OnLine Journal of Earth Sciences 1 (2): 76-84, 2007

Geoelectric Investigation of the Dape phase III Housing Estate FCT Abuja, North Central Nigeria

K.A. Mogaji, K.A.N. Adiat and M.I. Oladapo
Department of Applied Geophysics, Federal University of Technology,
P.M.B. 704, Akure, Nigeria

Abstract: A geoelectrical investigation involving fifty Schlumbeger vertical electrical soundings were carried out along traverses established in the west-east azimuth at the Dape phase III Housing Estate, FCT Abuja to evaluate the aquifer protective and corosivity of the near surface materials. Corrosivity, isopach and total longitudinal unit conductance (S) maps were generated from the combination of first and second order geoelectric parameters. The eastern, southeastern parts and parts of southwestern end of the estate are characterized by slightly corrosive to moderately corrosive materials (50ohm-m< p<150ohm-m) and moderate overburden thickness (>20 m). Using the total longitudinal unit conductance S, the estate is classified into zones of weak (0.1-0.19) and poor (<0.1) protective capacity. The results reasonably provide a basis for which groundwater potential zones are appraised for safety in case industrial facilities are planned for the area under study. The study also presents new environmental factors that may perhaps be considered at planning stages of residential and industrial estates.

Key words: Corrosivity, resistivity, isopach, longitudinal conductance and overburden

INTRODUCTION

The application of geophysical methods prior to the commencement of operation in any site is a good weapon for further environmental problems solution. The state of the environment is a major world wide concern today.

Pollution in particular is perceived as a serious threat in the industrialized countries, where quality of life had to be measured mainly in terms of growth in material output, mean while, environmental degradation has become a serious impediment to economic development and the reducing of poverty in the world.

Contamination of the hydrogeologic system in the metropolitan areas is gradually becoming a common feature. This is due to the uncontrolled location of the facilities most especially underground storage tanks of petroleum products, septic tanks of various households and shallow subsurface piping utilities. Under ground storage petroleum products can provoke permanent damage of underlying aquifers particularly in the areas where inhabitants rely mostly on groundwater.

Geophysical studies have proved to be one of the most effective ways of evaluating an environment without interfering with the hydrogeologic system.

In this study, Electrical resistivity method was employed at the Dape phase III Housing Estate, FCT Abuja, North Central, Nigeria, for environmental evaluation of the near-surfaces materials in the study area. This method is able to measure the physical property of rock and soil which are mostly affected by the presence of water. This method had been used successfully for evaluating the aquifer unit protective capacity study of Ondo State Housing Corporation Estate Ijapo Akure (Oladapo *et al*., 2004).

Study area description: The area studied is within the Dape District Phase 3, F.C.T. Abuja. it falls between latititudes 9° 3' 59" N and 9° 5' 21" N and longitudes 7° 22' 33" E and 7° 23' 6" E. Figure 1 is the schematic base map of the study area. Due to the rapid urbanization and restructuring of the FCT, the mass demolition in the territory has led to increase in number of the inhabitants of the estate with attendant threat to the environment. The need therefore arises to evaluate the protective capacity of the overburden materials in the study area in order to establish the level of safety of the hydrogeologic system, corrosivity of the subsurface materials for underground piping utilities, areas for future groundwater abstraction.

Geomorphology and geology: The vegetation here in Dape phase III Housing Estate, FCT Abuja is similar to that of tropical woodland which is peculiar to savannah zone.

The study area is underlain by rocks of the Precambrian basement complex of north central Nigeria. The lithological units include the migmatite-gneiss complex and granitoids, (G.S.N, 1994). The migmatite-gneiss complexes form generally the ridges and the inselbergs while the granitoids form lowland outcrops with coarse texture.

Corresponding Author: K.A. Mogaji, Department of Applied Geophysics, Federal University of Technology, P.M.B. 704, Akure, Nigeria

MATERIALS AND METHODS

Fifty vertical electrical sounding (VES) points were occupied on the location (Fig. 2) utilizing the Schlumberger electrode configuration. Electrode spacing (AB/2) was varied from 1.0-100 m. Field measurements were made with SAS 1000 Resistivity Meter. The VES data were utilized in generating field curves. The curves were interpreted using partial curve matching technique. The geoelectric parameters obtained from manual interpretation of each VES data were refined using the software algorithm RESIST version 1.0 (van der velphen, 1988). Second order geoelectric parameters called Dar Zarrouk parameters (Malliet, 1947) were determined from the iterated geoelectrical parameters. The second order parameter of interest in this study is longitudinal unit conductance (Si).

