The International Journal of Engineering and Science (IJES)
|| Volume || 12 || Issue || 1 || January || Pages || PP 01-11 || 2023 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

Evaluation of Aquifer Vulnerability to Contaminants in Ado Ekiti Municipality, Southwestern Nigeria.

[1]Agbemuko, Ojo S, [2]Amakiri Somiebi, T. [3]Inichinbia, Sonny, [4]Amakiri, A.R.C.
[1]AO-Geomograph Ltd, Port Harcourt, Rivers State Nigeria. [2]School of Foundation Studies Rivers State college of Health Science and Management technology Port Harcourt. Nigeria [3] Department of Physics, University of Port Harcourt. [4]Department of Physics, Rivers state University, Port Harcourt, Nigeria
Corresponding author: agbemukos@yahoo.com

ABSTRACT
Ground water contamination depends on porosity, permeability and overburden thickness of the geological formations. The ability of the subsurface rock to filter impurity before percolating into aquifer as a measure of overburden materials have been examined in this study. Vertical electrical sounding method using schlumberger array was employed in this study the result was used in calculating the longitudinal conductance and consequently the protective capacity. The study discovered six geo-electric layers of Top soil, Clayed soil, Lateritic soil, weathered layer, Fractured Basement and Fresh Basement in the study area. The top soil is low resistivity between 0.8 Ωm to 33.2 Ωm and thickness of 0.2 m to 2.4 m. Clayed soil underlay Top soil; the resistivity is between 2.6 Ωm to 81.8 Ωm with 1.4 m to 43.9 m thickness. Lateritic soil: a product of weathering occupy the third layer in lithological sequence in some places its resistivity is between 77.2 Ωm and 422.2 Ωm and thickness between 0.8 m and 26.3 m. Weathered layer resistivity is between 6.4 Ωm to 740.6 Ωm and thickness of 3.0 m to 97 m. Fractured basement and fresh basement is the last observable layer in the area. Fracture zone resistivity ranges between 9.5 Ωm to1902.6 Ωm. The result revealed that 34% of the study area has poor overburden bearing capacity, 16% is weak while 38% and 12% area have moderate and good overburden thickness respectively and hence 50% of the study area have adequate protection from underground water contamination, their geological formation comprises of migmatite-Gneis, Older Granite and partly Charnokite Bachite, these geological features offer high protective material such as clay which is believed to have been formed from weathering of feldspar mineral present in Charnockitic rocks.

KEYWORDS;- *Contaminants, Aquifer, Underground water, Overburden, Longitudinal Conductance*

Date of Submission: 20-12-2022 Date of Acceptance: 02-01-2023

I. INTRODUCTION

Aquifer is water bearing body of a geological formation; it is the source of underground water. Aquifer hold substantial volume of water depending on it porosity permeability and transmissivity, water stored in aquifer is known as groundwater it is stored in saturated zone in sediments and weathered or fractured in Basement terrain. It is recharged through rainfall, rivers, lakes and ocean. Surface water evaporate into atmosphere as vapour, the vapour precipitated back in form of rain, snow, dew, slack or frost, this process continues in cycle forever. The rainfall that percolates through the ground surface gets into water table through the joints, faults and voids of the rocks and holds in aquifer. The voids allow the movement of the ground water while some might not permit the movement of water hence the ground water occurrence depends upon the type of aquifer and the geology of the area.

Ground water occurrence in the study area is mainly from fissure, joints, weathered and fractured zone of crystalline rocks of older granite, charnokites or metamorphic origin of Precambrian age. The void and joints are interconnected permitting the movement of the ground water and consequently allowing passage of contaminants. Generally the movement of ground water is influence by topographical elevation and pressure. Contaminants from the surface through run off can easily leak into aquifer depending on the bearing capacity of the soil. Weathered loose materials over lay aquifer expose ground water to contamination while aquifers overlain and underlain by confining layers are less vulnerable to contamination. Aquifer is generally overlain by different soil material of variable thickness, the soil material include lateritic soil, clay, sandy and silt –sized particles deposited by run off and surface water [1]. These aquifers are localized and of low porosity and permeability, the occurrence also depends on secondary porosity.

Ground water contamination indeed depends on porosity, permeability and overburden thickness of the overlain geological formations. Leakages of underground pipes tanks such as petroleum tanks in unconsolidated formation could constitute environmental hazards and endanger human life. The characteristic of potable ground water aquifer geology can be determined through geophysical survey methods this is even more important in basement complex where aquifer nature is discontinuous and highly localized. In investigating aquifer vulnerability to contaminant, hydro geological implication of the study area is most important. The use of vertical electrical sounding (VES) method also known as resistivity method is very popular, this method was employed in this research work.

Resistivity method measures the subsurface electrical resistivity; ability of the subsurface to impede the flow of electric current this helps to differentiate between formation of sediment, weathered and fractured zone or formation filled with salty water (contaminant) and those filled with hydrocarbons, hard rock (granite charnokites) of poor conductors. The method is useful in investigating water quality in shallow aquifers and ground water pollution in oil field brine pollution, salt water intrusion and iron invaded zone of aquifer formations. It is also useful in investigating dump site location

The characteristic of potable ground water aquifer geology has been investigated of a recent through geophysical survey methods, [2] used the method in the same study area in 2009, in 51 VES stations their investigation revealed a generally good over burden protective capacity around the study area having rating 60% of the area to good / moderate protective capacity. The population of Ado-Ekiti has increased progressively as a result of the status of the city being the capital of Ekiti state Nigeria created in 1996. All the arable land regarded as cocoa farms around the old city are now residential quarters. The city center is congested. [3] studied the aquifer protective capacity of formations at Kafin Hausa metropolis Jigawa State, Nigeria their report indicated the longitudinal unit conductance of the study area ranges between $0.02\Omega m^{-1}$ to $11.87\ \Omega m^{-1}$. That 63% of the study area is poorly and weakly protected hence vulnerable to contamination. [4] combined 2D geo electrical method with vertical electrical sounding to determine the effect of dumpsite leachates on aquifer at Port Harcourt metropolis, a sedimentary environment, their result indicated that the dumpsites investigated has poor protecting capacity and that underground water at these sites vicinity are polluted through the leachate movement and percolation this was confirmed by the physiochemical analysis of bore hole carried out within the vicinity of the dump sites. To map leachate movement on groundwater area at Ikot Ekpene dump site in Akwa Ibom State, Nigeria, [5] combined vertical electrical sounding with hydro chemical analysis of sample of water from bore hole in the study area, the finding indicated high conductivity in the subsurface layers close to the dumpsite and that the effect of leachate is more dominant in the ground water path way near the dump site.

