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Geoelectric Investigation of Araromi Area Of Akure, Southwestern Nigeria.

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Abstract

Geoelectric resistivity sounding has been carried out at Araromi area, Akure, southwest Nigeria, an area underlain by Basement complex rocks. Eighteen wenner vertical electrical sounding were carried out along six traverses. Three geologic units which are Topsoil/Laterite, weathered Basement and fresh Basement were identified. Isopach, corrosivity, total longitudinal conductance, iso-resistivity and coefficient of anisotropy maps were generated from the combination of the first and second order geoelectric parameters. Isopach map of overburden revealed bedrock depressions, which serve as groundwater collection center. The longitudinal conductance map enabled the classification of the area into zones of good (0.7-1.0),moderate (0.2-0.65) an weak protective capacity(0.15).The results not only reasonably provide a basis for which groundwater potential zones were appraised for safety in case industrial facilities are planned for the area but also present environmental factors that should be considered at planning stages of residential and industrial estates.

Key words:Geoelectric,Resistivity,Sounding,Parameters,Basement,groundwater,Environmental.

1.Introduction

Contamination of the hydrogeological system in metropolitan areas is gradually becoming a common feature. This is due to uncontrolled location of facilities most especially underground storage tanks for petroleum products and septic tanks of various households (Oladapo et al,2004).A number of man's activities that also pose threats to hydrogeological systems include landfill solid wastes disposal, industrial activities, liquid waste disposal basins, septic waste infiltration systems, gasoline service stations, livestock feedlots, urban storm water infiltration e.t.c. Thus, the protection of environment is an essential part of development. Araromi area in Akure, which presently accommodates about 20,000 to 30,000 inhabitant, is transforming gradually into a new urban area with the building of complexes, medical centres, gasoline service stations etc., hence the need for its environment to be protected as development takes its course is a major concern. The fast growing rate of development in Araromi area necessitates an urgent environmental evaluation, otherwise the area may be plunged into a hazardous zone where environmental problems ranging from natural biophysical system disturbance, structural defects, flooding, overcrowding to pollution of all sorts may result. These features endanger lives and make an environment un-inhabitable. The hydrogeological systems especially the underlying aquifers may not be spared in this case. They may be contaminated and damaged by various pollution sources ranging from storage petroleum products, septic tanks of various households and landfills located inappropriately, particularly where inhabitants rely mostly on groundwater. Araromi area experience a high level of rainfall especially at the peak of rainy season between July and September .The surface expression of topsoil seen as Lateritic covers floor the entire western part of the area and causes the slow movement of water into the underground and hence an increase in surface water flows into the River Ala plain. The geomorphology of this area, indiscriminate disposal of household waste coupled with the infilling of River Ala course may also have contributed to the flooding experienced in this part of the area. The solid wastes deposited around the survey area may have caused blockage of passageway for the water to flow and thereby resulting to leachate enough to pollute the hydrogeologic system. Lack of proper drainage system caused by all the natural and geological system in this area may have caused the environmental problem(s) envisage in the area. Geoelectric investigation (using Vertical Electrical Sounding method) at Araromi has helped to evaluate the protective capacity of the overburden materials in the study area in order to establish a level of safety of hydrogeologic system within the area. The study has also been used to delineate areas of good groundwater potential, good geologically competent beds for probable siting of buildings/structures for immediate and future development of the area.

2.Geographic Settings

2.1Site description

Araromi is situated in Akure ,the capital city of Ondo state. Akure lies within latitude $7^{0}13$'N and $7^{0}17$'N and longitude $5^{0}7$'E and $5^{0}14$'E.The town is easily accessible through a good network of major and minor roads and footpaths.The surveyed area is bounded in the south by the flood plain of River Ala. This area is thickly vegetated with elephant and stubborn grasses. The area is adjacent the Sacred Heart Seminary and is separated by the Araromi road .The flood plain occupies about 40% of the region that is known as River Ala floodplain. This river passes through the entire area. The area of investigation covers Odojoka Street, Oke Ibukun,Ojo Ajayi and Araromi Road.