The second order parameter is derived thus (Zohdy *et al*., 1974):
For n layers, the total Longitudinal unit conductance;

$$S = \sum_{i=1}^{n} \frac{h_i}{\ell_i} = \frac{h_i}{\ell_1} + \frac{h_2}{\ell_2} + \ldots \frac{hn}{\ell n}$$

RESULTS

The results of this study are presented as sounding curves, table and maps. The curve types obtained from the study area are HA, KHK, AKH, KHA, KQH, KH, H, AA, A, HK, QH, KQHA, QHA. (Fig. 4). The A-type curves are characterized by an increase in resistivity from topsoil to the bedrock while the intermediate layer in the H-type is commonly water saturated and is often characterized by low resistivity, high porosity, low specific yield and low permeability (Olayinka and Olorunfemi, 1992).

The thickness of the overburden material and second layer resistivity values obtained from the curves interpretation are utilized in generating the overburden thickness and corrosivity maps, respectively (Fig. 4 and 5).

The second order parameters derived from the sounding interpretation results are presented in Table 1. The total longitudinal unit conductance (S) values obtained in the table are utilized in generating the map in Fig. 6.

DISCUSSION

The HA, KH, KHA and KQH curve types predominate in the study area (Fig. 7). Findings revealed that the KH and KQH in many instances indicate fracturing and are favourable zones for groundwater abstraction (Oladapo *et al*., 2004).

Table 1: Dar Zarrouk Parameters obtained from first order parameters

VES Station	$S = \sum_{i=1}^{n} \frac{h_i}{\rho_i}$
1	0.01715
2	0.07
3	0.07332
4	0.0924
5	0.00794
6	0.0279
7	0.0387
8	0.1204
9	0.12753
10	0.0928
11	0.065575
12	0.0482
13	0.1491
14	0.16779
15	0.11906
16	0.08729
17	0.042881
18	0.0643
19	0.0535
20	0.0198
21	0.0159
22	0.1551
23	0.185
24	0.119374
25	0.1302
26	0.06129
27	0.0556
28	0.124
29	0.1065
30	0.09417
31	0.07
32	0.07332
33	0.0924
34	0.00794
35	0.0279
36	0.0387
37	0.1204
38	0.12753
39	0.0928
40	0.065575
41	0.0482
42	0.1491
43	0.16779
44	0.11906
45	0.08729
46	0.042881
47	0.00224
48	0.024377
49	0.15459
50	0.07184

The study area overburden thickness map (Fig. 4) shows overburden materials thickness to be excess of 20 m(>20 m) at the western to the northwestern and the southern portions of the study area. Overburden materials thickness is less than 20 m (<20 m) at the central portions and the northeastern flank of the study area. The zone of excess overburden materials thickness >20 m in the study area are promising zones for groundwater abstraction while zone of thickness <20 m are not hydrogeological appeal. The residents in the study area rely on groundwater abstracted from hand-

