



GROUNDWATER EXPLORATION USING RESISTIVITY AND FLOWNET DATA AT THE EASTERN PART OF ILORIN, SOUTHWESTERN NIGERIA.

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ABSTRACT

Flownets, geo-electric layers construction and groundwater exploration analysis was investigated in the eastern and Western parts of Ilorin of Southwestern Nigeria. Apata-Yakuba, Eleko-yangan, Tepatan, Oke-Andi at the Eastern part and Akamo, Idi-Araba in the Western part of Ilorin were surveyed to depict the exact locations for potential future groundwater exploration. A preliminary step to collect lithologs of wells from the records of Nigeria Hydrological Services Agency used 35 water samples taken from hand dug wells and boreholes. Static water levels, total depth and coordinates of hand dug wells were measured using tape and GPS respectively. The Static water level (below ground surface and above sea level) values and their coordinates were processed using IPWIN resist software to generate the water level locations on topographical contour maps and the groundwater flow net of the study area. Result reflects the presence of crystalline rocks consisting of migmatite gneiss, granite gneiss, quartzite and granite. Analysis and interpretation of flownet shows ascending equipotential lines at the Eastern part indicating an easy groundwater movement, and divergent equipotential lines at the Western part indicating difficulty in water movement in the study area. The static water levels values together with the corresponding coordinates were superimposed on the geological map of the study area. This research reveals the water table is very close to ground surface in Oyun, Oke-Andi resulting into digging of shallow wells by the dwellers of the area. Water table is also far away from the surface in places Tepatan, Apata-Yakuba among others

Keywords: Equipotential line, Flownets, Geo-electric layer, Groundwater exploration. IPWIN resist software.

INTRODUCTION

Water is a vital resource for human existence and growth of any community is a function of availability of basic infrastructures such as portable water, good roads, electricity and industries (Olasehinde and Awojobi, 2004; Olasehinde, 2010; Amadi, 2010). Ilorin in Southwestern Nigeria is underlain by the Precambrian basement complex rocks with dependence on rain water, surface water and groundwater for its water supplies.

The rapid population growth in Ilorin which is partly due to the north-south migration caused by insurgency and partly, because of economic activities has made the sources of water independents for its dwellers and hence the need for exploration and exploitation of groundwater resources in the study area. Groundwater resources in any regions of the study area are dependent on nature, and the type of aquifer determines the quantity of groundwater that can be derived in a particular area to support her population (Ifabiye et al., 2013; Ifabiye and Ashaolu, 2013). That is the reason it is very essential to determine the groundwater potential of an area for a sustainable exploration and exploitation. Groundwater occurrence in the Precambrian basement terrain is within zones of weathering and fracture which often are not continuous in vertical and lateral extent. The research is significant due to declining sources of surface water and to differentiate between zones of high water bearing to low water bearing within the weathered layer and to determine joints variation in degree of weathering saturation.

Granite gneisses were found in many places within the study area. They were found in the northeastern, northwestern and southern parts of the study area. The minerals formed from hand specimen include quartz, feldspars, biotite and muscovite.

DESCRIPTION OF THE STUDY AREA

The study location falls within parts of Ilorin Metropolis. The area is bounded by longitudes 4030'0''E and 4040'0''E with latitudes 8030'0''N and 8035'0''N. The area covered is about 58.32sqkm as part of sheet 202 (Fig 2). The study area falls within the intermediate zones of semi-arid (north) and sub humid climate (south) which are characterized by two different seasons, the wet and dry seasons. The wet season typically starts in late March and ends in October, while cold and dry season called harmattan is observed in the month of December and January. The vegetation is basically Guinea savannah interspersed with tropical forest remnants. The general annual average rainfall in the study area is about 1250 mm with maximum rainfall occurring in the month of June and August (Olaseinde 2010). The average annual temperatures of the wet and dry seasons are about 27.2oC and 31oC respectively (Olasehinde, 2010). Oyun River and Oke-oyi River are the major drainage analyzing the wavy topography of the area. Oke-andi and the western part of the study area have the highest altitude of about 1250 m above sea level (Olasehinde, 2010).

The geology of the study area falls within the basement complex of Southwestern Nigeria which belongs to Precambrian to Paleozoic age, the major rock types in the study area includes Migmatite gneiss and Granite (Fig 2)

METHODOLOGY

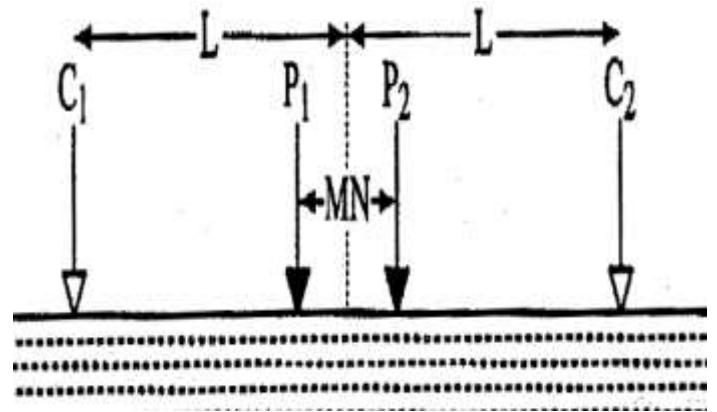
A preliminary survey or step was conducted to gather lithologs of wells from the records of Nigeria Hydrological Services Agency. About thirty-five (35) water samples were taken from hand dug wells and boreholes. Hand dug wells were sampled using tape tied with a stone at the tip while boreholes equipped with hand pumps and submersible pumps using Vertical Electrical Sounding Methods to obtain data and compare with data gotten from Nigeria Hydrogeological Services Agency. A GPS Instrument was used to determine dug well and boreholes coordinates using IPWIN resist software in generating groundwater flownet direction from the calculated head distribution (Fig 6).