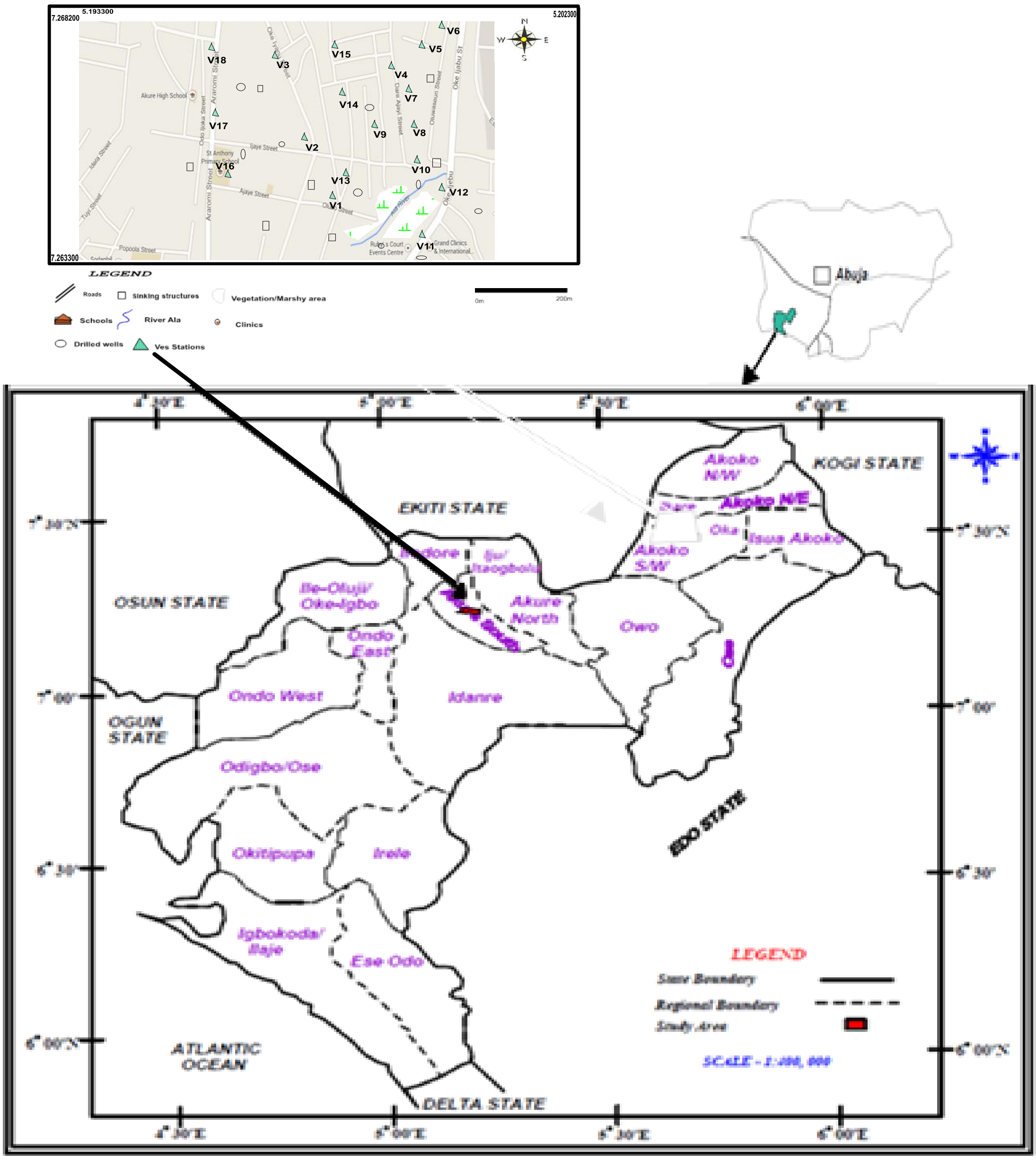


Figure 1. Map of Ondo State showing the Study Area

2.2 Geology and Hydrogeology of the Area

The geology of Nigeria is an overview of the Precambrian Basement Complex and the Sedimentary terrain. The Basement occupies over 60%of Nigeria's landmass (total=934,000km).The younger Cretaceous to Tertiary sedimentary rocks covers the remaining 40% of the landmass. Rahaman,(1976),classified basement rocks in the state to include migmatite, gneiss, metasediment and older granites. Akure, which occupies the survey area, belongs to Precambrian crystalline Basement complex rocks of southwestern Nigeria. Several authors who include Olarenwaju(1981) and Owoyemi(1996) had attempted the classification of the geology of Akure into: Migmatite gneiss, Porphyritic granite, Granite gneiss, Charnockite, Quartzite, Pelitic Schist. Araromi area of Akure is underlain by two main petrologic units,which include the Granite gneiss and migmatite gneiss (Owoyemi,1996).The geology of the area reveals no form of exposed outcrop but at the southern part within the vicinity of the Sports Council complex is a large gneissic boulder, so also the eastern part. It is therefore evident that the site is underlain by gneissic rich in biotite. The surface expression of the geology of this area consists of unconsolidated to semi-consolidated sand in the south underlain by lateritic hardpan and oolitic sandstone to the north and northwest of the surveyed area. River Ala, which flows Southeast and its numerous tributaries, provide the surface water resource of the surveyed area. This study area has abundant surface water resources, which serves as potential source of recharge for undergroundwater. Also,the high level of rainfall experience throughout the year also enhances groundwater recharge. The groundwater is contained within pore spaces of weathered, jointed or fractured basement rocks and ancient buried stream channels. The quality of groundwater in Basement Complex area is generally good unless otherwise polluted through human and industrial activities(Langenegger,1981).Discharge sources of groundwater in this area include abstraction from shallow hand dug well/boreholes and evapotranspiration.