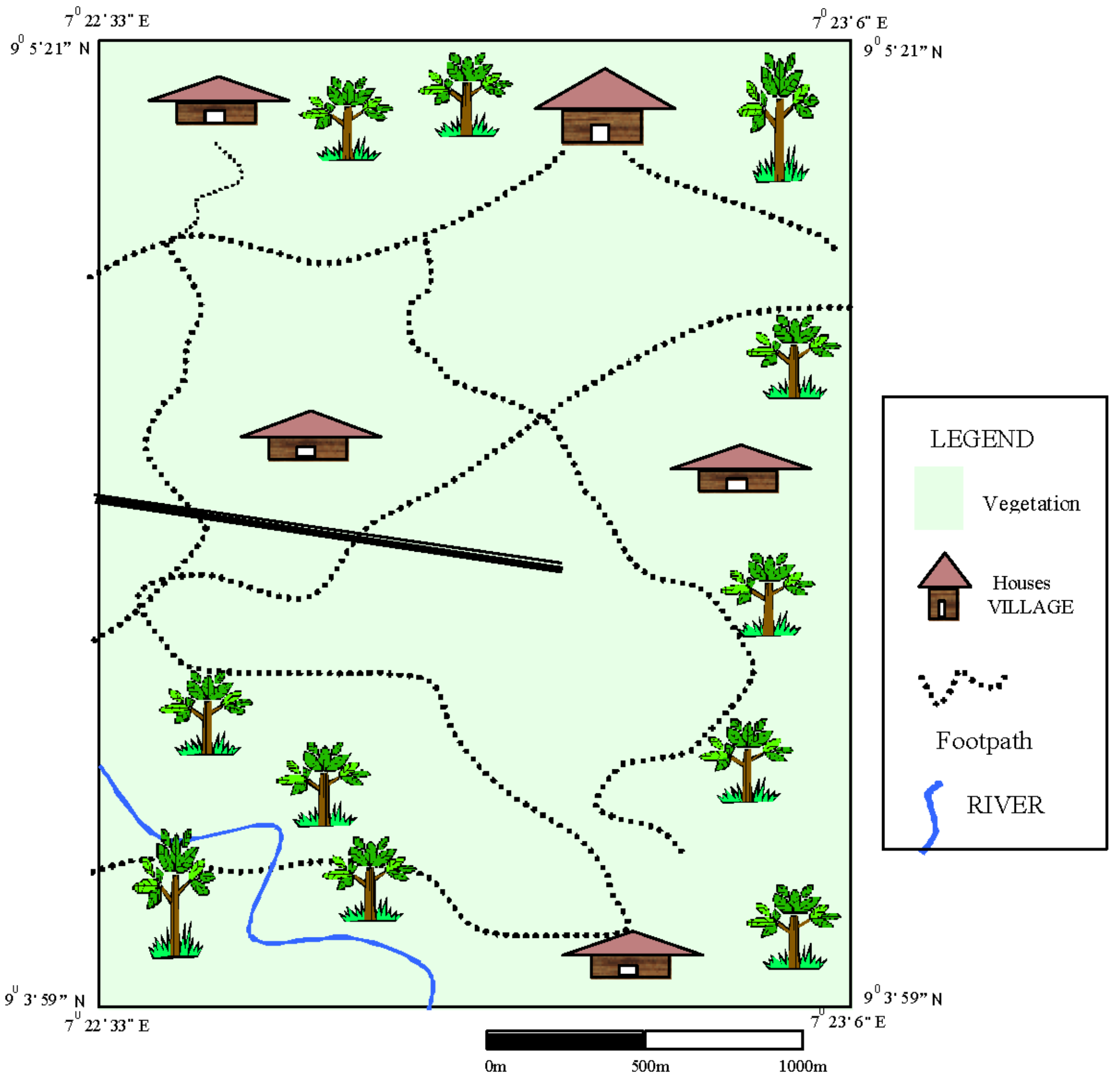


Fig.1: Schematic base map of the study area

dug wells; therefore, it is of paramount need that the overburden protective capacity in all area of the estate is evaluated to establish the level of safety of the hydrogeologic system.

The resistivity values obtained from the second layer at all VES locations are utilized in the evaluation of corrosivity of the soils in the estate (Fig. 5). This is because burial of utilities and underground storage tanks are restricted to shallow depth. The areas considered to be of high corrosivity ?<150 Ohm-m are at the eastern to southeastern parts and parts of southwestern end of the study area. These areas are characterized by low resistivity and high moisture content.

The total longitudinal unit conductance values were utilized in evaluating the overburden protective capacity in the study area. This is because the earth medium acts as natural filter to percolating fluid. Its ability to retard and filtered percolating fluid is a measure of its protective capacity (Olorunfemi *et al.*, 1998). Henriet (1976) described the protective capacity of an overburden overlying an aquifer as being proportional to its hydraulic conductivity. High clay content which impede fluid movement is generally characterized by low resistivity values and low hydraulic conductivities.

Table 2 presents the modified longitudinal conductance/ protective capacity ratings. This modified rating table after Henriet (1976) enables the zoning of the study area into good, moderate and weak protective capacity zones. The modification involves the increase protective capacity rating owing to the geologic and geolectric complexity characterizing the basement complex rocks. The longitudinal unit conductance map (Fig. 6) therefore presents the protective capacity distribution of the study area. The map generally shows