FIELD DESCRIPTION AND OBSERVATIONS

The field work was carried out in part of Ilorin East and its metropolis, Kwara State in Southwestern Nigeria. Collection of hydrogeological data from twenty-five (25) boreholes within the main rock types, namely migmatite, granite gneiss and granite in part of Ilorin metropolis were undertaken. Thirteen (13) of the boreholes were sited within migmatite, eight (8) within granite gneiss and four (4) within granite. The hydrogeological data were collected in November 2018 when the boreholes were completed by Lower Niger River Basin Ilorin. Location and elevation of each of the boreholes were determined using Geographical Positioning System (GPS). Computation of static water level, above sea level (SWLasl) from static water level, below ground level (SWLbgl) and elevation above sea level was measured with GPS equipment. Depths to basement, depth to the overburden and basement aquifers, as well as aquifer thickness were extracted from borehole log reports.

ELECTRICAL RESISTIVITY METHOD. The electrical resistivity method is the most effective and economical means of groundwater investigation (Schwarz, 1986; Olasehinde et al., 2015) and operates on the principle that electric current is passed into the ground through two electrodes (C1 and C2) and the resulting potential difference

is measured by another two electrodes (P1 and P2) as illustrated in Schlumberger Figure (Fig 1) and Wenner arrays (Schwarz, 1986).The electrode spacing is progressively increased, keeping the center point of the electrode array fixed(Olasehinde and Taiwo,2000). At small electrode spacing, the apparent resistivity is nearly the resistivity of the surface material, but as the current electrode spacing increases the current penetrates deeper within the ground and so the apparent resistivity reflects the resistivity of the deeper layers (Olarenwaju et al.,1996). Geophysical investigation provides information on the subsurface geology, stratigraphy and structural signatures as well as aquifer properties of the study areas (Singh, 1984).



Schlumberger Array

Fig1: Electrode Array

DATA ACQUISITION

This research determines the inference of flownet, geoelectric layers constructions and analysis on groundwater exploration. This is to ensure the depiction of the best locations that can be used for future groundwater exploration. This study is essential in investigating the declining sources of surface water and to differentiate between zones of high water bearing to low water bearing within the weathered layer and to determine point-point variation in degree of weathering saturation. The study area is underlain by crystalline rocks which consist of migmatite-gneiss, Granite-gneiss, Quartzites and granites (Fig 4).

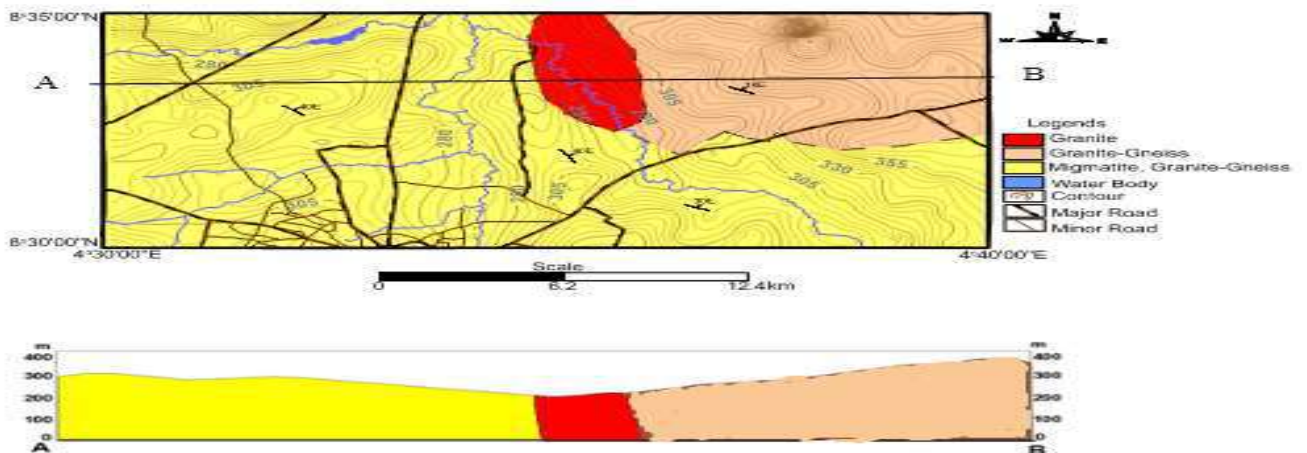


Figure 2: Geological map of Kulende and Environs on share sheet202 SW (Superimposed on the Topographical map produced from satellite map)

From field observations, three distinct types of granite were encountered (Fig 2.); characterized by varying grades of

heterogeneity as some portions appear granitic while some others appear foliated.
I. The Fined Grained Granite