These observations show the underline uniqueness of VES in mapping contaminants and its favorable integrated approach with other electrical method. Hazardous chemicals, such as pesticides, herbicides and solvents are used ubiquitously in everyday life [5], this scenario prevail in the study area, pesticides and herbicides are used in the nearby farm settlements and in living quarters to weed the surroundings, the rugged topography of the study area gives room to overflow of rivers and streams beyond their bank, impurity carry along during run off spread over and percolate into underground water. Hand dug well drilled into shallow aquifer becomes contaminated.

This study investigated the aquifer protective capacity of Ado-Ekiti municipality using vertical electrical sounding (VES) method. The aim of the study is to evaluate aquifer vulnerability to contaminant in the metropolis. The objective is to determine the overburden capacity of the underline geological formation of the survey area with a view of accessing the portability of underground water.

II. THE STUDY AREA AND HYDRO GEOLOGICAL FORMATION.

Ado-Ekiti is located within the North East of old western region of Nigeria. The grid coordinates is within world geodetic system (WGS 84) coordinates of 734000 mE to 761000 mE and 835100 mN to 851600 mN [7] Figure 1. The study area is located on tropical rain forest of western Nigeria underlain with hard rock terrain of Precambrian crystalline rocks of the western Nigeria basement complex a rugged terrain with rocks of older granite Charnokites Bauchite, Migmatite-Gneiss forming slope and undulating topography. The surface elevation ranges from 300 m to 510 m. The hydrogeological setting of the study area depends on rain water, surface water and ground water for its water supply which follow the process of hydrologic circle. Weathering and fracture created secondary porosity, the unconsolidated materials from weathering constitute reliable aquifer unit while faults and joints constitute water filled fracture.

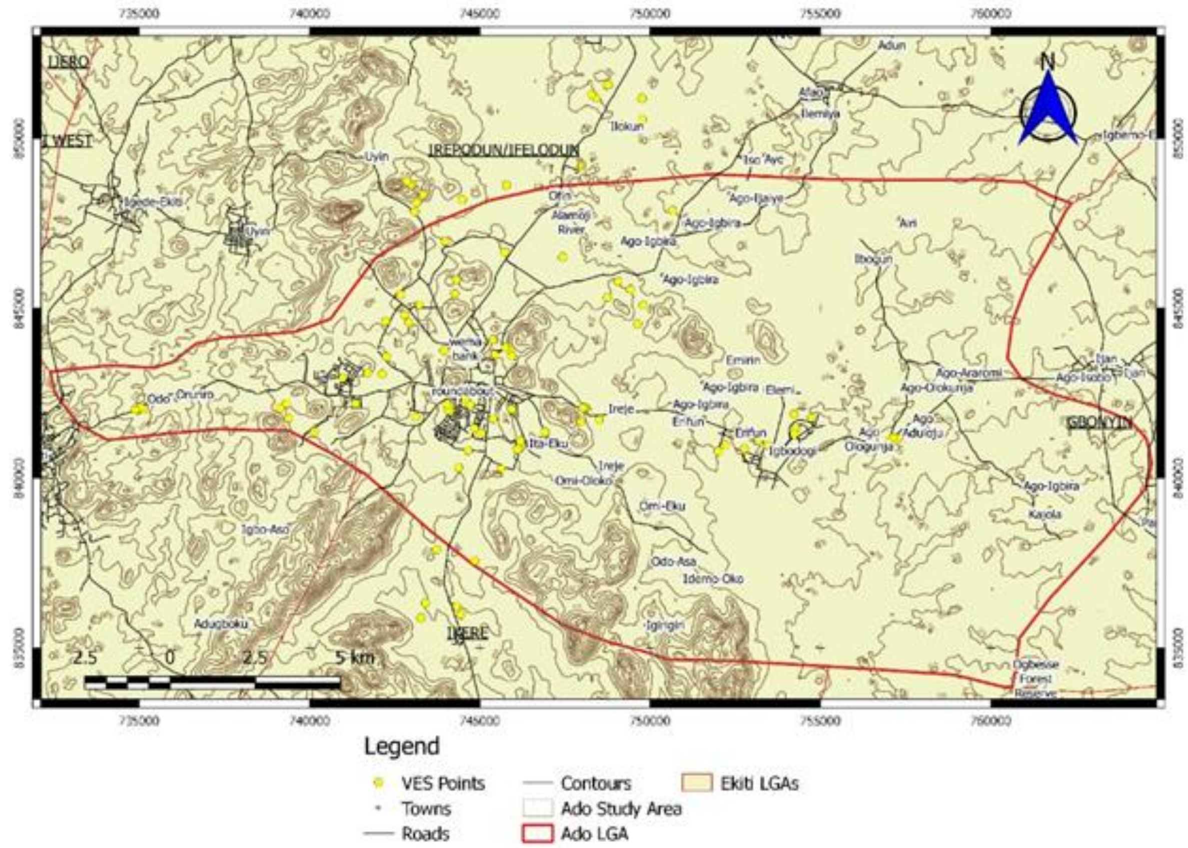

Figure 1. Map of the study area (Agbemuko et al., 2021)