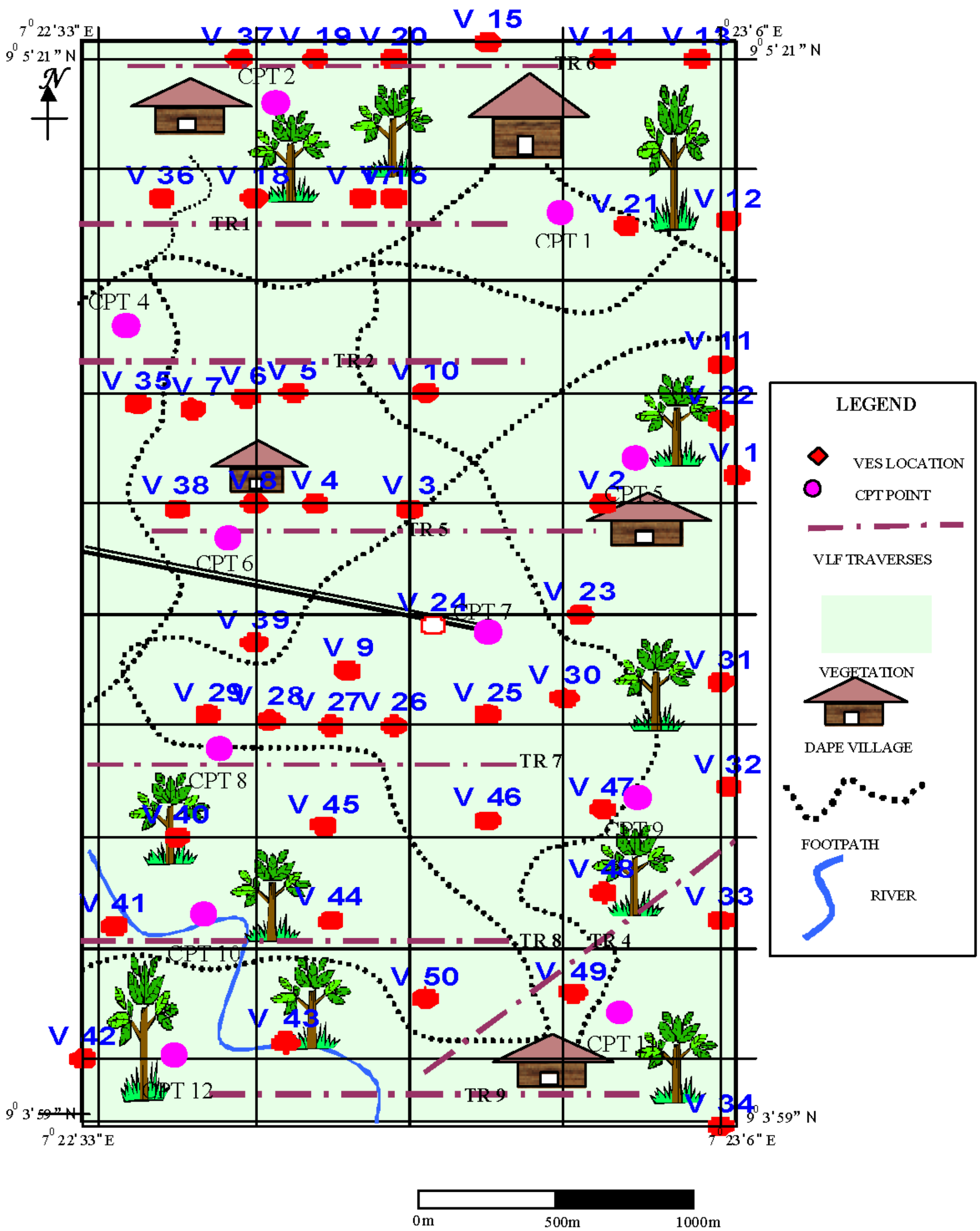
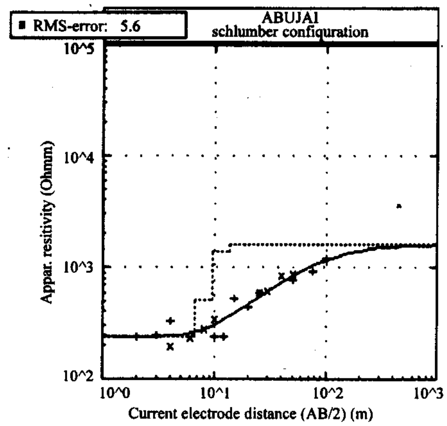


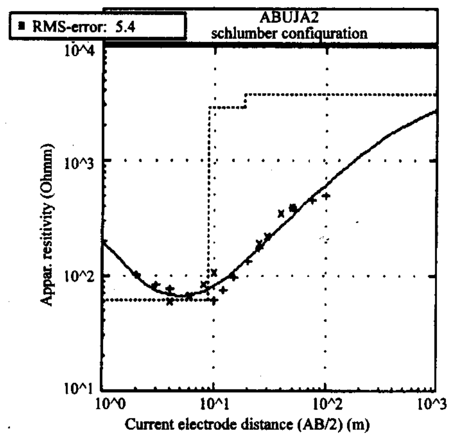
Fig. 2: Schematic map of the study area showing VES locations

that the aquifer protective capacity within the study area is rated weak (0.1-0.19 mhos) to poor (<0.1mhoms). The map reveals that nearly all The overburden materials overlying the aquifer in the area have poor protective capacity with the exception of small areas underlain the eastern and southwestern parts of the area are characterized by materials of weak protective capacity.