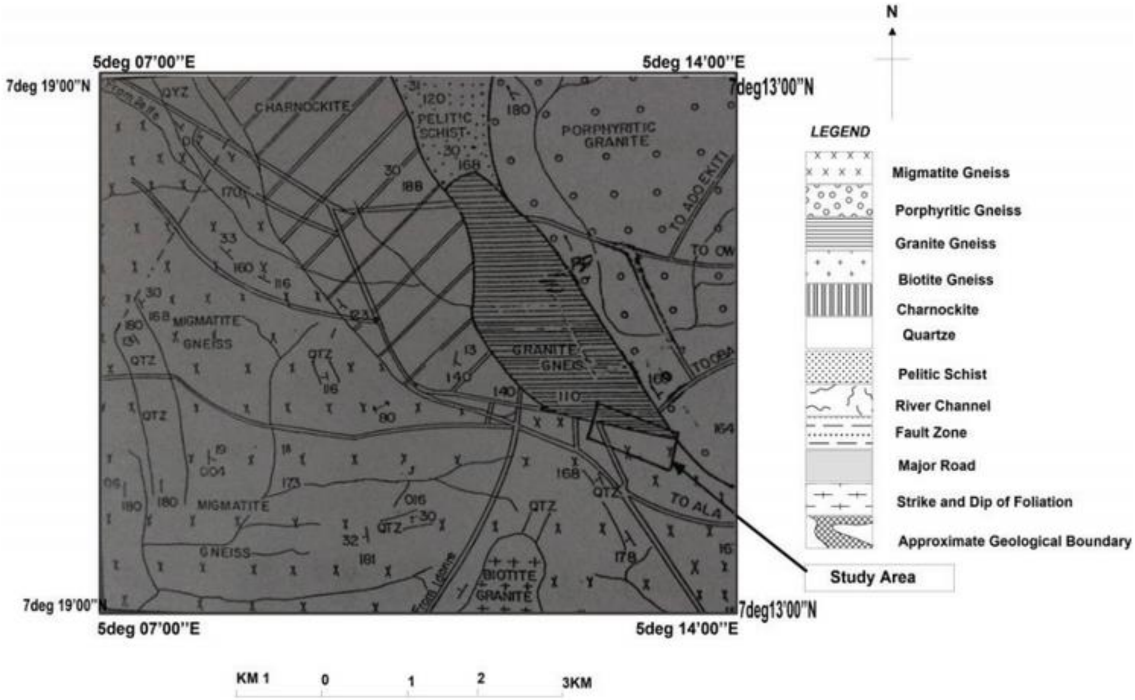


Fig.2.Geological Map of Akure area (After Owoyemi,1996).

3.Method of Study

3.1 Field Procedure/Data Acquisition

The field procedure involved wenner vertical electrical sounding, which is synonymous to drilling i.e. investigating vertically downward with respect to a fixed point. vertical variations in ground apparent resistivity are measured(using the ABEM SAS 1000 Resistivity meter) with respect to a fixed centre of array .The survey is carried out by gradually increasing or expanding the electrode space about a fixed centre of array. The depth of investigation is a function of spacing(AB).Roy and Apparao (1971) have calculated depths of various types of arrays. For wenner, the larger the value of a or AB/3,the deeper is the probe. Apparent resistivity measurements were carried along six(6) traverses: AB,CD,EF,GH,IJ and KL. A total of eighteen (18) vertical electrical soundings (VES) locations were occupied along the six traverses utilizing the wenner electrode configuration. Electrode spacing (AB/3) varied from 1.0m to a maximum of 128m.This was achieved by inserting two electrodes (current electrode,C_1 and C_2) and applying a current through a transmitter. The circuit is completed by flow through the subsurface, which is measured by two similar electrodes (potential electrodes,P1 and P2) hammered into the ground.

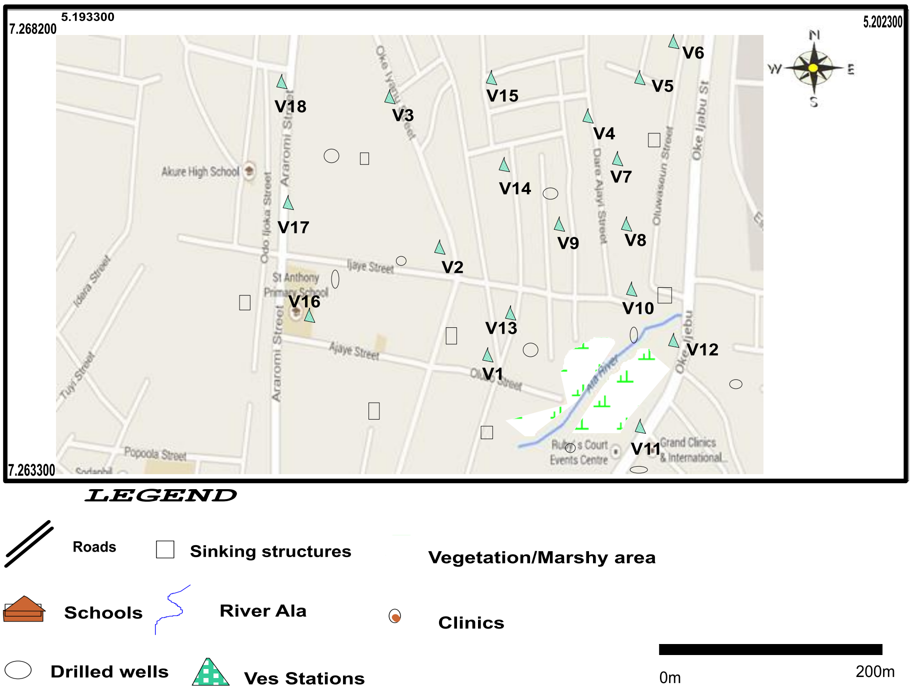


Fig 3. Data Acquisition map of the study Area

3.2 Data Processing/Analysis

Wenner vertical electrical sounding data from the stations are presented as depth sounding or field curves. This is achieved by plotting the apparent resistivity (ρ_a) data against electrode spacing (a) on a log – log paper. The plots are connected using a smooth curve. The curve obtain were used to determine the configuration of the subsurface .Logarithm scale is used on both axes due to large variation in apparent resistivity. They were interpreted using partial curve matching technique. The VES curve was matched segment –by-segment starting from small electrode spacing until a satisfactory match was obtained .while the partial curve matching was in progress, the axes of both field curve and the master layer curve/auxiliary curve were made parallel. This interpretation is based on the principle of superposition or replacement resistivity .The interpretation assumes that all layers or interfaces are horizontal i.e. the angle of dip is 0^0.The interface differentiate layers with different resistivity values. Such interface may or may not correspond with geological interface. Follow partial matching techniques, the algorithms RESIST version 1.0 (Velpen,1988) was utilized for the computer iteration. First order geoelectric parameters derived from iteration were utilized in deriving second order geoelectric parameters or the Dar Zarrouk parameters(Maillet,1947).