II. The Granite Gneiss

III. The Medium Grained Granite

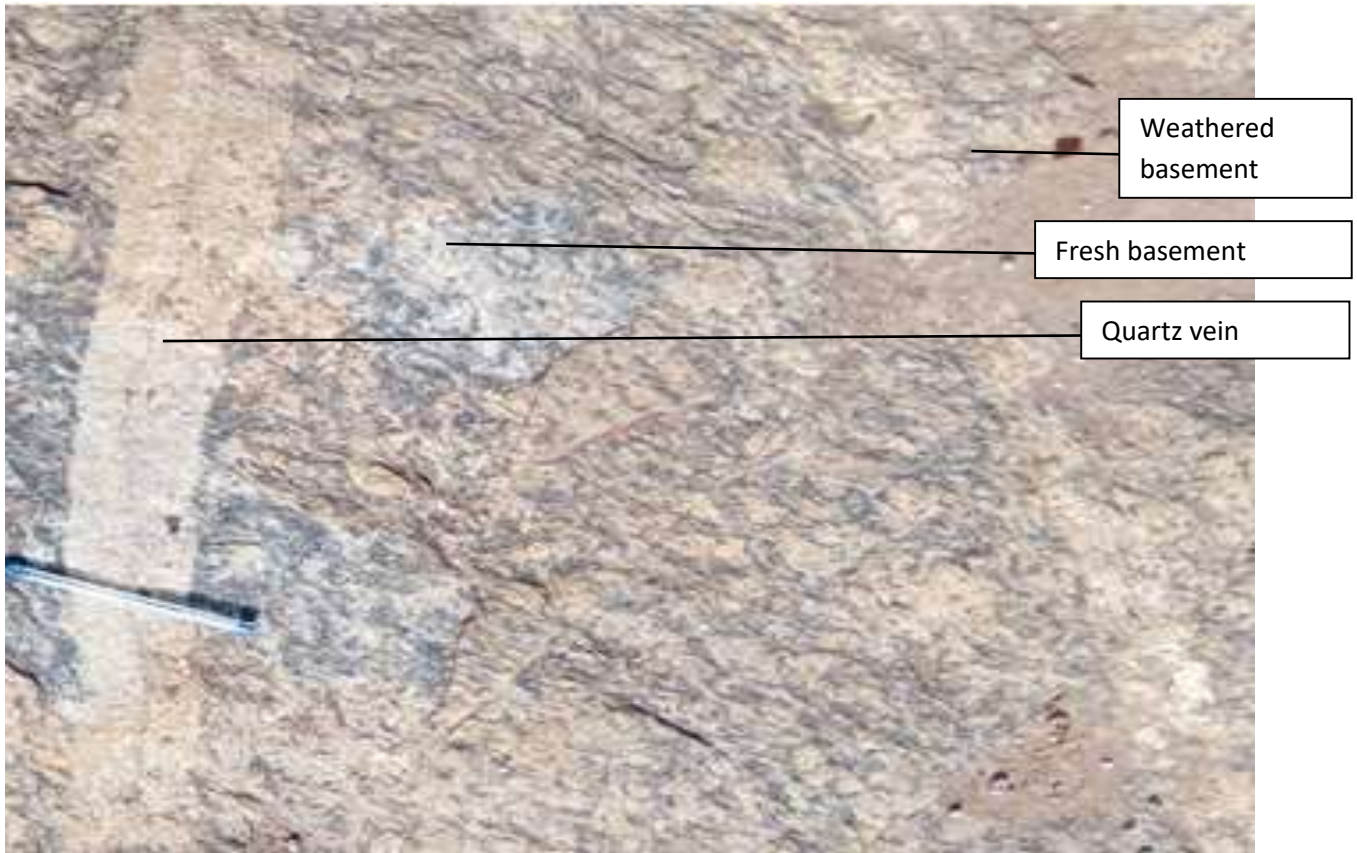


Fig. 3: Low- lying coarse grained granite with an intrusion of quartz vein at Yakuba.



Fig. 4:Low-lying medium grained granite gneiss showing quartz vein intrusion at Oke-Ose.



Fig.5: Medium grained granite showing quartz vein intrusion at Tepatan.

DATA INTERPRETATION

Static water levels, total depths and coordinates of hand dug wells were measured using tape and GPS respectively. Flownet was constructed by plotting flow lines against equipotential lines (Table 1, Fig 6). Analysis and interpretation of flownet shows that the eastern part of the study area such as Apata-Yakuba, Eleko-Yangan, Tepatan, Oke-Andi with convergent equipotential lines which shows

easy groundwater movement. The western part which includes places such as Akamo, Idi-Araba shows divergent equipotential lines which are indication of difficulty in water movement.

Generally Static water level in dug wells and boreholes in the area at a spread of 80 m-100 m is highly recommended for future use.