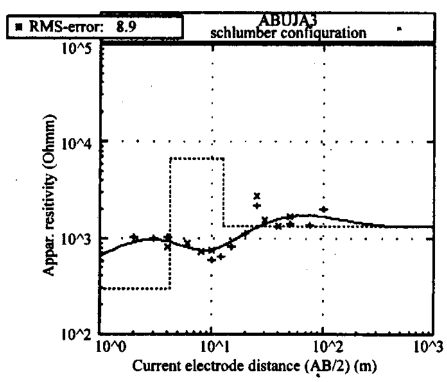
No	Res	Thick	Depth
1	237.8	6.6	6.6
2	516.5	2.5	9.4
3	1367.8	4.1	13.5
4	1590.4	-.-	-.-

■ RMS on smoothed data



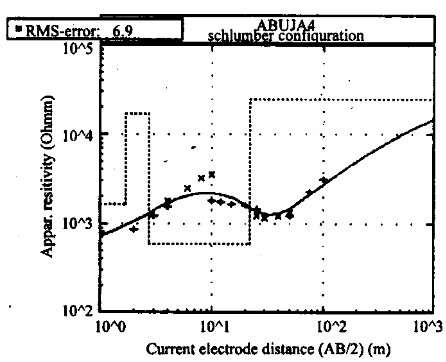
No	Res	Thick	Depth
1	274.0	6.6	6.6
2	61.0	8.0	8.8
3	2881.0	9.7	18.5
4	3696.0	-.-	-.-

■ RMS on smoothed data



No	Res	Thick	Depth
1	333.0	0.4	0.4
2	11127.0	0.2	0.6
3	291.4	3.6	4.2
4	6598.0	8.4	12.6
5	1320.1	-.-	-.-

■ RMS on smoothed data



No	Res	Thick	Depth
1	619.0	0.8	0.8
2	1637.0	0.9	1.7
3	16948.0	1.0	2.7
4	599.0	18.9	21.6
5	24643.0	-.-	-.-