4. Results and Discussion

The results of geoelectric study of this area are presented as vertical electrical sounding curves, table, geoelectric sections, isopach map of overburden, Longitudinal unit conductance map, iso-resistivity map, Corrositivity map and Coefficient of anisotropy map .The curves obtained range from simple 3-layered H,K to complex 5-layered HKH and KHA curves.

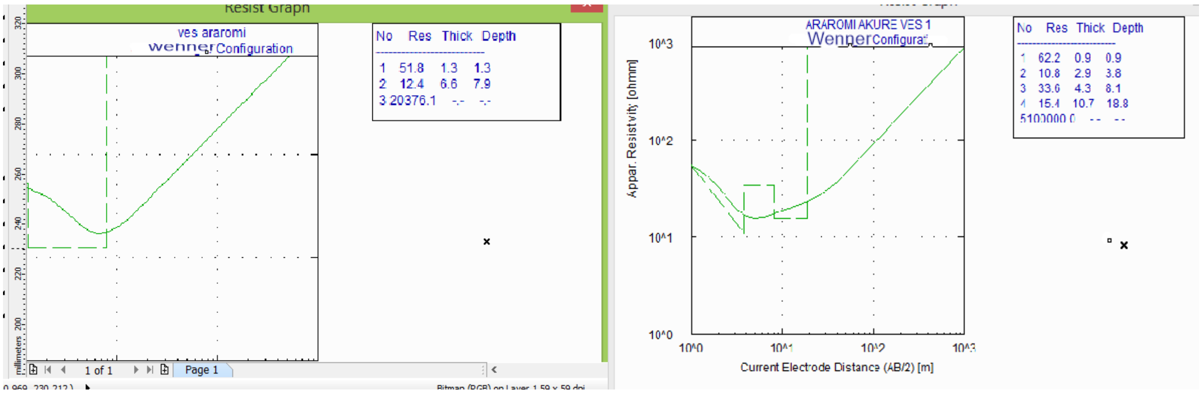


Figure 4.Typical sounding Curve (KH Curve Type) in the Area

Geoelectric Sections

The identification of different subsurface layering is aided by the resistivity spectrum. This enabled the construction of the geoelectric sections. Six geoelectric sections were drawn along approximately North-South direction profiles A-B,E-F,G-H,I-J,K-L.and East-West direction profiles C-D. The sections display geoelectric sequence composed of clay,sandy clay and laterite/topsoil underlain by weathered layer and then the fresh basement .The geoelectric characteristics are the following:

1st Layer :Top soil/Laterite ;Resistivity:25-849 ohm-m;Thickness:0.6-1.9m

2nd Layer: weathered layer: clay, sandy clay and clayey sand.

Resistivity:4-844 ohm-m; Thickness 2.0-34.1m

3rd Layer: Fresh Basement

Resistivity: 1156-∞ ohm-m; Depth to Rock head.2.7 -42.1m

The weathered layer constitutes the major aquifer unit. The layer is significantly thick in the north western, north eastern and south-western parts of the area but clayey with characteristic low permeability and low groundwater discharge capacity.

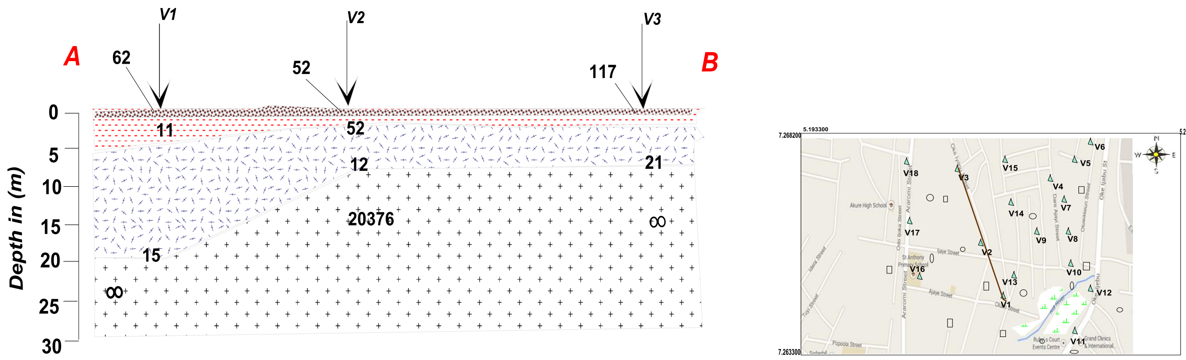


Figure 5 a. A NW-SE Geoelectric section obtained along line A-B(Resistivity values in ohms)

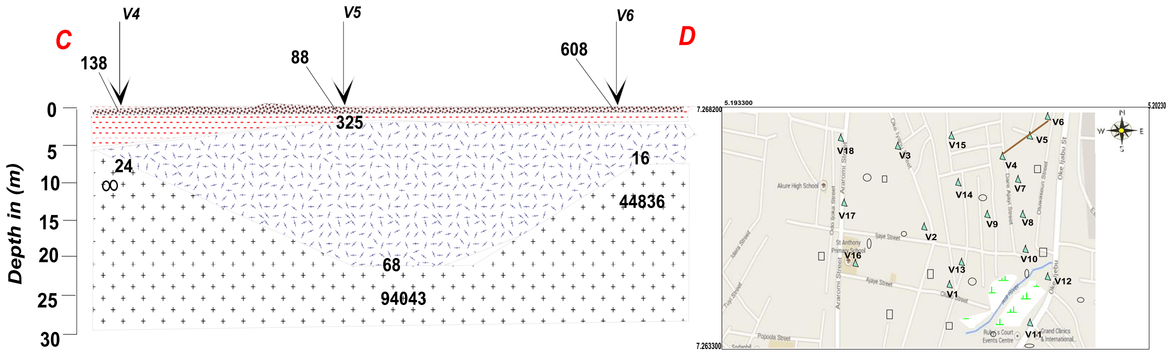


Figure 5 b. A SW-NE Geoelectric section obtained along line A-B(Resistivity values in ohms)

