92	0.28	60.44	73.59	0.91	1113.3
VES 39	1114.7	0.56	12.7		1.96	2184.81
VES 40 MALETE	2129.68	0.47	41.93	107.56	0.62	1330
VES 41 NEAR OKORU	403.22	0.16	35.93	69.52	0.72	290
VES 42 OKORU 2	1772.85	0.26	63.38	106.16	0.77	1370
VES 43 OKORU 3	3352.13	0.29	58.62	199.53	0.54	1817
VES 44 OKETE	548.93	0.51	14.63	74.18	0.44	244
VES 45 ALAAYE SOSOKI	2978.07	0.52	51.53	111.12	0.68	2030

VES 46 ALAAYA	2444.95	0.29	86.22	96.64	0.95	2312
VES 47 ALAAYA	3099.63	0.20	123.18	127.03	0.99	3052.2
VES 48 Olomigbona	546	0.46	16.64	71.84	0.23	126.5
VES 49 Olomigbona 2	898.52	0.29	18.65	112.32	0.41	366.1
VES 50 Olomigbona 3	417	0.14	37.12	78.68	0.67	286.4
VES 51 AGAR 1	256.52	0.094	16.86	160.33	0.32	83.2
VES 52 AGAR 2	261.25	0.08	31.04	104.60	0.55	142.3
VES 53 AGAR 3	789.78	0.36	36.93	59.83	0.79	620.5
VES 54 AGAR 4	4504.79	0.16	99.60	276.37	0.60	2704.4
VES 55 Ojutaiye	5497.87	0.24	131.11	177.35	0.86	4728.1
VES 56 Ojutaiye 2 Gaa Sanni	8180.96	0.31	94.41	283.08	0.58	47245
VES 57 Paku 1	429.48	0.11	26.60	153.39	0.42	179
VES 58 Paku 2	102.37	0.09	25.90	44.51	0.76	78.1
VES 59 Omilende Gaa Dauda	562.24	0.26	42.29	51.58	0.91	509.1
VES 60 Ogbagba	1403.08	0.29	35.78	133.62	0.52	726
VES 61 Iyemoja	1503.79	0.26	47.77	123.26	0.06	941
VES 62 After Iyemoja near Okolowo	683.78	0.47	28.52	51.03	0.75	511.2
VES 63 Okoolowo/Aiyelabowo	3955.46	0.50	83.87	94.18	0.94	3733
VES 64 Alalubosa	813.72	0.52	13.94	113.01	0.35	285
VES 65 Ita - Yamu-Yamu	7402.69	0.54	44.35	308.44	0.37	2807.1
VES 66 Alalubosa	1636.37	0.53	34.51	88.45	0.62	1023.4
VES 67 Ita Yamu-Yamu	94.15	0.08	17.23	67.25	0.51	47.66
VES 68 Ita Yamu-Yamu 3	89.22	0.07	20.01	59.48	0.58	51.76
VES 69 Ita Yamu-Yamu 4	407.04	0.48	13.52	61.67	0.46	190.59
VES 70 Kwasu Campus near College of Hummanity	11287.52	0.15	137.35	532.43	0.50	5733.1
VES 71 Kwasu Gaa Alaanu	2847.01	0.10	89.12	302.87	0.54	1544.4
VES 72 Malete Near Market	913.18	0.18	60.28	83.77	0.84	775
VES 73 Front of white House close to University Round About	1083.06	0.15	84.29	88.05	0.98	1060