■ RMS on smoothed data

Fig. 3: Examples of computer interpretation for VES 1, VES 2, VES 3 and VES 4

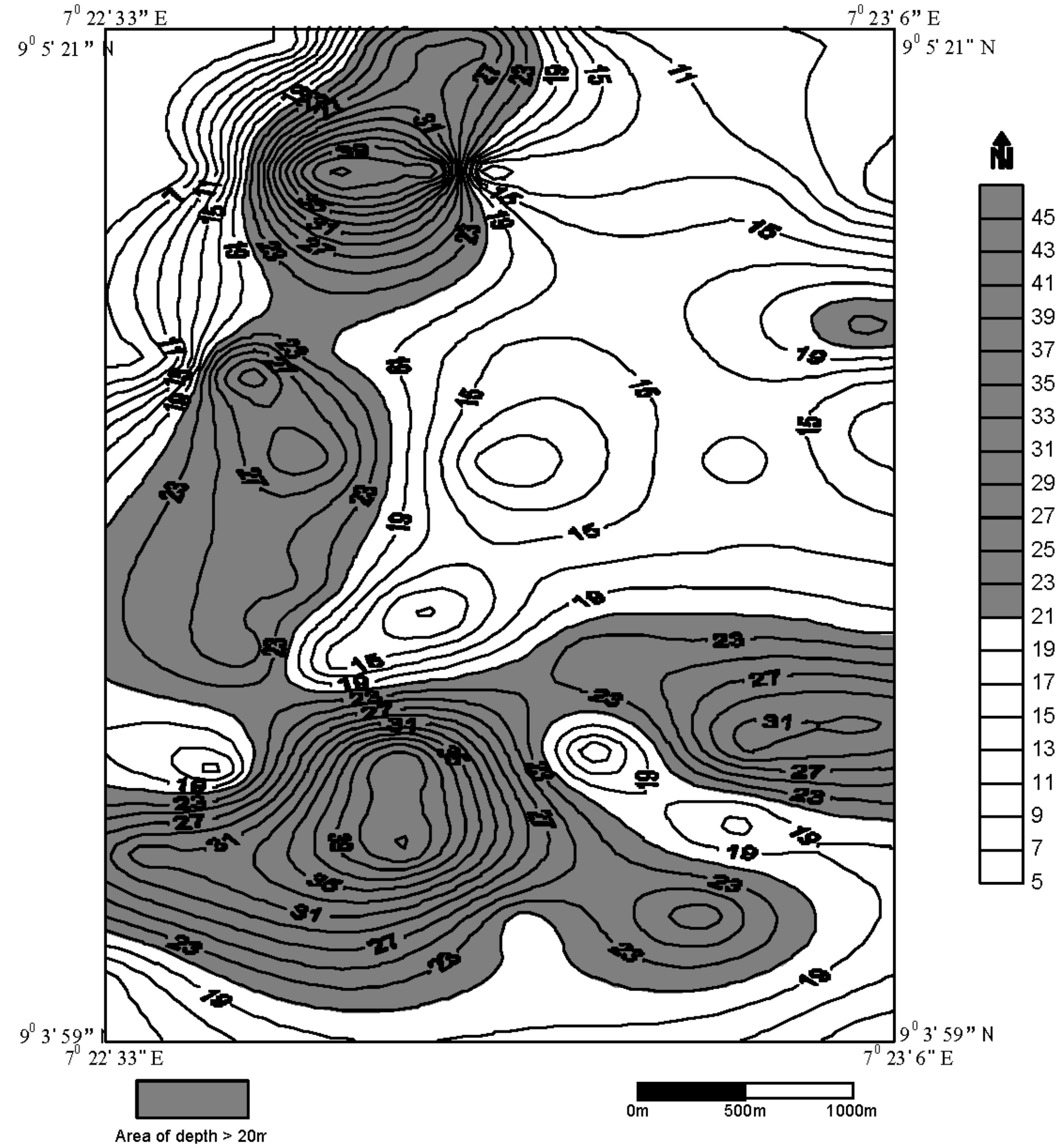


Fig. 4: Isopach map of the study area

In this study, a geoelectric investigation has been use to evaluate the aquifer protective capacity and corosivity of the near surface material in the basement complex of Dape phase III Housing Estate, FCT Abuja, North Central Nigeria.

Longitudinal conductance map prepared fom the second order geoelectrical parameters of the near surface materials show that the generality of the entire area studied are underlain by materials of weak to poor protective capacity. This suggests that the groundwater in these areas is vulnerable to pollution if there is leakage of buried underground storage tanks or an infiltration of leachate from decompose refuse dumped in any region within the studied area. Therefore, petrol filling station and refused dumping should be some meters away from the landed area of the Estate for safety appraisal of groundwater consumptions within the Estate.

The result of this study has highlighted a set of environmental factors (corrosivity and protective