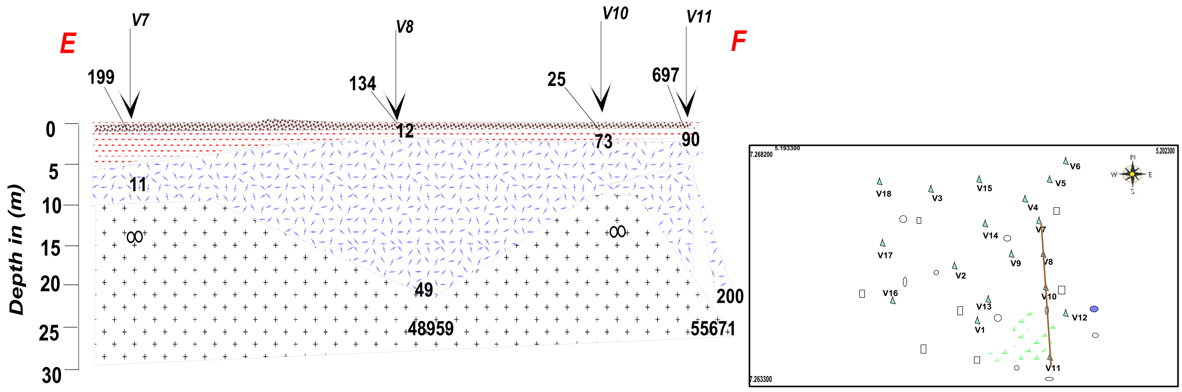


Figure 5 c. A N-S Geoelectric section obtained along line E-F(Resistivity values in ohms)

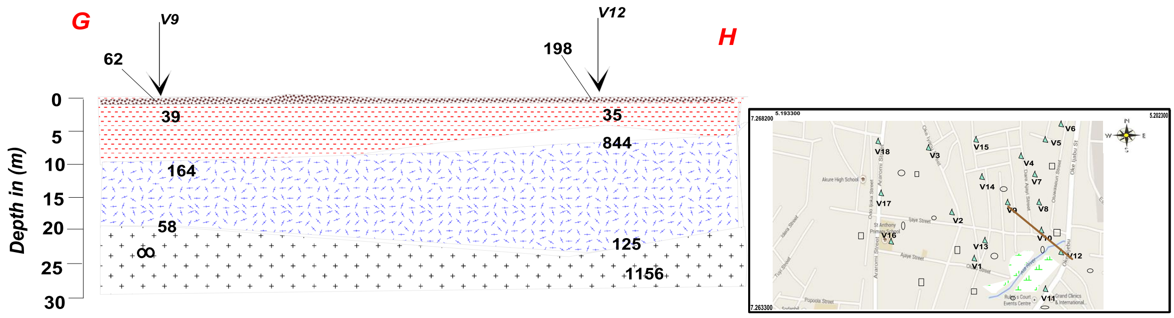


Figure 5 d. A NW-SE Geoelectric section obtained along line G-H(Resistivity values in ohms)

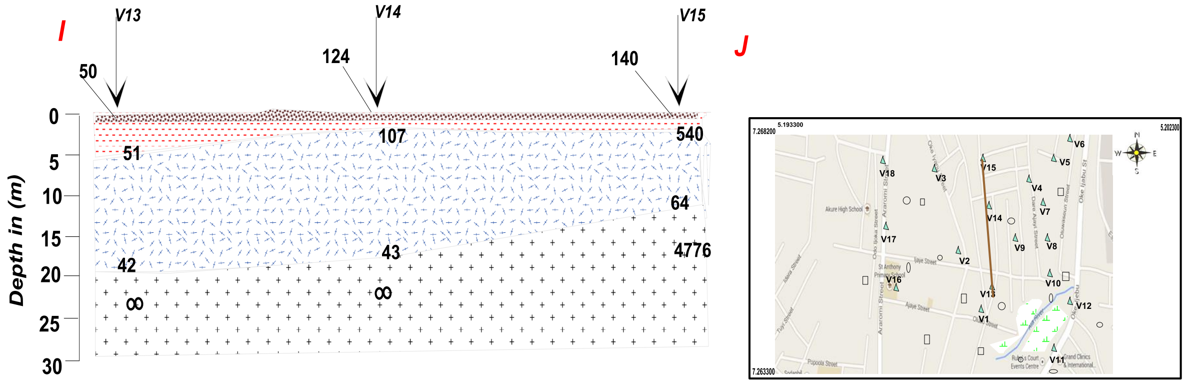


Figure 5 e. A N-S Geoelectric section obtained along line I-J(Resistivity values in ohms)