III. MATERIALS AND METHOD

Basic equipment were used in gathering data on the field, the equipment include Ohmega campus Terrameter, cable on 4 wheels, metal electrodes, linear Tape, Hammers, Hand held GPS (Garmin12). Schlumberger electrode configuration method was adopted. VES stations were selected randomly based on the geological and geographical spread of Ado- Ekiti metropolis, the handheld Garmin 12 (GPS) was used to obtain spatial reference coordinates of all the points this is often necessary not only in locating VES positions but also in mapping the overburden thickness. Sounding points were covered with half electrode separation of AB/2 maximum of 150 m (Figure 2).Current introduced into the current electrode through a 12 volts motor battery plugged into the Ohmega campus tetrameter, the potential different developed is measured and the resultant resistance (R) displayed and recorded on the terrameter, the two potential electrodes MN kept constant for some spread of current electrode reading thereafter the potential electrode distance increased and kept constant for another three to four sets of current electrode separation. The electrode movement was designed in such a way that the potential electrode space 'MN' is never larger than 0.4AB/2. The measured resistance was converted to apparent resistivity (ρ_a) using the equation given below.

$$\rho_a = \frac{\mathbf{\Delta V}}{\mathrm{I}}\pi\left[\frac{[\frac{AB}{2}]^2-[\frac{MN}{2}]^2}{MN}\right] \quad (1)$$

Or $\rho_a = RK$ (2)

Where $R = \frac{\mathbf{\Delta V}}{\mathrm{I}}$

Where 'K' is the geometrical factor for Electrode field arrangement

The result from the field data were process into subsurface layers resistivity and thickness of the sounding points using WIN RESIST Geophysical computation software. From the ratio of resistivity to the thickness the total longitudinal conductance of each VES station were computed using the follow equation.

$$S_L = \sum \frac{hi}{\rho i} \quad \text{i.e.} \quad S_L = \frac{h1}{\rho 1} + \frac{h2}{\rho 2} + \frac{h3}{\rho 3} \ldots\ldots\ldots\ldots \frac{hn}{\rho n} \quad (3)$$

Where 'S_L' is the total longitudinal conductance, 'h_i' is thickness of first layer and 'ρ_i' is the resistivity of first where 'h_n' and 'ρ_n' are thickness and resistivity of the last layer above aquifer respectively. The longitudinal conductance is a measure of the protective capacity of aquifer. The thickness and degree of permeability determine the vulnerability of the aquifer to surface pollution and therefore it potability. The results were analysed using protective capacity rating of Table 1 of [8] as modify by [9].

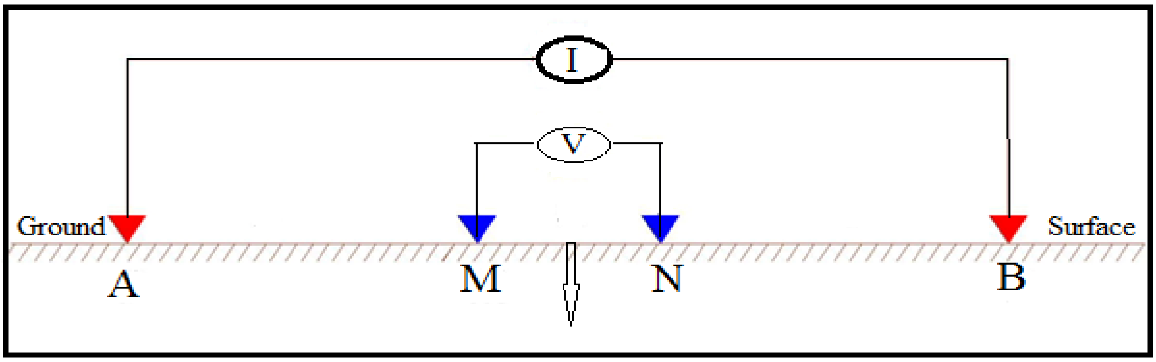

Figure 2. Sketch diagram of field configuration of Electrodes

Table 1. Modified Protective Capacity Rating (Oladapo and Akintorinwa, 2007)

SUM OF LONGITUDINAL CONDUCTANCE (mhs)	OVERBURDEN PROTECTIVE CAPACITY CLASSIFICATION
<0.1	POOR
0.1-0.19	WEAK
0.2-0.79	MODERATE
0.8-4.9	GOOD
5.0-10	VERY GOOD
>10	EXCELLENT

III. RESULTS AND DISCUSSIONS

The study was based on sounding data from vertical electrical sounding observation and physical observation of hand dug borehole lithology. The interpretation discovered different type of Geo electric curves. The most predominant is KH- type, KH- type is said to be common in tropics [10]**.** Six geo electric layers of Top soil, Clayed soil, Lateritic soil, weathered layer, Fractured Basement and Fresh Basement were also discovered. The top soil usually of low resistivity consists of humor soil, sandy wet clay and lateritic clay the resistivity is between 0.8 Ωm to 33.2 Ωm and thickness of 0.2 m to 2.4 m in this study. Clayed soil in some area underlay Top soil while in others it is sandwich between lateritic and weathered layer, the resistivity is generally low it is between 2.6 Ωm to 81.8 Ωm with 1.4 m to 43.9 m thickness. Lateritic soil: a product of weathering occupies the third layer in lithological sequence in some places its resistivity is between 77.2 Ωm and 422.2 Ωm and thickness between 0.8 m and 26.3 m. Weathered layer occupy third or fourth lithological layer in this study, overlay laterite or clay in some stations sometimes it forms the last layers in the absence of fresh basement, it resistivity is between 6.4 Ωm to 740.6 Ωm and thickness of 3.0 m to 97 m the low resistivity is due to the present of substantial volume of clay content this composition will be added advantage to the overburden capacity of the layer.

Weathered layer consist of clayed sandy, sand clay as a result of weathering of the underling rocks caused during tectonic movement and hydro thermal process. Fractured basement and fresh basement is the last observable layer in the area exception is in some stations as reported in [7] that have no record of fresh basement layer. Fracture zone resistivity ranges between 9.5 Ωm to1902.6 Ωm. Weathered and fracture zone have been considered as water bearing feature in basement topology [11]**, [**[12]. Figure 3 shows samples of 1-D model curve obtained from WIN-RESIST iteration.

