Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2017, 4(11):258-264**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Delineation of Groundwater Potentials and Overburden Layers using Vertical Electrical Sounding Techniques in Parts of Etche Lga, Rivers State, Nigeria

Amechi, Bright. U., AMONIEAH, Jiriwari, HORSFALL Opiriyabo. I.*

Department of Physics, Rivers State University, Port Harcourt, Nigeria

Abstract A geoelectrical survey was conducted in parts of Etche local Government Area of Rivers State, aimed at delineating the aquifer zones and overburden layers in the study area and consequently identifying the most economically viable potential portable groundwater areas. Vertical Electrical sounding (VES) technique using the Schlumberger configuration with a maximum current electrode spreads of 600m was used for fifteen locations. The field data were obtained by the use of R-Plus resistivity meter and analyzed using the IPI2Win 1D resistivity inversion program. Four soundings were made at existing boreholes in the area for comparative purposes. Distinct geoelectrical layers overlying a conductive geoelectric basement were identified. Based on the model parameters obtained, zones of groundwater potentials were delineated which were found to consist of fine grained-medium to coarse sands. Variation in the thickness and resistivities of the layers as well as broad water-bearing zones were indicated. The results also revealed that the depth to aquifer level were less than and in some cases equal to 18m in the study area. The water table lies between (8 – 26) m moving towards the hinterland. All these are in close agreement with the existing borehole information of the area. The VES depth explored indicates high prolific aquiferous zones of the area considering the overburden sands delineated.

Keywords Geoelectric, Groundwater, Aquifers, Aquiclide, Schlumberger

Introduction

Groundwater is that water that lies in the saturated (phreatic) zone, below the water table which can be collected with wells, tunnels or drainage galleries. Water as a source of income as well as source of life and the increasing demand of water for multipurpose needs has shifted attention from ordinary search for surface water to prospecting for steady and reliable subsurface or groundwater from boreholes. Groundwater is stored in an underground reservoirs known as aquifer. Aquifers are rocks (which typically consists of gravels, sands, sandstones or fractured rocks etc.) that hold and transmits enough water to be used as a source of water. Many of the best aquifers are sandstones, but any other type of rock may serve as aquifer if it is sufficiently porous and permeable. Aquifer is basically of two types viz: confined and unconfined.

Confined aquifer is one that is overlain by an aquitard (a rock with low permeability and the flow of water is very slow, so it is not useful as a water source) or aquiclide (a rock that is effectively impermeable on a human timescale and thus acts as a barrier to water flow. Unconfined aquifers are overlain by permeable rocks and soils. Most of the accessible groundwater comes from unconsolidated aquifers which are largely made up of loose sands and gravels etc. Groundwater is characterized by certain parameters which are determined by geophysical studies. These studies have confirmed that the water on the surface and groundwater play vital roles in the society, it has domestic, agricultural and industrial uses.

Electrical resistivity method in geophysics has proven reliable for the exploration of groundwater in a sedimentary environment because the resistivity of rock is sensitive to its water contents. The electrical resistivity method depends on variation of the resistances in subsurface materials to the conductance of electric current. The study area is in Etche Local government Area (LGA) of Rivers State, Nigeria, situated in the hinterland of the adjoining coastal plain of Niger Delta Complex. This area is basically underlain by the Benin formation with its characteristics unconsolidated sand and interfingering clays underlying the area [1,13]. The area lies within the coastal plain sands of the Niger Delta region of Nigeria.

This survey is very important following the expanding industrial and commercial activities in and around the area. The inadequate portable water supply for the increasing population, both for domestic, industrial and agricultural use has informed the need to search for alternative sources of water supply. The inhabitant depends on few hand dug wells, hand operated pumps and surface water as a source of water supply, hence the need for a meaningful geophysical/geological investigation for good water resources management. The study will also serve as a source for basic geophysical/geologic information of the area for proper water planning, development and management [2].

Records also show that the resistivity method has been used with appreciable success in investigating groundwater resources and aquifer characterizationin Utagba-Ogbe Kingdom Ndokwa Delta State [8]. [4,6] showed that the depths of aquifers differ from place to place because of variational geothermal and geo-structural occurrence. A preliminary finding of the groundwater resource potentials from a regional geolelectric survey of the Obudu basement area of Nigeria [6]. [9] carried out a geolelectric investigation of ground water resources at Onibode area near Abeokuta South –West of Nigeria

Study Area

The study area is in Etche Local Government Council covering an area of 803km^3 and enclosed by Lat. 4^0 50' N and 5^0 15' N and Lon. 6^0 55' and 7^0 20' E. The area has network of access roads, foot paths which made access to most area surveyed possible. Etche LGA lies within the Niger Delta Complex with the area predominantly located in the Benin formation and low land zones of South Eastern Nigeria. Three fresh water rivers (Otamiri, Ogochie and Imo) spanning across, the area and fan into the sea. Runoff is negligible because of the thick vegetation and the groundwater obtains its recharge from the rivers and the heavy annual rainfall estimated at an average of 2400mm [5].