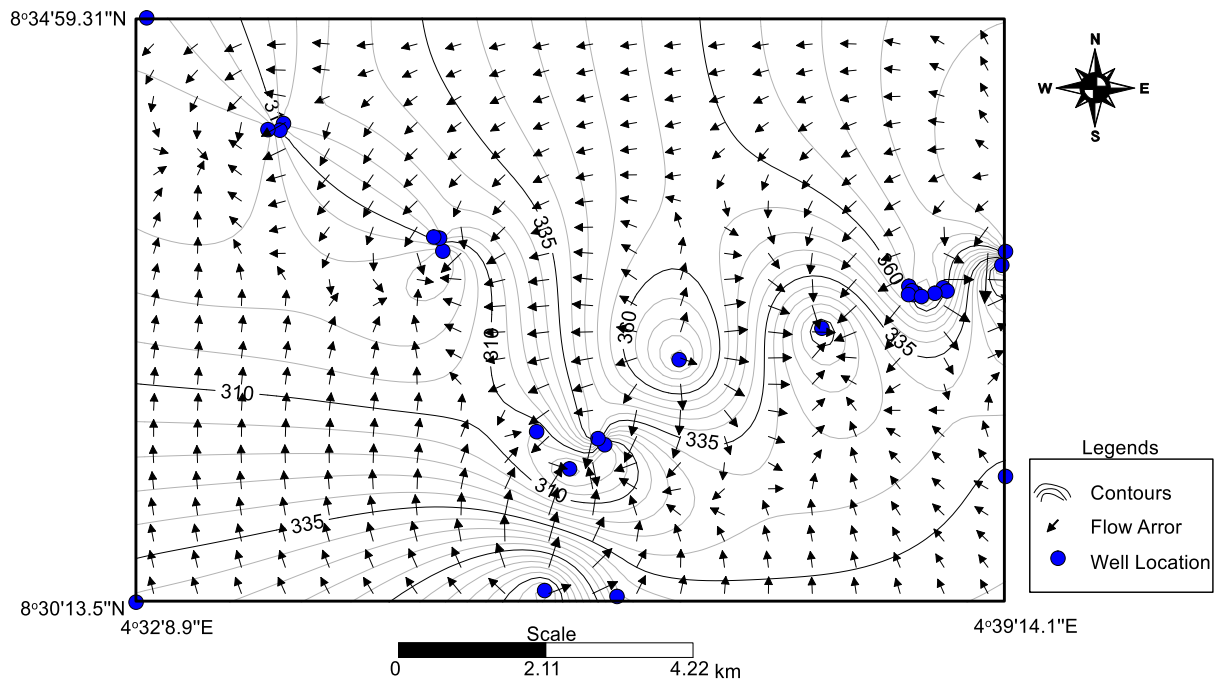


Figure 6: Groundwater flownet of Kulende and its environs.

Table 1: Readings of Static Water Levels obtained from hand dug wells in Kulende Area

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Locations	Total depth(m)	Swl (bgl)	Elevation(m)	Swl(m)	Coordinate
1. Apata-Yakuba	9.0	6.5	292	285.50	8°33'5.188 4°34'38.932"
ss2. Oyun	9.5	5.4	328	322.60	8°33'11.526 4°34'37.332"
3. Oke-Andi	8.45	6.10	315	308.90	8°33'12.114" 4°34'34.475"
4. Ara	8.00	5.30	292	286.70	8.53643° 4.30882°
5. Tepatan	10.32	6.10	322	315.90	8.53643° 4.60743°
6. Eleko-Yangan	8.12	5.04	326	320.96	8°34'7.62" 4°33'21"
7. Idi-Araba	9.50	6.4	311	304.60	8 °34'4.340" 4°33'19.271"
8. Kere-Aje	10.60	8.675	293	284.33	8°34'4.625" 4°33'13.396
9. Layeri	10.10	6.10	302	295.90	8°34'59.31" 4°32'14.095"
10. Ajabesin	9.0	6.10	313	352.90	84855 4.5342
11. Ajabesin	8.23	6.10	359	352.90	8.49070° 4.59762°
12. Alangbadi	6.0	6.0	376	370.00	8.49300° 4.59762°
13. Sango	11.50	7.0	371	364.00	8°32'47.28" 4°38'43.662"
14. Sango	10.50	6.60	362	355.40	8°32'45.683" 4°38'45.509"
15. Gobin;Okon	16	6.50	389	382.50	8°32'44.584" 4°38'30.535"
16. Kulende	9.8	6.40	371	364.60	8°32'44.584" 4°38'39.535"
17. Idi-Ismi	15.90	7.40	352	365.60	8°32'43.929" 4°38'29.017"
18. Adanlawo	18.60	7.35	375	367.65	8°32'48.023" 4°38'26.817"
19. Gaa-Laduba	3.05	7.40	313	305.70	8o48'55" 4o53'42"
20.Tagbesun	12.47	7.47	367	359.53	8 °32'45.817" 4°38'28.288"
21. Akamo	11.0	8.00	364	356.00	8°32'43.946" 4°38'26.656"
22. Ajabesin	14.40	9.00	375	366.00	854469° 4°63917°

23. Ajabesin	11.20	7.70	294	286.30	8°32'58.3" 4°39'12.3"
24. Oke-Ose	6.4	5.1	384	378.90	8°32'43" 4°38'33"
25. NECO Office (Sango)	7	5.5	305	299.50	8°32'27.5" 4°37'44.3"
26. Sango	7	4.7	293	299.50	8°31'18.7" 4°35'40.9"
27. Sango	11.3	7.6	345	337.40	8°30'13.5" 4°32'8.9"
28. Gobin-Okon	9.1	6.4	298	288.30	8°31'30.5" 4°35'58.1"
29. Kulende	10.4	6.5	351	344.90	8°31'33.5" 4°35'54.8"
30. Basin	10	5.8	384	378.20	8°33'05" 4°39'14.1"
31. Basin	10.5	6.6	309	302.40	8°31'36.9" 4°35'24.8"
32. Idi-Ismi	7	5.3	400	394.70	8°30'19.2" 4°35'28.7"
33. Adanlawo	6	6.0	342	336.00	8°30'19.2" 4°35'28.7"
34. Akamo	4.8	4.8	364	341.20	8°30'16.3" 4°35'64.1"
35. Idi-Araba	3.05	3.05	337	333.95	8°31'15.0" 4°39'14.1"
36. Idi-Araba	3	3	284	281.00	8°32'12.114" 4°36'34.475"

KEY:s

Swl (bgl) = Static water level (below ground level)