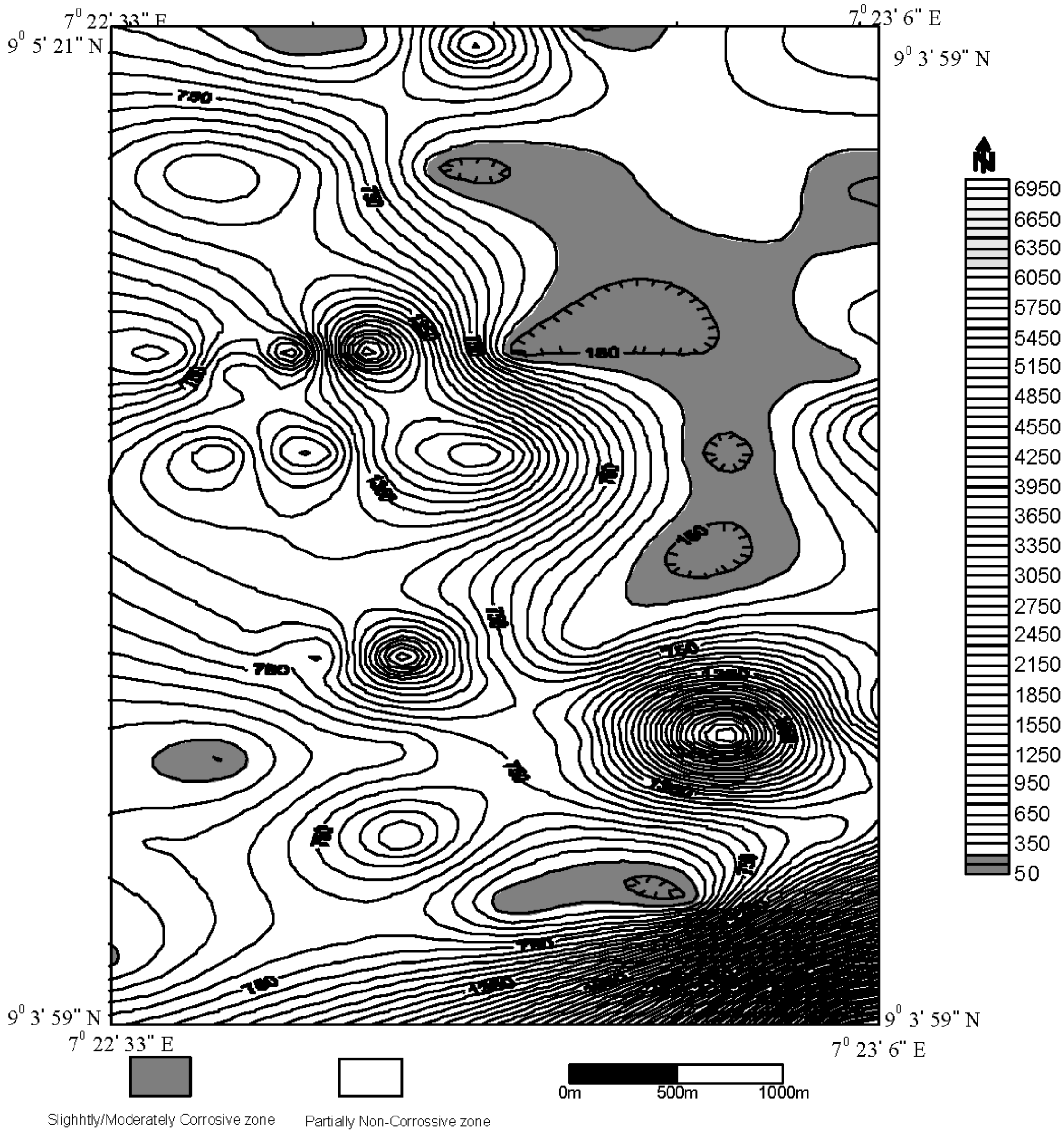


Fig. 5: Corrosivity map of study area

Table 2: Modified longitudinal conductance/ protective capacity rating

Total longitudinal Unit Conductance (mhos)	Soil protective capacity classification
<0.1	Poor
0.1-0.19	Weak
0.1-0.2	Weak
0.2-0.69	Moderate
0.7-4.9	Good
5-10	Very good
> 10	Excellent