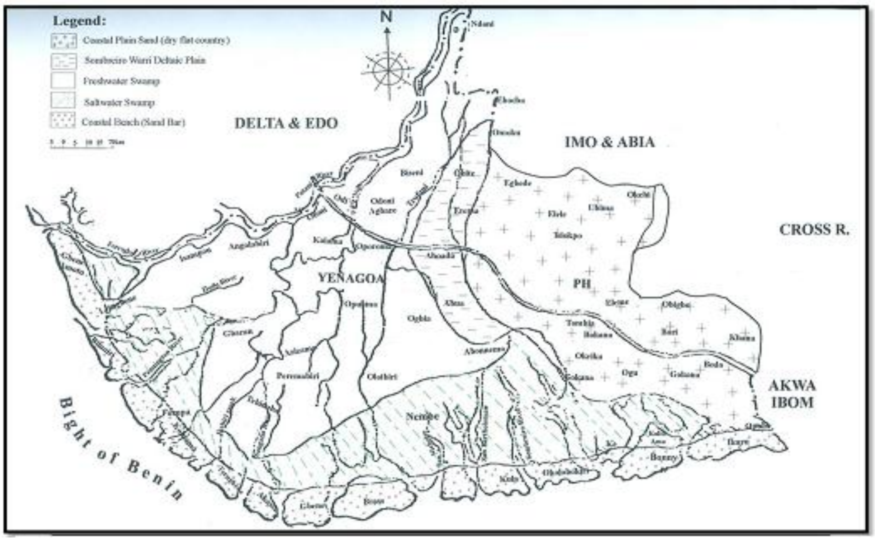

Figure 1: Geomorphologic zones of the Niger Delta Region

The area consists of medium to coarse unconsolidated sands with groundwater level at the water table with pressure equal to the atmospheric pressure. The top sediments are aerated, unconsolidated and of variable thickness throughout the area. [7]. The subsurface geology of the Niger Delta consists of three lithostratigraphic units (Benin, Agbada and Akata Formations) which are in turn overlain by quaternary sediments. The Benin formation is about 2100 m thick and is made up of over 90% massive, porous, coarse sands with localized clay/shale interbeds [1].

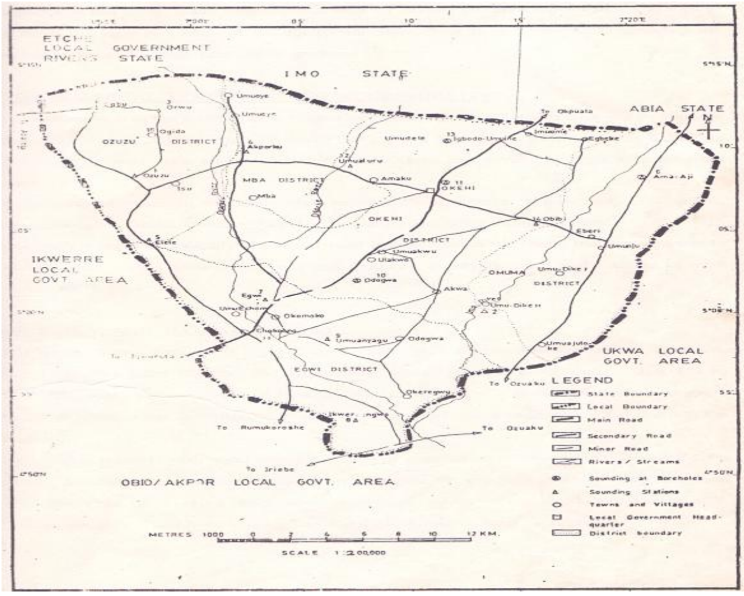

Figure 2: Map of Etche LGA showing the VES locations

VES FIELD SURVEY/ INTERPRETATION

To actualize the aim of this work,Fifteen vertical electrical soundings along different traverse locations using Schlumberger array were carried out in the study area. Four of the soundings were made at existing boreholes for comparative analysis (Fig. 2). The locations are Egbu, Okehi, Odagwa and Igbodo. With the Schlumberger array, the potential electrodes separation was kept constant while the current electrode separation was increased in steps. A maximum current electrode spread AB of 600m was achieved in the field with R-Plus Resistivity meter which displayed the apparent resistivity and the compensated Self-Potential (SP) on the Liquid Crystal Display (LCD) window.