Table 2. Protective Capacity Rating in the Study Area- VES 1-33

VES	Resistivity layers ohms-m					Thickness (m)					Longitudinal Conductance	Protective capacity rating
	1	2	3	4	5	1	2	3	4	5		
1	112.9	47.4	48.2	12.4	955.6	0.6	3.9	6.3	17.3	_	0.218298313	Moderate
2	92.7	21.3	148.8	237.9	2590	1.2	4.8	4.7	6.1	_	0.269883118	Moderate
3	310.7	56.5	83.6	844.2	_	0.8	4.3	13.8	_	_	0.08132893	Poor
4	173.4	102.2	1554.2	640.5	_	1	3.6	34.4	_	_	0.063125635	Poor
5	227.7	286.5	191.7	352.5	946.5	0.9	4	7.5	8.7	_	0.057037805	Poor
6	155.3	143.1	128.3	1729.9	_	1	4.9	6	_	_	0.040680939	Poor
7	191.6	149.1	222.4	336.8	3494	1	3.1	9.3	33.1	_	0.067827169	Poor
8	80.9	154.8	73.2	422.8	63	1.4	9.2	12.4	32.6	_	0.323240761	Moderate
9	318.9	119.8	155.6	119.6	142.6	0.7	10.3	19.8	33.3	_	0.21542103	Moderate
10	293.2	84.6	657.8	1101.5	74.5	0.6	2.3	4.3	7.1	_	0.04221584	Poor
11	11.5	14	330.6	1285.9	_	0.8	2.2	11.5	_	_	0.22670807	Moderate
12	33.2	232.1	115.5	208	869.1	2.4	18.2	13.6	36.9	_	0.27267673	Moderate
13	491.8	120.3	545.6	2554.1	_	0.6	6.8	18.4	_	_	0.05774536	Poor
14	93	82.2	279.6	1227.2	13.6	0.9	2.8	3.4	16.2	_	0.06910169	Poor
15	116.2	104.5	19.2	369.6	1339	0.9	3	8.4	20.9	_	0.47439534	Moderate
16	37.5	52.5	291.6	200.4	41.2	0.9	1.4	22.5	32.5	_	0.29000281	Moderate
17	52.3	26.5	45.4	648.8	2115	0.8	1.7	2.2	16.3	_	0.12790546	Weak
18	22.6	2.6	139.9	1201.9	812.9	0.6	1.8	4.6	57.4	_	0.79949471	Good
19	0.8	47	27008	681.4	_	0.2	0.4	117.2	_	_	0.26285013	Moderate
20	47.3	23.5	167.3	864.4	_	2.7	6.7	8.9	_	_	0.34218884	Moderate
21	675.2	269.4	141.6	344.1	_	0.6	7.8	12.2	_	_	0.02984185	Poor
22	63.8	55.6	163.3	226.2	103.7	1	2.6	7.6	10.9	_	0.15716413	Weak
23	17.7	123.7	64.7	10395	_	0.7	2.8	6.2	_	_	0.06218343	Poor
24	72.6	15.7	254	6182.9	_	2.5	6.9	11.6	_	_	0.47392571	Moderate
25	169	24.3	5496.1	1902.6	_	1	3.7	102.4	_		0.17681193	Weak
26	291.9	93.2	255.9	599.6	-	2	4.6	8.1	-		0.05844837	Poor
27	263.8	12.1	156.2	25.7	660.2	1	2.2	7.9	26.8		0.23618512	Moderate
28	225.8	75.1	22.3	523.9	_	0.9	2.3	5.5	_		0.27570372	Moderate
29	59	19.6	186.5	431.2	_	0.8	4.2	24.5	_		0.22784504	Moderate
30	9.1	20.8	88.5	287.2	_	1.2	3.1	21.1	_		0.51932467	Moderate
31	27.7	21.2	17.7	423.5	404.1	1	1.8	4.3	75.7	_	0.54269312	Moderate
32	124.4	108.7	42.3	215.7	471.8	0.9	1.4	4.4	19.3	_	0.12413312	Weak
33	83	16.5	66.2	70.7	334.7	1.2	4.4	8.9	11.8	_	0.41556559	Moderate

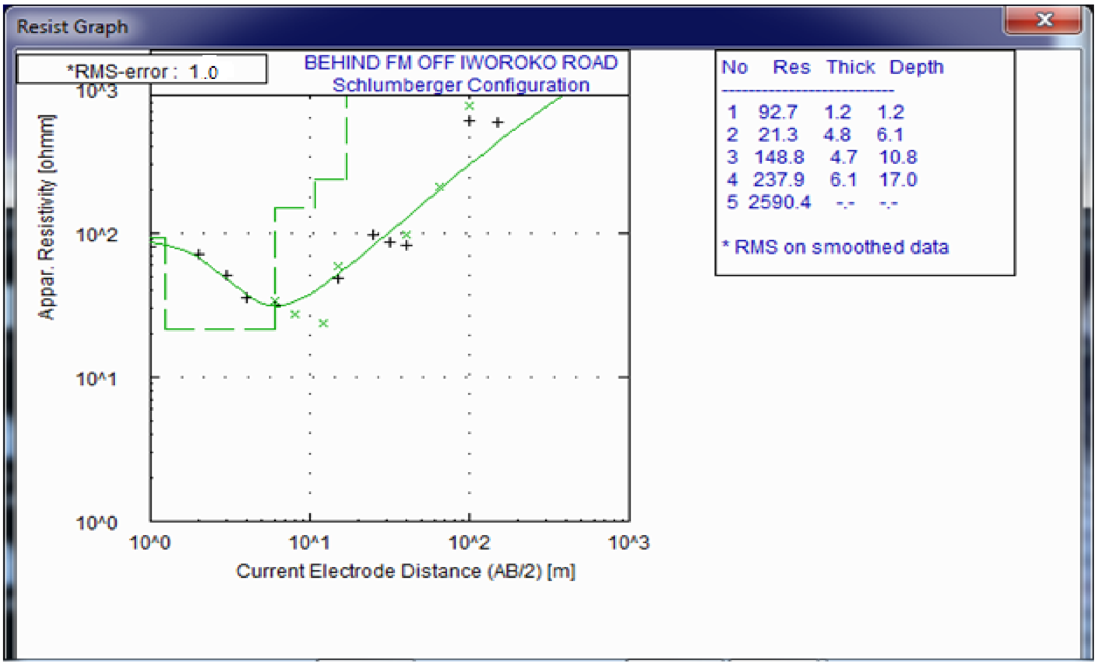

Figure 3a. Vertical electric sounding curve and layers (VES 2 Curve and Layers)