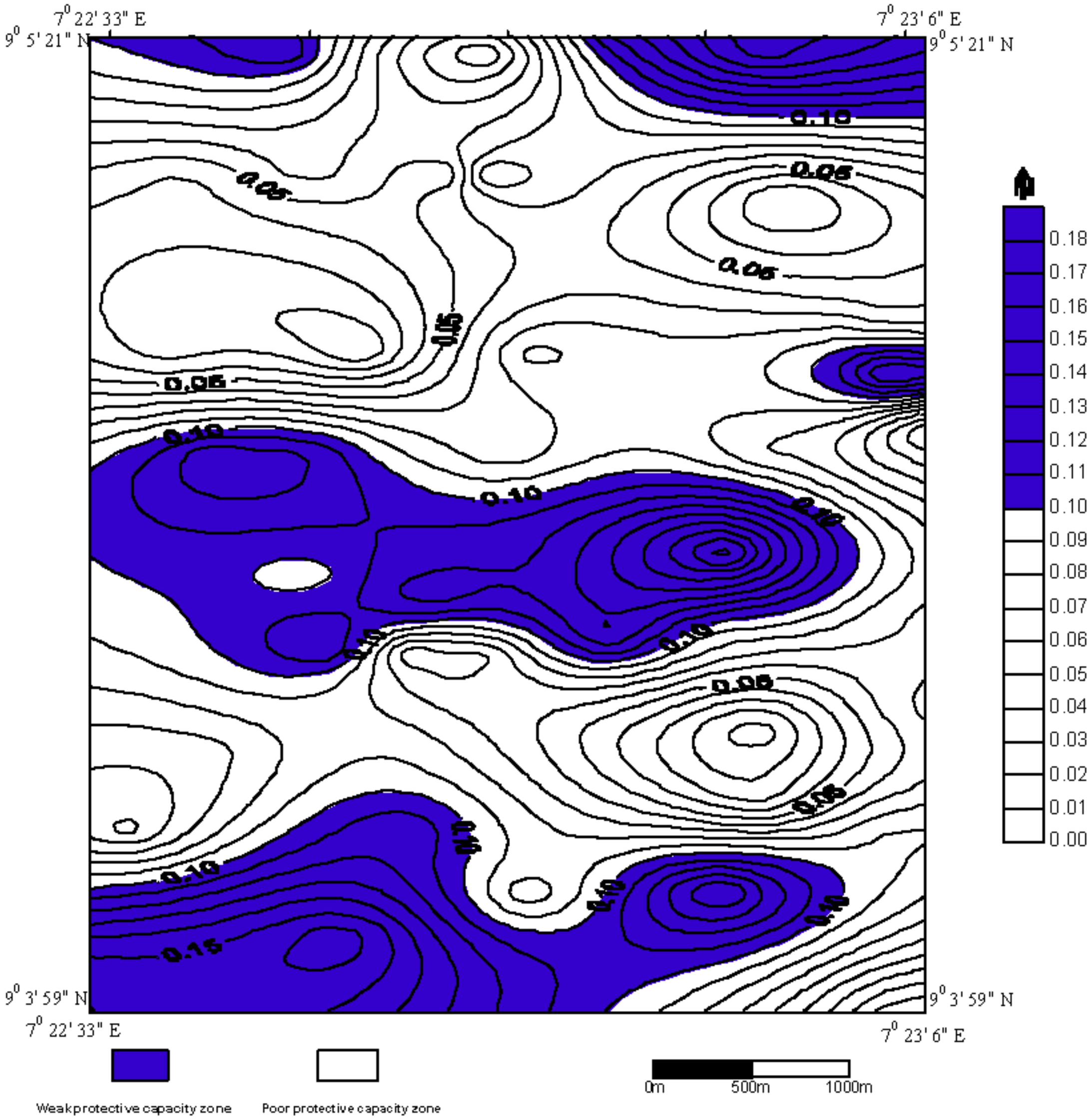


Fig. 6: Aquifer protective capacity map of study area

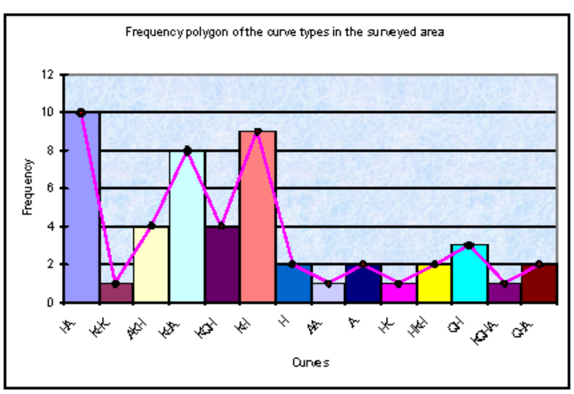


Fig. 7: Chart showing frequency of the curve types in the study area

capacity) that should not be ignored at planning stages of residential and industrial estate by estate managers.

AKNOWLEDGEMENT

The authors gratefully acknowledge the contributions and suggestions of the anonymous reviewers. We have drawn from their wealth of knowledge and experience while making the needed corrections.

REFERENCES

Henriet, J.P., 1976. Direct application of the Dar Zarrouk parameters in groundwater Surveys. Geophys. Prospect., Vol. 24.

Maillet, R., 1974. The fundamental equations of electrical prospecting. Geophysics, 12: 529-556.

Oladapo, M.I. and B.A. Adetola, 2004. Geoelectrical investigation of the Ondo-state housing corporation estate, Ijapo, Akure. Southwestern Nigeria. J. Min. Geol., 40: 41-48.

Olayinka, A.I. and M.O. Olorunfemi, 1992. Determination of geoelectric characteristics of Okene area and implication for a borehole sitting. J. Min. Geol., pp: 403-414.

Olorunfemi, M.O., J.S. Ojo and M.I. Oladapo, 1998. Geological, hydrogeological and geophysical investigations of exposed 20. Escravos Lagos Pipeline Technical Report.

Vander Velpen, B.P.A., 1988. Resist Version 1.0 M. Science Research project, ITC, Netherlands.

Zohdy, A.A.R., G.P. Eaton and D.R., Mabey, 1974. Application of surface geophysics to groundwater investigations: Techniques of water resource investigation of the united geological survey book. United States Government Printing Office, Washington D1, pp: 42-55.