Swl = Static water level

Results and Discussion

The static water level (below ground surface and above sea level) values and their coordinates (longitude and latitude) were processed using IPWIN resist software as shown in Table 1. The static water level was used to generate the water table locations on topographical contour maps and the groundwater flownet of the study area (Table 1). The data of the static water levels together with the corresponding coordinates were superimposed into the geological map of the study area shown in Fig 4. Static water level ranges from 9.0 m to 3.0 m in places like Oke-Adini, Oyun, Eleko-Yangan, Apata-Yakuba. This shows that water level is closer to the surface in these areas. Also in locations like Gaa-Laduba, Akamo, Idi-Araba, Adanlawo, Idi-Ismi have static water level that ranges from 3.05 m to 7.40 m. Areas where static water levels are very close to the ground surface may be vulnerable to contaminations from surface and subsurface

activities. Other places like Kere-Aje, Alangbadi, Ajabesin, Layeri, Akamo, Gobin-Okon among others have static water level from 6.5 m to 9.5 m. Static water level that ranges from 9.0 m and above the ground surface was recorded in places such as Eleko-Yangan, Oke-Adini, Oyun, Tepatan among others. This shows the static water level are farther to the surface in these areas compared to other areas in the study area. Shallow wells located in these areas may not be productive especially during dry seasons. This shows that the depth to water table varies across the various stations. Olasehinde et al., 2015 evaluated the groundwater potential of Agaie and environs by taking the data of some hand dug wells. Some measurements such as static water level, total well depth, longitude, latitude and elevations were also taken. The study revealed that the area with shallow and deep wells are uniform in the direction of NE and SW as areas with high groundwater potential while the southern part of Agaie has medium groundwater potential. The groundwater potential of the study area was evaluated using vertical Electrical

sounding (VES) to find out the resistivity values of the subsurface.

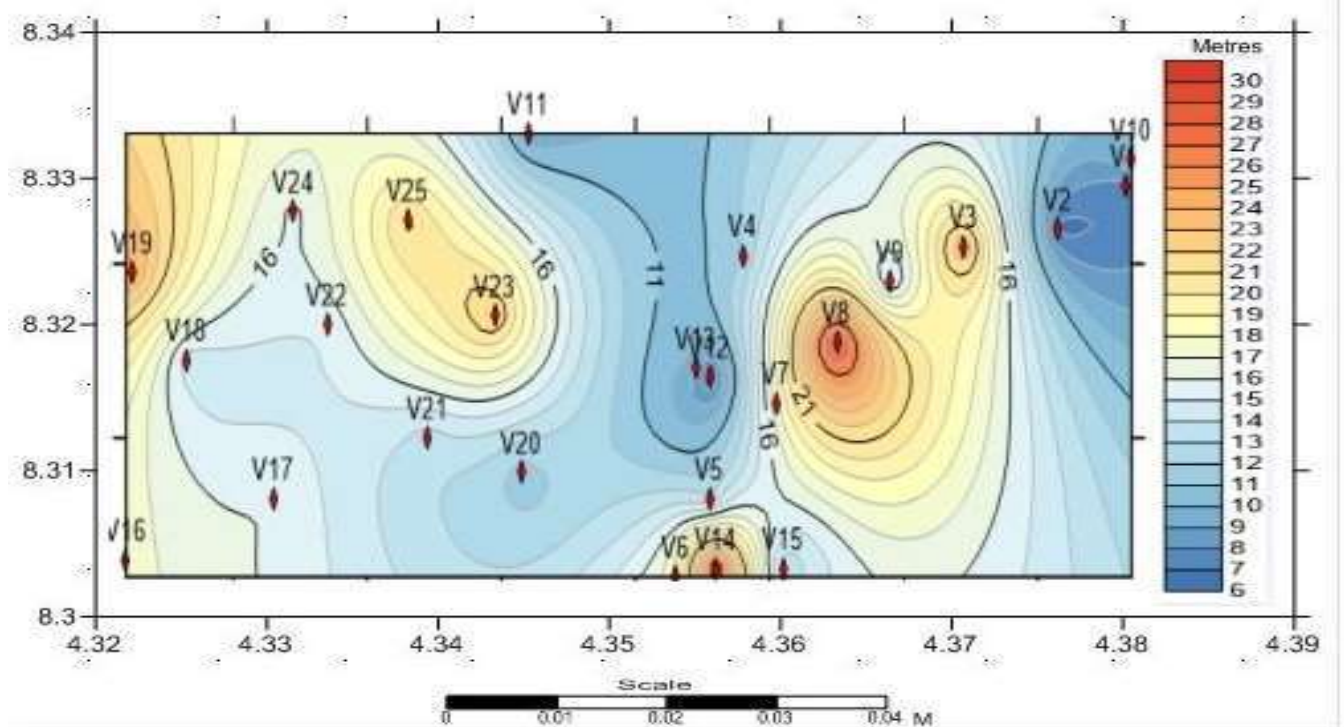


Fig.7: Isopach Map of Kulende area.

As shown in figure 7 the North eastern area correlates with areas that have high depth to water. This shows that the static water level on higher ground is always deeper compared to underground. For example, Idi-Ismi is an area with the lowest elevation which is 284 m above sea level and it lies within the areas with static water level below 3.5 m. While places like Kere-Aje, Layeri and Ajabesin which are on higher grounds (elevation range of 371 m to 400 m) have static water level ranging between 9.5 m and above (below the surface).

The weathered layer resistivity as defined in this work is the resistivity of the rock layer between the topsoil and fractured or fresh bedrock. The purpose of generating (Fig 7, Fig 8) is

to differentiate between zones of high water-bearing to low water-bearing within the weathered layer, and to determine point-to-point variation in the degree of weathering/saturation. The peak of the aquifer's resistivity (2978 ohm-m) is recorded at VES 6, the high resistivity value associated with these parts is possibly due to the sandy nature of the aquifers, which suggests a negligible potential. VES 6 and 12 have aquifer resistivity range from 476.6 ohm-m to 2978 ohm-m which suggests high groundwater potential. VES 4, 8, 10 and 12 have aquifer resistivity range from 476.6 to 1862.9 ohm-m. This suggests a basement aquifer of groundwater potential. This is probably due to high weathered nature of the weathered basement layer (Olugboye, 2008; Summonu et al., 2015)