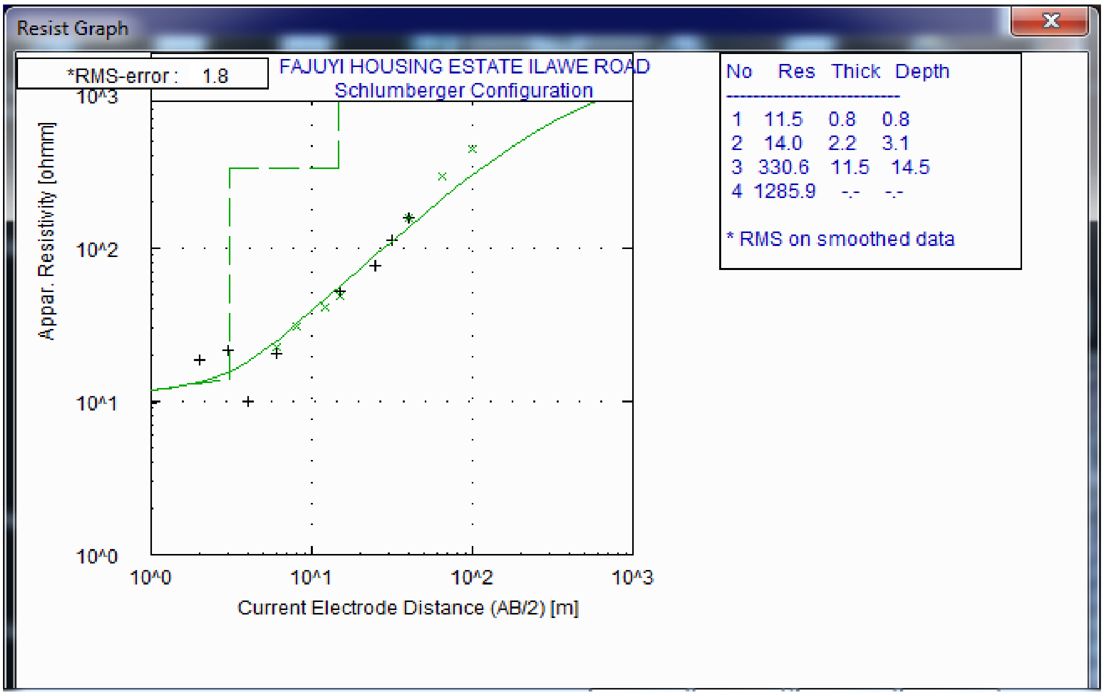

Figure 3b. Vertical electric sounding curve and layers (VES 11 Curve and Layers)

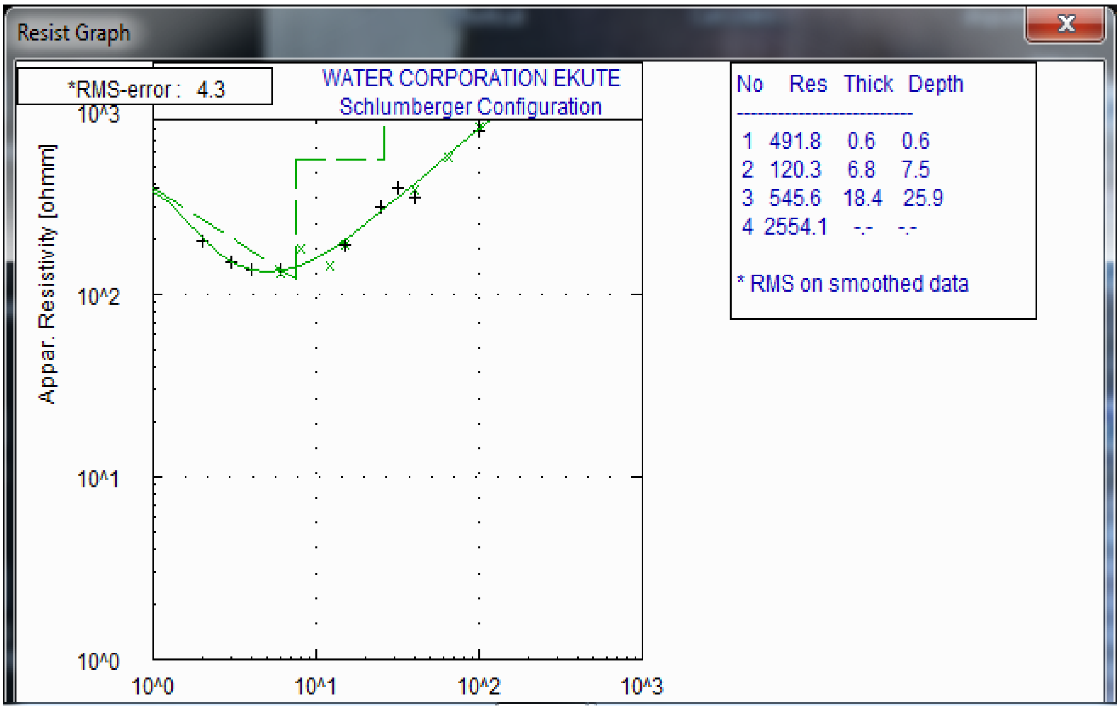

Figure 3c. Vertical electric sounding curve and layers (VES 13 Curve and Layers)