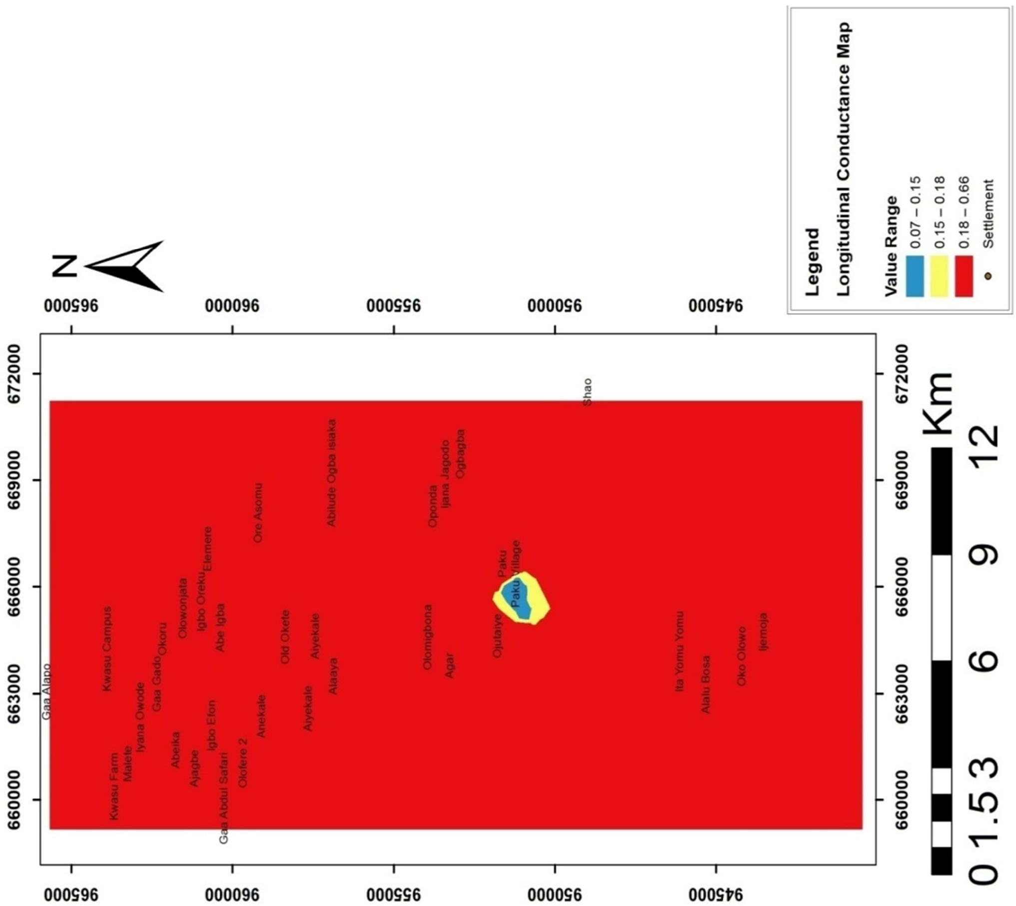

Fig. 7. Total Longitudinal Conductance Map of the study are

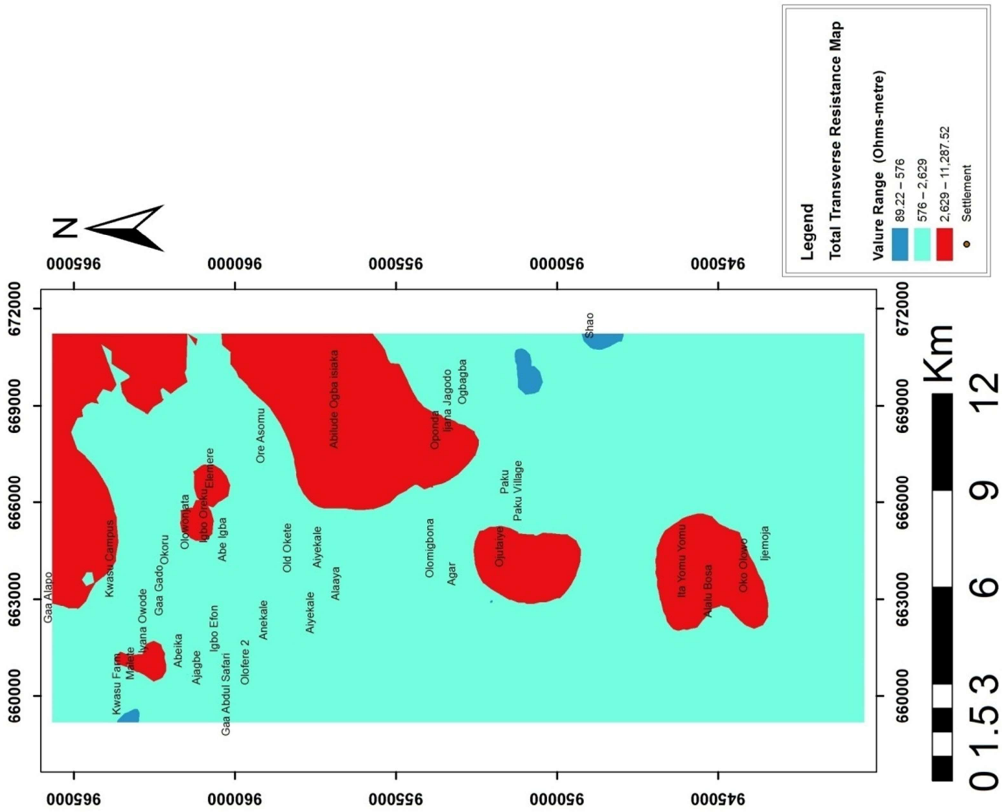

Fig. 8. Total Transverse Resistance Map of the study area

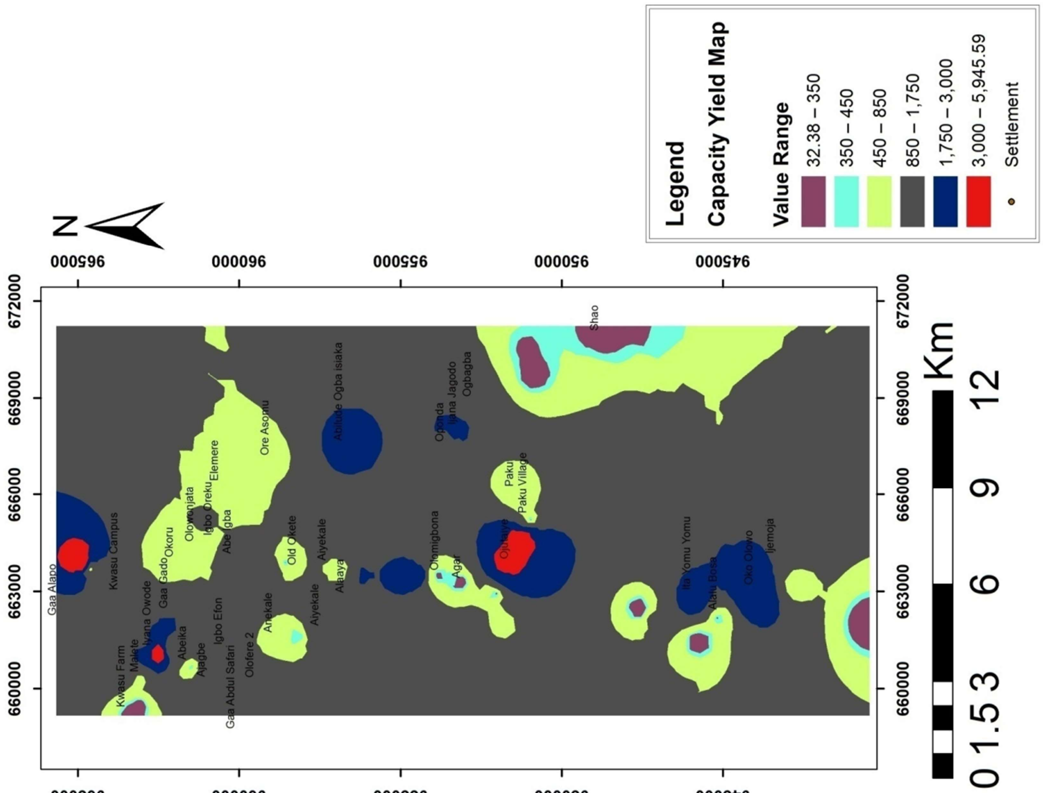

Fig. 10. Groundwater Yield Capacity Map of the study are

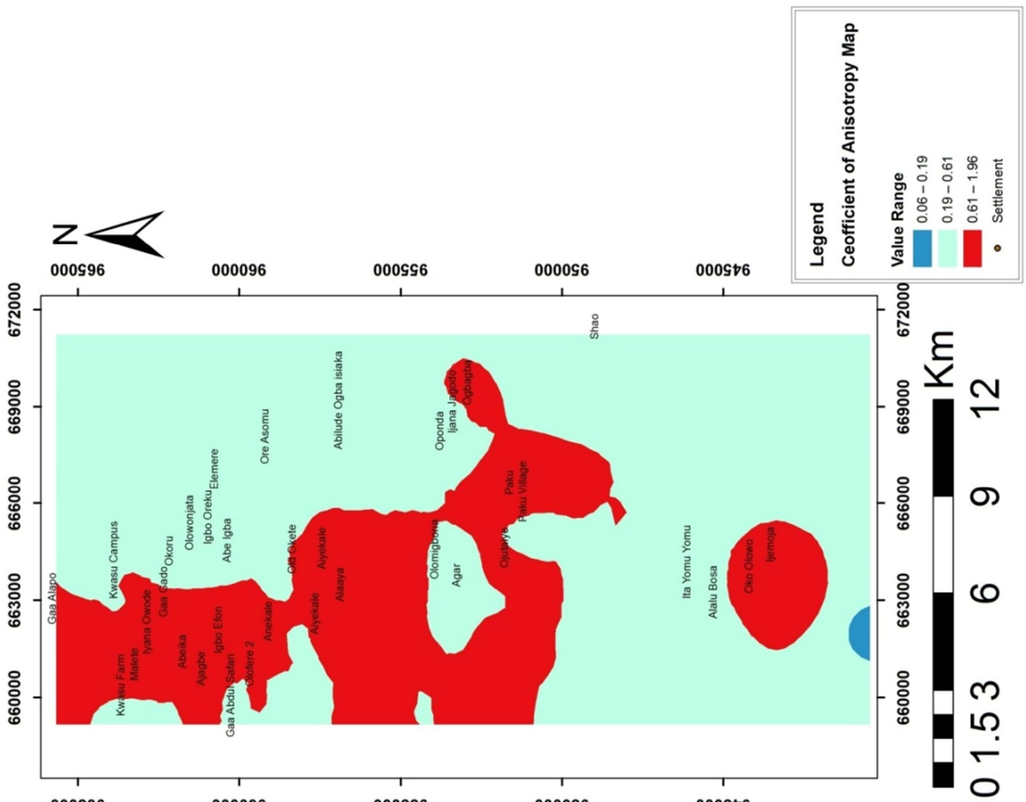

Fig. 9. Coefficient of Anisotropy Map of the study are

5. Conclusion

The study has been able to justify the curiosity and worry of people of Central Kwara, in an attempt to know the reasons behind incessant abortive borehole/well, as well as common occurrence of boreholes with low yield. Also established the relationships that exist between the geology of the area and groundwater yield capacity. It has also justified the need for detailed geophysics studies of any area within the Central Kwara region in other to harness maximum benefit from any groundwater project in the area

Data Availability Statement

The authors confirm that the data supporting the findings of the study are available within the article and its supplementary materials. Authors have declared that no competing interests exist and the data was not use as an avenue for any litigation but for the advancement of knowledge. Also, the research data acquisition was funded by personal efforts of the authors.

Acknowledgement

The author gratefully acknowledges Kola Olajugberin, Ajayi-Gidi I.O., Omosuyi G.O, Enikanselu P.A., Oladeji J., Oloru and Kehinde for their valuable contribution at improving the quality of these research work.

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