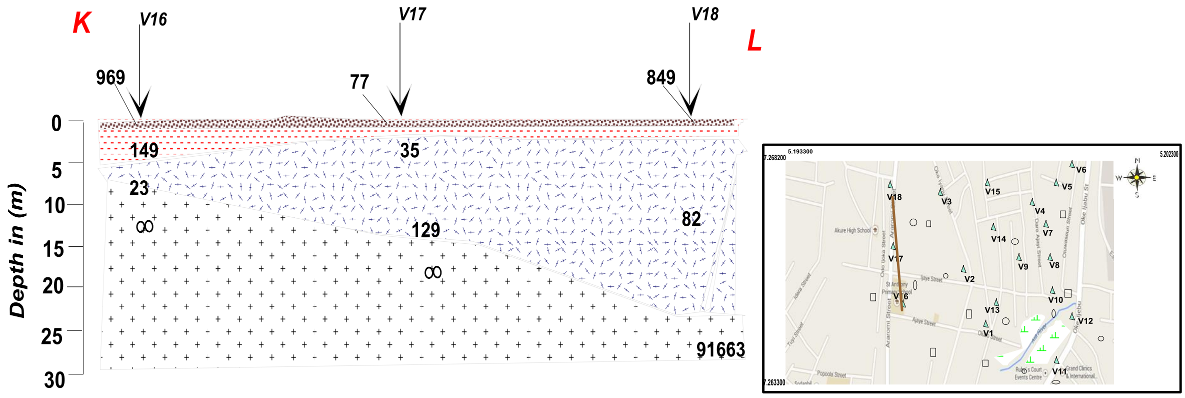
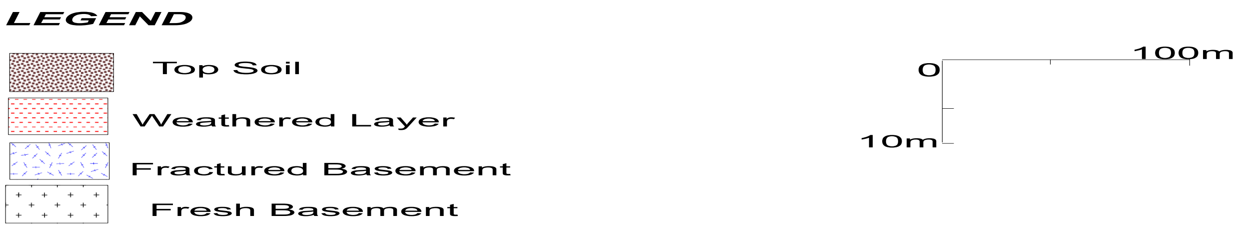


Figure 5 f. A N-S Geoelectric section obtained along line K-L(Resistivity values in ohms)



Isopach Map of Overburden

The thickness of overburden material obtained from the curve interpretation is utilized in generating the isopach map.(Fig.6)

The isopach map of overburden(topsoil/laterite and weathered layer) shows overburden thickness varying from 8m to 40m within the area. Overburden thickness is thinner at the north central and south eastern parts (Oke ibukun and Odokoja street)of the area as evident from the Fig.6.The overburden is generally less than 18m,and this suggests that the area is of less hydrogeologic appeal. However most of the residents rely on groundwater abstracted from hand dug wells. The north western and south western parts (Ojo Ajayi street and Temidire street) of the area are characterized by high overburden thickness designated as typical basement depression zones D_1,D_2 and D_3.These high thickness zones have thickness that range from 18m to 40m with the three bedrock depressions zones having the highest thickness value. Bedrock depressions in a typical basement complex area are groundwater collection centres (Olorunfemi and Okhue,1992).These show typical depressions that serve as groundwater collection centre for groundwater development in this area. The groundwater flows from other parts of the area into the bedrock depressions. The River Ala floodplain, which falls within this area, also serves as recharge zone for the area and the depressions inclusive.

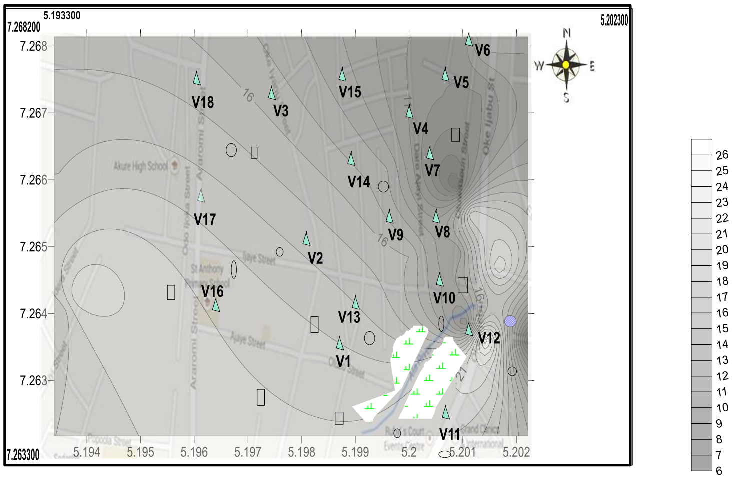


Figure 6: **Isopach Map of Overburden**

Corrosivity Map

The first layer resistivity values obtained from the curve interpretation were utilized in generating corrosivity map. The map is used in the evaluation of corrosivity of the soils within the area .This is because burial of utilities and underground storage tanks are restricted to shallow depths .Soils with layer resistivity values greater than 180 Ohm-m are practically non-corrosive (Baeckmann and Schwenk,1975) and (Agunloye,1984).The areas considered to be of high corrosivity (ρ< 180Ωm) are north central (Oke Ibukun and Temidire street) south western (extreme of Ojo Ajayi street, towards the flood plain),southern and northern parts of the area (Fig.14).These areas are characterized by relatively low resistivity values. Area with high resistivity values experience less corrosion. These areas include the eastern and southeastern (Araromi road and Odokoja street) and western (between Ojo Ajayi and Temidire street) parts of the area. The eastern flank is overlain by lateritic hardpan, its high resistivity values, this corroborates the result from the geoelectric section. More than 60% of the study area display low resistivity values/high corrosivity. Hence, metallic tanks, pipes etc. buried within high corrosive areas are susceptible to corrosion tendency while those buried within practically non-corrosive areas may stand out from the risk of being corroded.