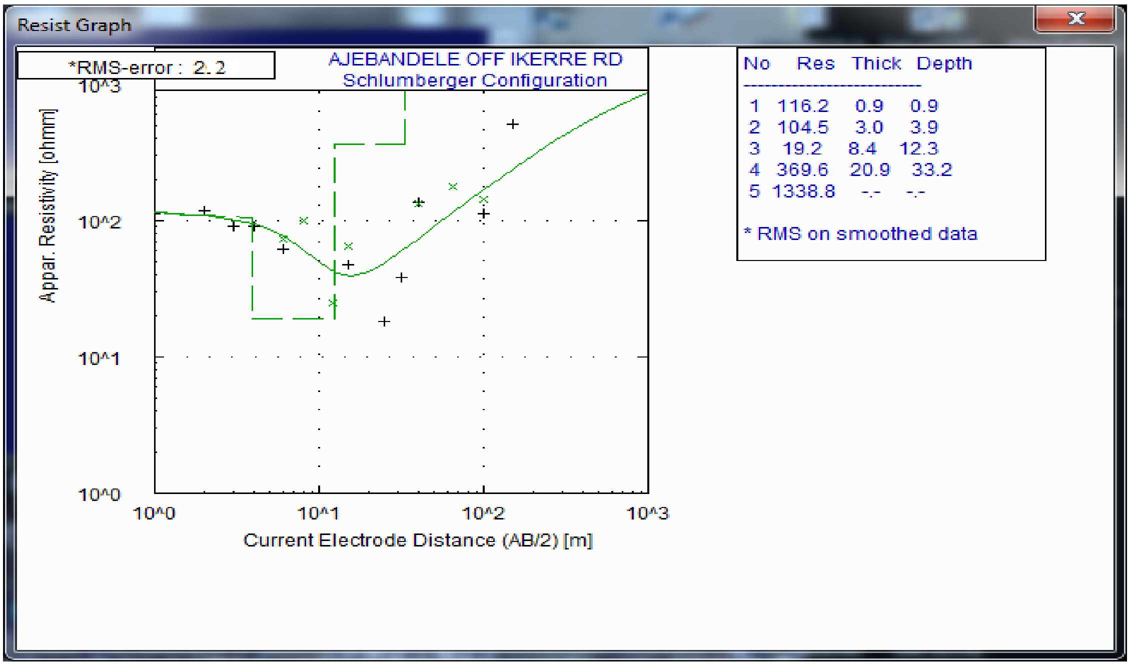

Figure 3d. Vertical electric sounding curve and layers (VES 15 Curve and Layers)

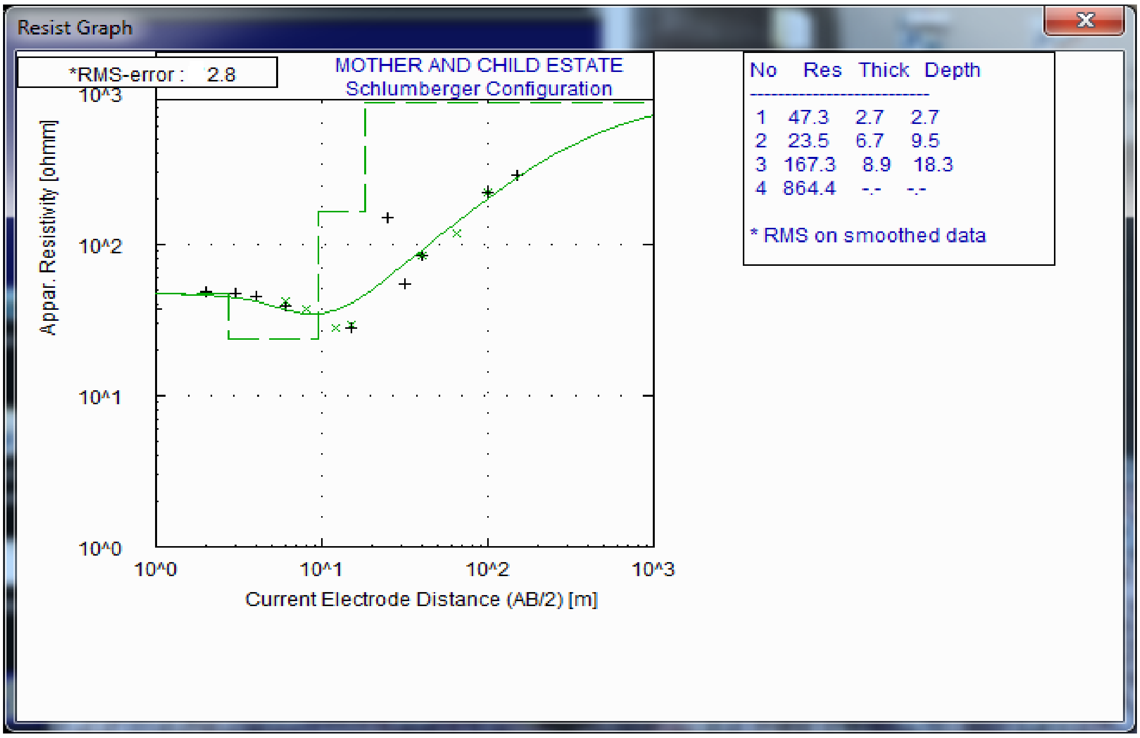

Figure 3e. Vertical electric sounding curve and layers (VES 20 Curve and Layers)

V. OVERBURDEN

The aquifer overburden capacity was determined using longitudinal conductance (s) as presented in Table 2 and the protective rating in Table 1. The ability of the earth formation to retard and filter percolating ground surface fluids is a measure of its protective capacity [13],[14] this is determined through it longitudinal unit conductance.

All layers above the aquifer are assumed to be the overburden. The thickness and type of rock is important to the quality of water in the aquiferous zone. Thick overburden with impermeable overlay will retard or slow than percolation and hence impurity must have been filtered naturally before getting to the underling layer. High longitudinal conductance offers protective cover on aquifer. The rating was tabulated in Table 2 under good (12), moderate (40), weak (17) and poor (35) respectively. Figure 4 shows the overburden spatial mapping of the study area while profile AB is horizontal profile on line W-E of the study area. The ash colour indicates area with poor and weak protective capacity this area tends toward the North and North East of the study area, Olorunda toward Elemi housing Estate, Afao road, Afe Babalola University and part of Kajola community, this zone occupy 34% and 16% of the study area respectively. The lithological data shows that the underling materials are weathered in situ materials without clay or shale content.

Moderate zone lies south and North West of Ado Ekiti Township, this area includes Ikere road, Fagbohun area, Fajuyi housing Estate, Odo community and Owode area, about 38 % of the study area. 12 % of the study area is within good overburden, this zone is observed within Ado West, Olaoluwa /Ile Abiye area, Igirigiri/Ita Eku area and llawe road. This area has good material abutting the aquifer layer. Ilawe road (VES 58) has 43.9 m thickness of clayed soil and so Ola Oluwa area average of 25.7 m thickness.