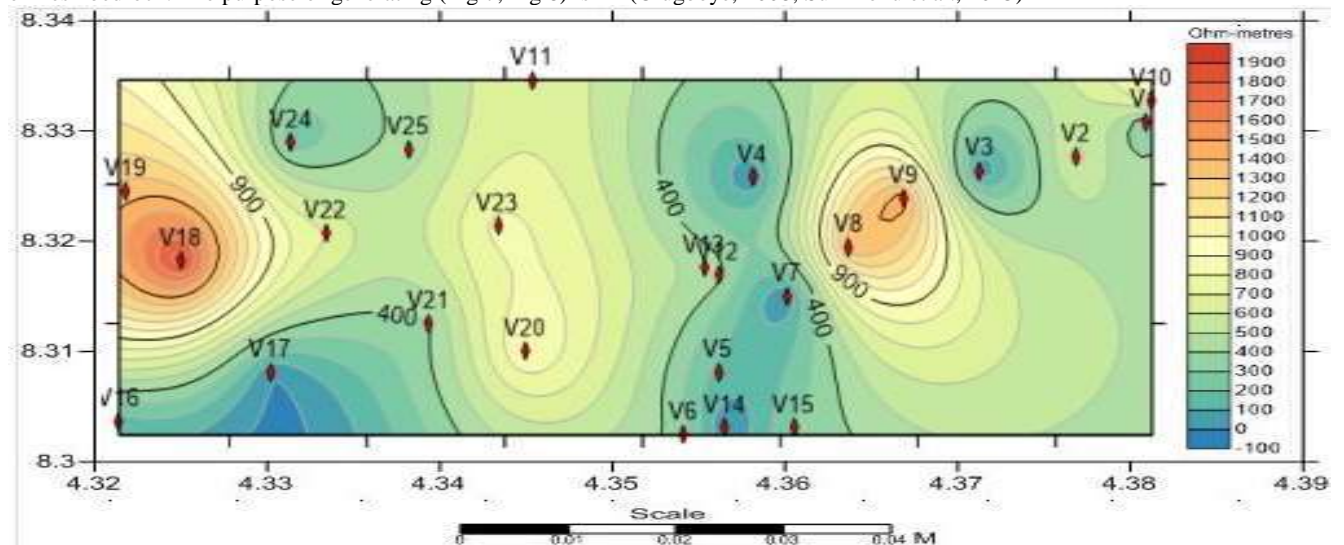


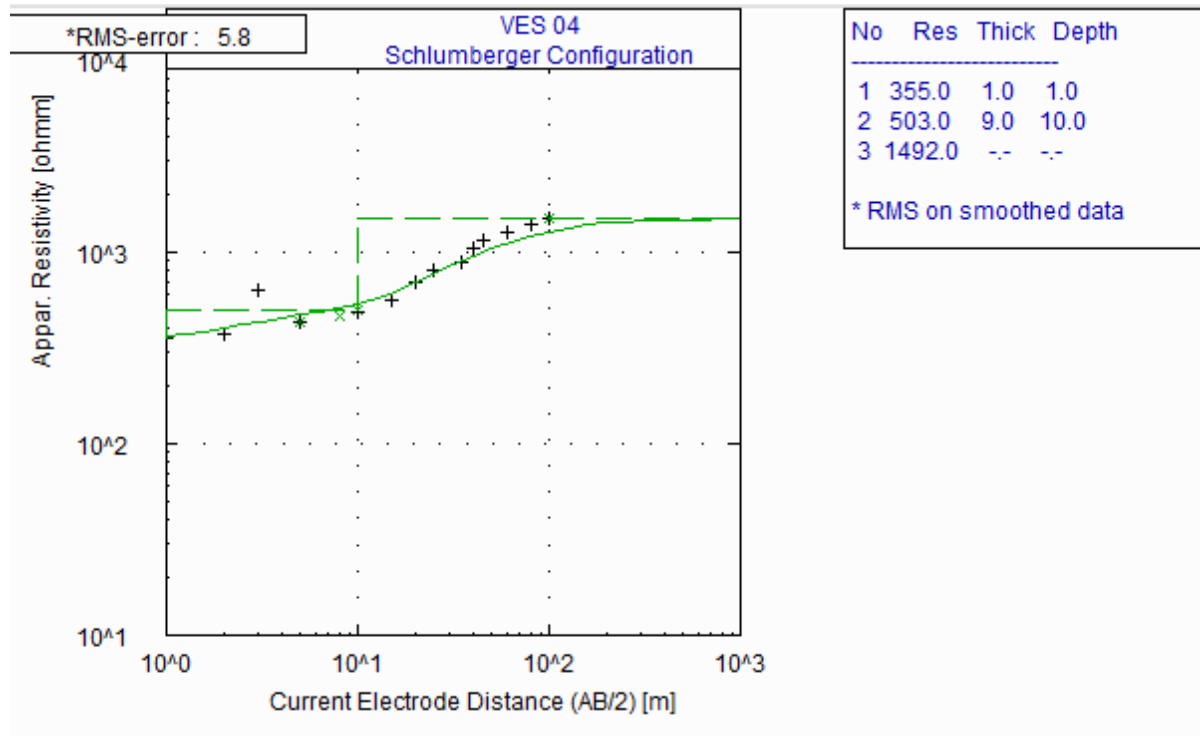
Fig.8 : Iso-resistivity map of top soil of the study area.