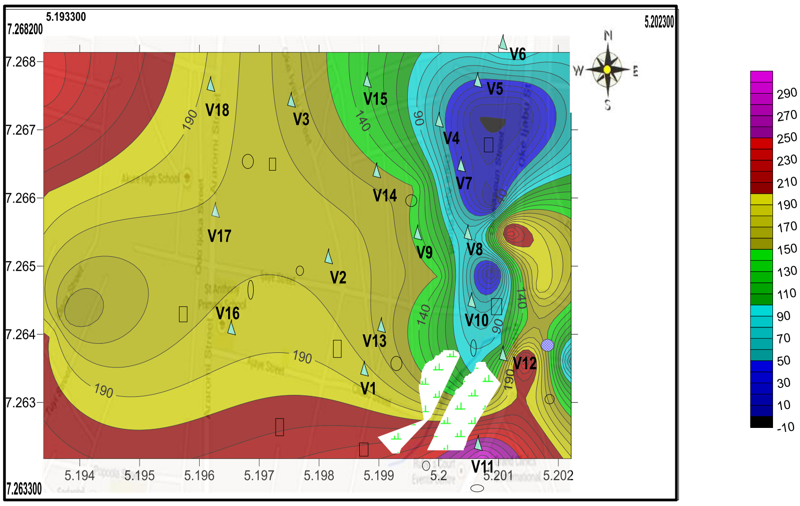


Figure 7:Corrosivitiy Map

Longitudinal Unit Conductance Map

The total longitudinal unit conductance values are used to construct the longitudinal unit conductance map. The map helps to evaluate overburden protective capacity of an area. This is because the earth medium acts as a natural filter to percolating fluid. its ability to retard and filter percolating fluid is a measure of its protective capacity (Olorunfemi et al.1998). Henriet (1976) described the protective capacity of an overburden exerted by retardation and filtration of percolating pollutants as being proportional to its hydraulic conductivity. High clay content ,which resists fluid movement, is generally characterized by low resistivity values and low hydraulic conductivity. Hence the protective capacity can be considered as being proportional to the longitudinal conductance (S).In essence, the higher the overburden longitudinal conductance, the higher the protective capacity. The classification of Henriet (1976) is modified to suite a crystalline Precambrian Basement complex environment (Oladapo et al., 2004).

Table 2:Modified Longitudinal Conductance/Protective Capacity Rating.

Longitudinal conductance (mhos)	Protective capacity rating
>10	Excellent
5-10	Very Good
0.7-4.9	Good
0.2-0.69	Moderate
0.1-0.19	Weak
<0.1	Poor

Table 2 is adopted for the evaluation of the protective capacity in the study area .The modification involves the increase of protective capacity rating owing to the geologic and geoelectric complexity characterizing the basement complex rocks (Oladapo et al.,2004) The total longitudinal conductance map (Fig.15) therefore presents the protective capacity distribution of the study area.The map shows that the overburden material in southern part (Temidire street) has a good protective capacity (0.7-1.0mhos).

The Northeastern (Oke Ibukun street),southeastern (Araromi road and Odojoka street), northwestern (Ojo Ajayi street) and southwestern (around River Ala floodplain) are characterized by materials of moderate protective capacity (0.2-0.65mhos).The extreme western part (River Ala flood plain) has a weak protective capacity (0.15mhos).

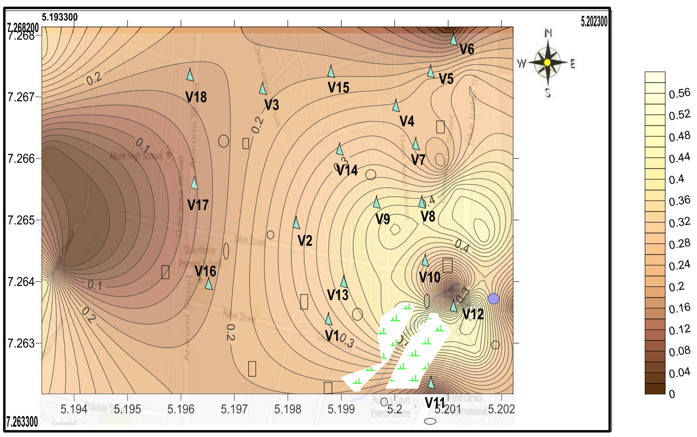


Figure 8: **Longitudinal Unit Conductance Map**

Iso-Resistivity Map

The weathered layer resistivity values are used to plot the iso-resistivity map (Fig.16).The iso-resistivity map of the weathered layer shows resistivity ranging from 20 Ohm-m to 190 Ohm-m within the area. The extreme south western (Temidire street and the area covered by the floodplain) and eastern (Araromi road) parts of the area shows relatively high weathered layer resistivity values (60-190 Ohm-m),which imply that the areas are dominated by clay/sandyclay, with characteristic fairly hydrogeological appeal because of their relatively good thickness as evident from the isopach map of the area. The north central (Oke Ibukun street),northwestern (Ojo Ajayi street), northeastern and southern parts of the area are characterized by low resistivity values indicative of clay subsurface environment with less hydrogeologic appeal.