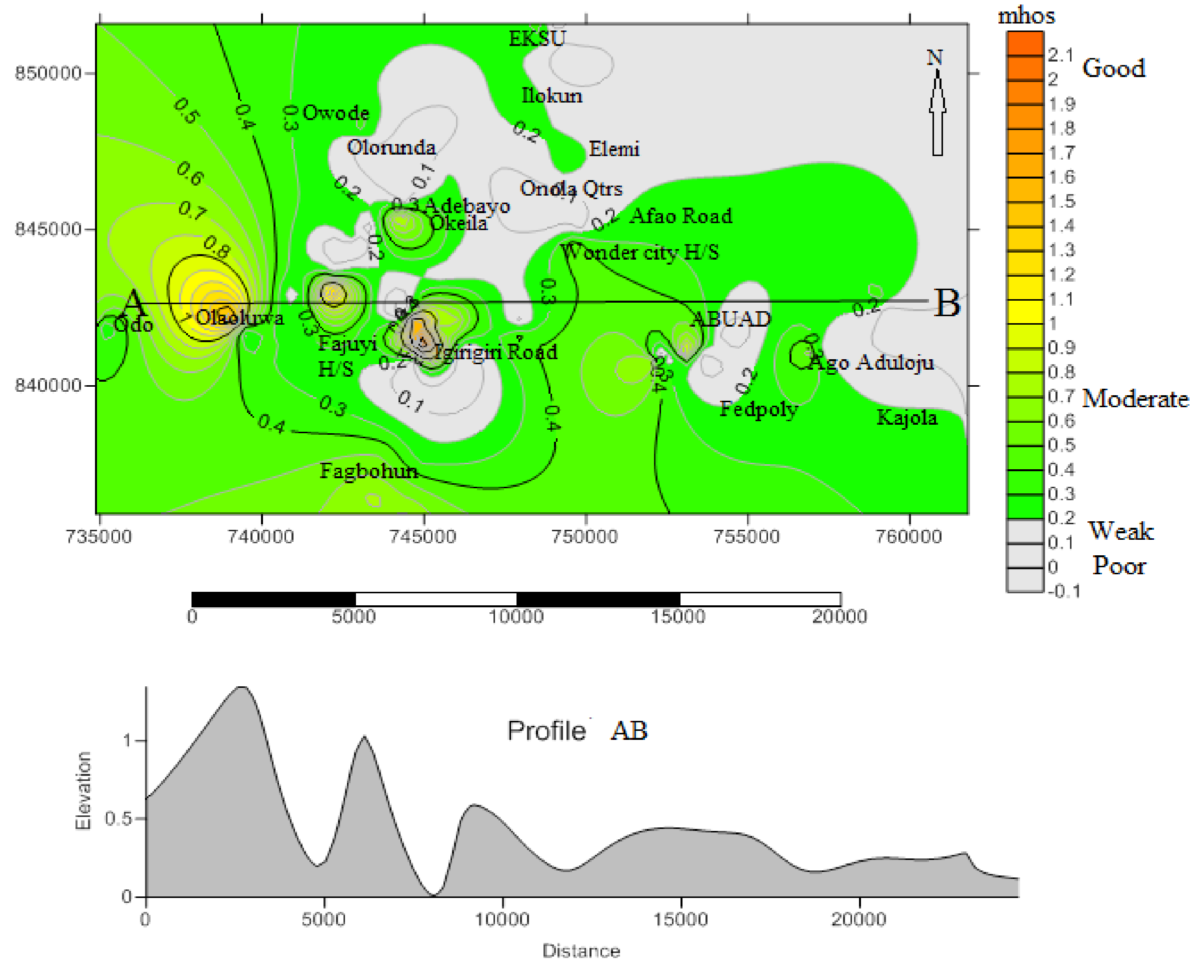

Figure 4. The overburden spatial mapping of the study area

Longitudinal conductance is a measure of impermeability of the rock, low total longitudinal conductance means low resistivity and a shallow basement. Figure 5 shows the 3D displacement of the spatial variability of overburden capacity.