The investigation of this research shows that water table is very close to the ground surface in locations like Tepatan, Yakuba resulting to digging of shallow wells by the dwellers of the area. However, these shallow wells in the basement complex of these areas may respond to fluctuations of weather and/or climate and dry up during dry season. Consequently, the people of these areas will be vulnerable to contamination from human and surface activities. Furthermore, in locations like Oke-Andi, Sango and Fate where static water level is far from the surface, the static water level will drop during the dry season leading to increase in the amount of energy required in hand-pumping the water to the surface. Since groundwater flow in the study area is from high static water level above sea level to low static water level above sea level. The direction of groundwater flow in the study area is from Eastern, Southern and Western parts towards the Northern part of the study area where high possibility of ground water is expected. This implies that groundwater flow in the study area is from locations like Ara, Fate, Basin, Tagbesun areas.

CONCLUSION

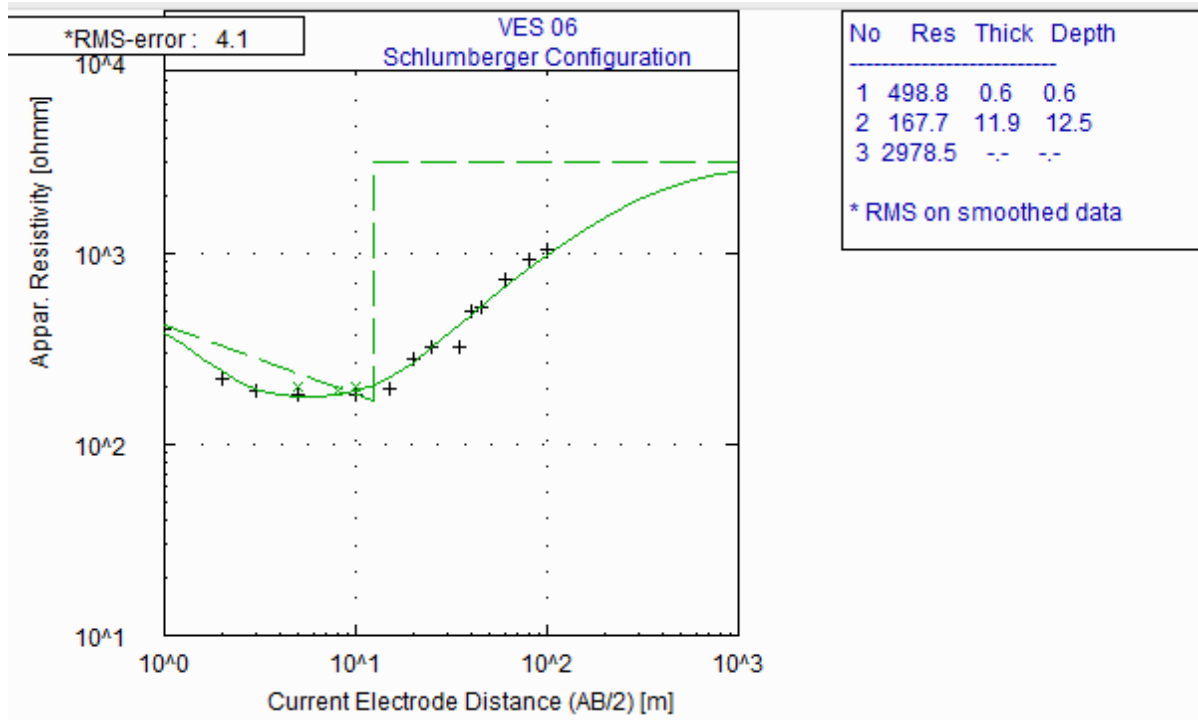
Currently, the geological, geophysical, structural and hydrogeophysical investigation have been found useful in investigating the groundwater potential of Ilorin East and its environs. Southwestern Nigeria. A number of wells have been dug in the area and the causes of their failures have been efficiently analysed and scientific based solutions have been proffered. The abnormalities detected have been overcome in this study by incorporating geophysical investigation with geological, structural and hydrological mapping. Qualitative and quantitative interpretation of the collected data were carried out through visual inspection and computer interpretation using IPWIN resist software to generate resistivity curves.

The interpretations of the result of the geophysical survey showed that the number of Lithological layers in the study area varies between 3 and 4 layers which are predominant. These layers correspond to topsoil, laterites, weathered basement and fractured basement rocks. The electrical resistivity underneath coincides with groundwater flow direction of the area. Digging of boreholes and hand dug wells way from soakaway, toilet and dumping ground is advised. Good hygiene practice is also advocated for the people in the area.