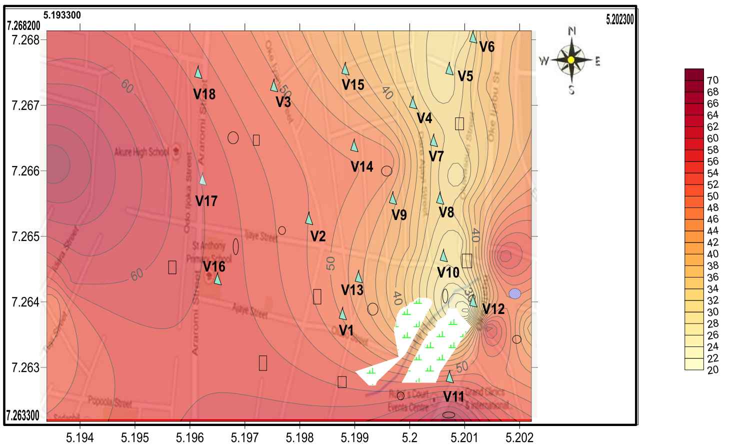


Figure 9: Iso-Resistivity Map

Coefficient of Anisotropy Map

Coefficient of anisotropy has been used to delineate lithological contacts in typical basement terrain (Olorunfemi and Okhue,1993).In the study area ,two rock types were identified namely the granite gneiss and migmatite gneiss.The coefficient of anisotropy over metamorphic rocks was found to be generally lower than those over igneous rocks.Significant overlap exists in the values to preclude rock type differentiation on this basis (Olorunfemi and Olorunniwo,1985).The granite gneiss is characterized by relatively high values (>1.20) and dominates the northwestern, northeastern, southeastern and southwestern parts of the study area. The migmatite gneiss characterized by low values (<1.20) dominates parts of the southwestern and western(Temidire and Oke Ibukun) and western (Araromi road) area. The broken lines distinguish between the two rock types. This suggests that the weathering end products of the migmatite gneiss are less anisotropic than those of granite gneiss.In this study,the zones of low coefficient of anisotropy values correlate with zones of high conductance .

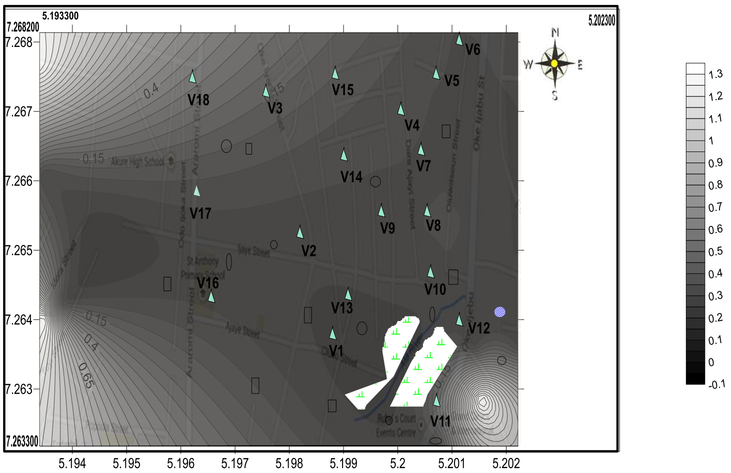


Figure: Coefficient of Anisotropy Map

Conclusion and Recommendation

A geoelectric study has been reported in this work. The analysis of eighteen vertical electrical sounding carried out revealed the presence of three to five geoelectic layers with depth to bedrock of between 2.7m and 42.1m.The Isopach map of overburden revealed bedrock depressions which serve as groundwater collection centers.The Longitudinal unit conductance map of the study area showed that materials of moderate to good protective capacity (clay/sandyclay) underlie major parts of the area. The groundwater resource development across some stretched in this area is therefore safe from pollution in case of leakage of buried liquid waste sewage tanks ,underground storage tanks, contaminated surface water e.t.c Safe zones include Temidire street, Odojoka street, Ojo Ajayi street, Oke Ibukun street and Araromi road. The only weak zone is around the River Ala floodplain in the extreme western part of the area. More than 60% of the study area has high corrosivity. These areas include north central (Oke Ibukun and Temidire street), south western (extreme end of Ojo Ajayi street,towards the flood plain), northern and southern parts of the area. Less corrosive areas include the eastern and southeastern (Araromi road and Odojoka street) and western (area between Temidire and Ojo Ajayi street).The Iso –resistivity map indicates areas with low resistivity values ,and the areas include north central (Oke Ibukun), northwestern (Ojo Ajayi street),north eastern and south eastern parts of the area.Two major rock types ,which are granite gneiss and migmatite gneiss , were delineated based on their relative coefficient of anisotropy responses and signature. The flooding experienced in Araromi area is caused by the inability of the water to percolate into the ground quickly because most of the area is underlain by clay/sandy clay materials whose porosity is high but with low .The infilling of River Ala's course with household wastes e.t.c also contributes to the flooding is experience in this study area. It is therefore concluded that the development of low to medium capacity borehole is feasible and safe .Safety of hydrogeological system is also guaranteed and hence Araromi area is good for residential estates development.

Recommendation

The result of this study has revealed a set of environmental factors (protective capacity and corrosivity) that should not be ignored at the planning stages of residential and industrial estates. Hence, the Araromi area of the study is therefore recommended for residential estates developments. Other recommendations include adequate drainage facilities to allow water to flow freely during the rainy season, provision of moveable sewage/refuse dumping cans at strategic locations for house wastes dumping and indiscriminate dumping of refuse should be discouraged.

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