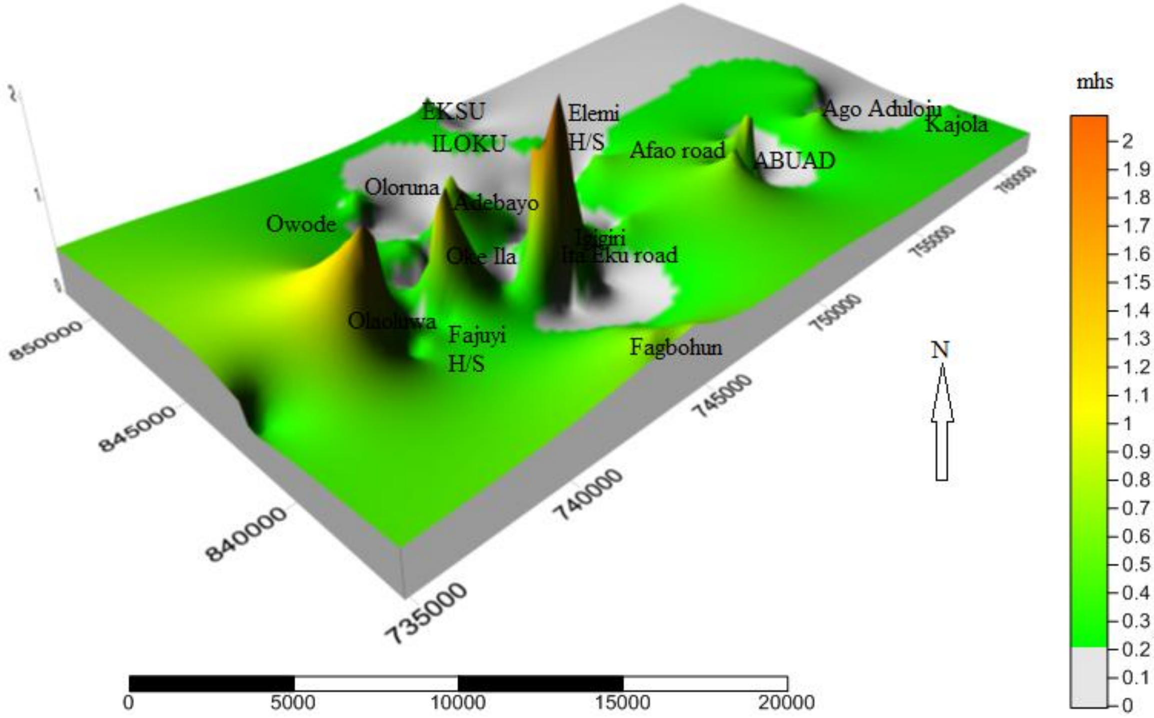

Figure 5. The 3D surface mapping of overburden capacity in the study area

VI. CONCLUSION

The result revealed that 34 % of the study area has poor overburden bearing capacity, 16 % is weak while 38 % and 12 % area have moderate and good overburden thickness respectively and hence 50 % of the study area have adequate protection from underground water contamination, These area are Owode, Olaoluwa Ile Abiye Ilawe Road, Fagbohun, Fajuyi housing Estate, Adebayo part of EKSU and ABUAD,Ago Aduloju and Igirigiri. Their geological formation comprises of migmatite-Gneis, Older Granite and partly Charnokite Bachite, these geological features offer high protective material such as clay which is believed to have been formed from weathering of feldspar mineral present in Charnockitic rocks [15] hence residents of these area are sure of potable underground water. Thus the study can serve as guide to sitting residential estates and choice of landed property for commercial development.

ACKNOWLEDGEMENTS

The authors are grateful to all those who contributed to the success of the research work, Dr. O. Talabi, Field assistants and Staff of AO-Geomograph Ltd.

REFERENCE

[1]. Raji, W. O., Abdulkadir, K, A, (2020). "Evaluation of groundwater potential of Bedrock aquifer in Geological sheet 223Ilorin, Nigeria, using Geo-Eletrical sounding". Journal of Applied water science (Springer) **10**(220). 1-12

[2]. Abiola O, Enikanselu P. A and Oladapo, M.I. (2009). 'Ground water potential and aquifer protective capacity of overburden units in Ado Ekiti, Southwestern Nigeria'. International Journal of Physical Sciences,**4**(3),120-132.

[3]. Shitu, I. G, Sulaimon B.A, Idris, M. C and Muhammad A (2018). 'Aquifer protective capacity evaluation using vertical Electrical Resistivity method at Kafin Hausa metropolis Jigawa State, Nigeria'' FUDMA Journal of Sciences (FJS) **2**(4). 67-79.

[4]. Agbemuko O.S, I. Tamunobereton-Ari, S.A. Ngah (2017). ' Determination of the effect Dump site on Aquifer at Port Harcourt metropolis, Rivers State'. IOSR Journal of Applied Physics, **9**(1) 41-54.

[5]. N. J. George, A. I. Ubom and J. I. Ibanga (2014). 'Integrated Approach to investigate the effect of leachate on groundwater around the Ikot Ekpene Dumpsite in Akwa Ibom State. Southeastern Nigeria'. International Journal of Geophysics1-12.

[6]. Daniel N. Obiora, Adeolu, E. Ajala and Johnson .C. Ibuot (2015).' Evaluation of aquifer protective capacity of Overburden unit and Soil corrosivity in markudi, Benue State, Nigeria Using Electrical Resistivity method." Journal of Earth System Science. **124**(1) 125-135.

[7]. Agbemuko Ojo S, Abam, T. K. S, I. Tamunobereton-Ari, Amakiri A. R. C. (2021). ''Hydrogeological and Geophysical Investigation of Ground Water Potentials in Basement Terrain of Ado Ekiti, Southwestern Nigeria''. IOSR Journal of Applied Geology and Geophysics, **9**(4) 11-25.

[8]. Henriet, J.P. (1976)." Direct application of Dar Zarrouk parameters in groundwater survey". Geophysics Prospect. **24,** 344–353. https://doi.org/10.1111/j.1365-2478.1976.tb00931.x.

[9]. Oladapo M.I, Akintorinwa O.J. (2007). "Hydrogeological Study of Ogbese Southwestern, Nigeria". Global J. Pure and Applied Science. **13**(1):55-61.

[10]. Olayinka, A. I, Olorunfemi M.O. (1992) ".Determination of geo electrical characteristic in Okene area and implication for boreholes setting". Journal of Mining and Geology, **28**(2) .403-412.
[11]. Tajudeen, O. Adeeko, Damilola O. Samson and Medina Umar. (2019)." Geophysical Survey of Basement Complex Terrain Using Electrical Resistivity method for ground water potential". World News of Natural Sciences(WNOFNS). **23**, 154-165.
[12]. Oni T. E, Omosuyi G.O, Akinlalu A.A, (2017) "Groundwater vulnerability assessment using hydrogeologic and geoelectric layer Susceptibility indexing at Igbara Oke, Southwestern Nigeria." NRIAG Journal of Astronomy and Geophysics **6**.452-458.
[13]. O. S. Ogunyemi, G. O.Badmus, O. G. Ayeni. O.Ologe (2013)."Geoelectric Investigation of Aquifer Vulnerability within Afe Babalola University of Ado Ekiti, South western Nigeria. Journal of Applied Geology and Geophysics" **1**(5). 28-34.
[14]. Olorunfemi, M.O., Ojo J.S and Akintunde,M. O. (1999). Hydrogeological evaluation of the groundwater potentials of the Akure metropolis southwestern Nigeria. Journal of Mining and Geology, **35**(2).201-228.
[15]. Okoli, F.U, Aigbedion, I. P, Marcellinus, L M, Oludiji, S. N, Idoko, I. A (2019) "Groundwater Potential mapping in Ado Ekiti, Nigeria using GIS and remote sensing Techniques"International Journal ofAdvanced research and Publications,**3**(3) 18-21.

Agbemuko, Ojo S, et. al. "Evaluation of Aquifer Vulnerability to Contaminants in Ado Ekiti Municipality, Southwestern Nigeria." *The International Journal of Engineering and Science (IJES)*, 12(1), (2023): pp. 01-11.