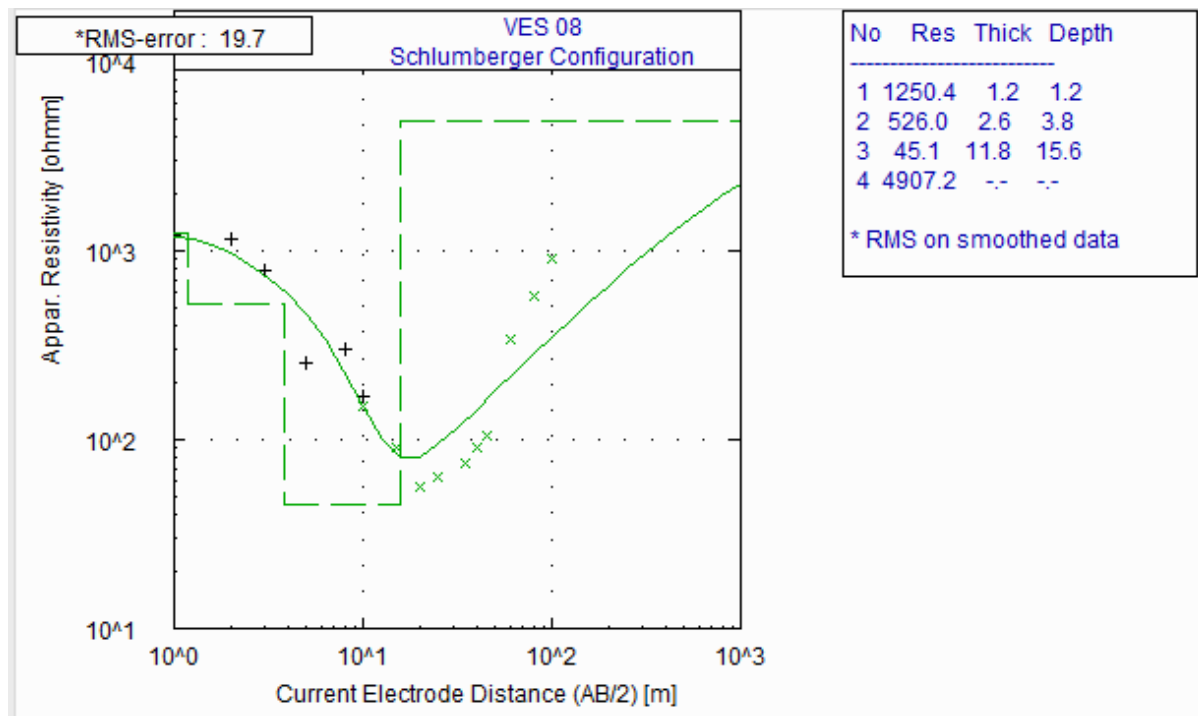
APPENDIX A: Shows (A) type

Location: ARA



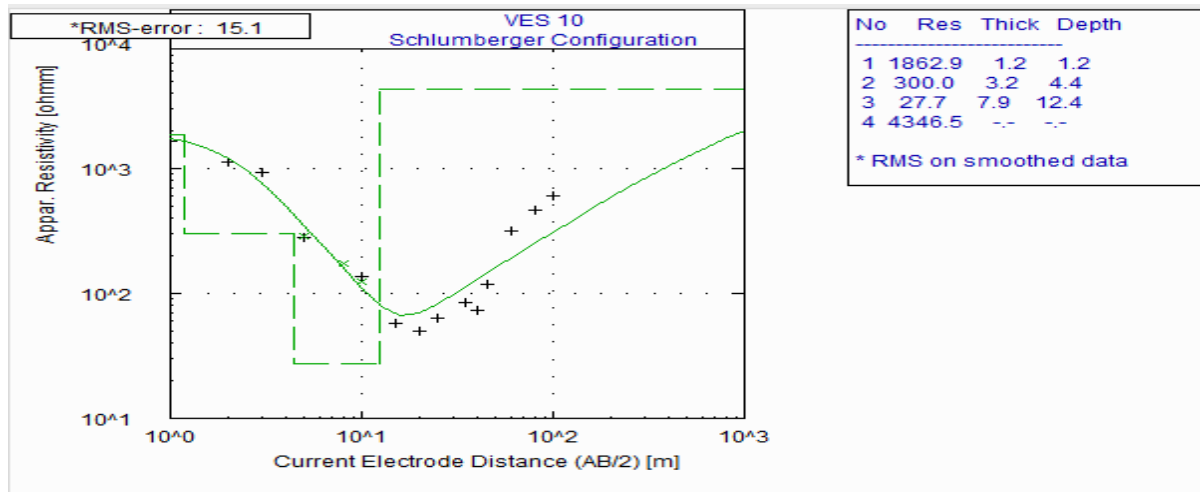
APPENDIX B: Shows (H) type

Location: ELEKO YANGAN



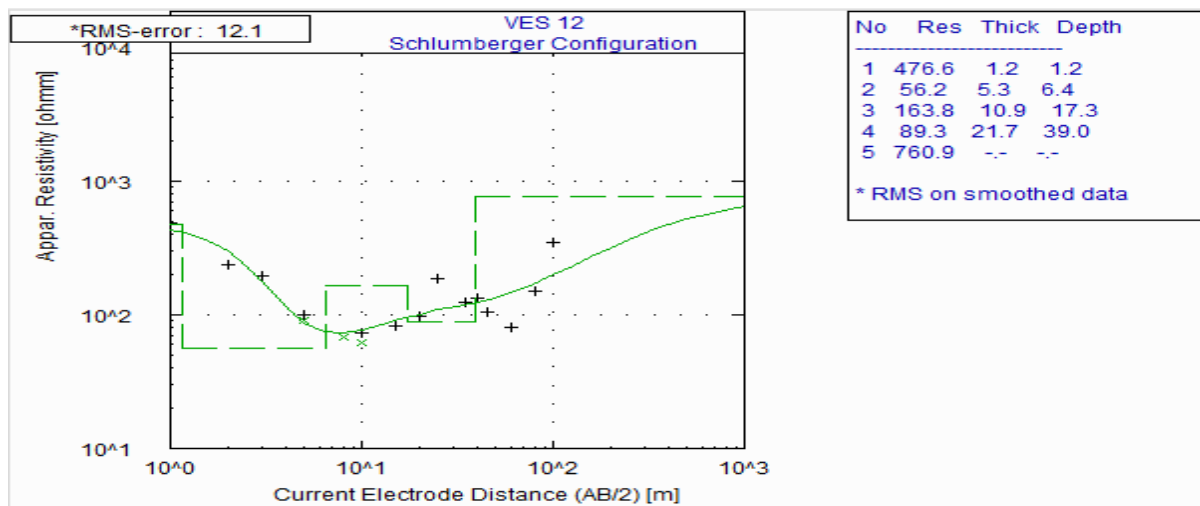
APPENDIX C: Shows (KH) type

Location: OKE-ADINI



APPENDIX D: Shows (H) type

Location: KULENDE



APPENDIX E: Shows (QH) type

Location: FATE

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