These results were made possible as the four electrodes driven into the ground are connected to ABMN, (ie, two current electrodes AB and two potential electrodes MN), fig 3 and the terminals of the R-Plus meter through the reels of cables. The ratio between the potential and current electrodes (MN and AB) respectively ranges from 1/3 to 1/5 [10]. The layer parameters (apparent Resistivity and thickness) obtained from the quantitative interpretation is shown in Table 2a and 2b. IP12Win inversion program software in 1D was used for resistivity interpretation. Typical field curves, overburden thickness and layer resistivities were revealed in Fig. 4. The VES curves are generally used to determine the electrical resistivity variation as a function of depth [12]. The lithological logs of four existing boreholes drilled at Egbu (VES 15),Odagwa (VES 10), Umuaturu (VES 12) and Igbodo (VES 13) were found to be in agreement with the water – bearing characteristics of the Benin formation of the study area. [11].

The survey also mapped out the water level distribution pattern across the entire study area. (Table 3) as well as the contour map as shown in Fig. 5.

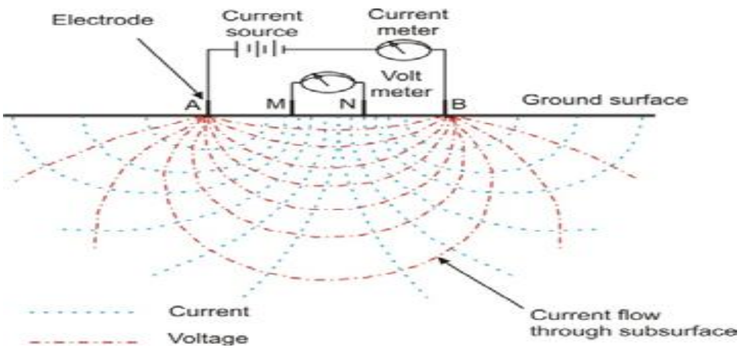

Figure 3: Electrodes arrangement and Current flow in the ground for Resistivity determination

Table 1: Existing borehole logs in the study area (Rivers State Water Board, 1986)

Station No	Lithology of existing Borehole (surface to Depth) (m)	Geoelectric field data (surface to Depth) (m)	Apparent Resistivity (Ωm)	Lithology
BH_{10} Odagwa	19.70	20.26	5456.4	Coarse sand
BH_{12} Umuaturu	24.00	22.20	298.8	Medium coarse
BH_{13} Igbodo	15.00	7.24	409.6	Coarse sand
BH_{15} Egbu	15.24	16.88	2318.1	Medium gravel

Table 2a: Summary of the results of the interpreted VES curves points

VES Location No/Name	No of layers	RESISTIVITY OF LAYERS (Ωm)					THICKNESS (m)				DEPTH (m)				Fitting Error %
		ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	t_1	t_2	t_3	t_4	h_1	h_2	h_3	h_4	
01 Ozuzu	4	458.7	6204.8	795.6	4241.0	-	1.45	20.90	26.15	-	1.45	22.35	48.50	-	1.58
02 Umudike	4	371.2	309.6	1602.1	1104.7	-	2.55	15.16	204.93	-	2.55	17.71	222.64	-	6.37
03 Orwu	4	2454.5	1838.8	5481.0	3305.5	-	3.47	7.42	77.62	-	3.47	10.89	88.51	-	9.33
04 Akpoku	4	644.3	2607.0	921.8	3240.9	-	2.03	19.64	37.62	-	2.03	21.67	59.29	-	4.30
05 Elele	3	85.1	2433.5	2504.1	-	-	0.41	54.30	-	-	0.41	54.71	-	-	10.64
06 Amaji	5	1263.4	778.3	2515.7	984.6	1137.0	2.29	4.02	54.93	304.43	2.29	6.31	63.53	368.0	4.51
07 Egwi	4	314.6	7924.6	1384.5	6781.6	-	0.21	5.27	31`.07	-	0.21	5.48	36.55	-	10.01
08 Ikwerengwo	3	693.5	6758.1	405.9	-	-	2.24	44.16	-	-	2.24	46.40	-	-	5.01
09 Umuanyagu	4	2783.5	1186.6	7445.6	317.9	-	3.09	3.22	25.85	-	3.09	6.31	32.16	-	7.20
10 Odagwa	4	1712.4	5458.4	582.5	3879.8	-	3.87	20.26	58.99	-	3.87	24.13	83.12	-	4.92
11 Okehi	4	3549.1	1125.1	3986.5	395.2	-	0.33	5.93	59.38	-	0.33	6.26	65.64	-	6.68
12 Umuaturu	4	98.6	258.8	2419.2	782.2	-	0.19	22.20	77.58	-	0.19	22.39	99.97	-	7.57
13 Igbodo	4	788.4	409.6	4311.8	454.4	-	1.97	7.24	87.56	-	1.97	9.21	94.80	-	6.17
14 Umuola	4	808.4	4843.7	1253.8	0.001	-	0.81	5.32	124.59	-	0.81	6.13	130.72	-	10.92
15 Egbu	4	510.5	2318.1	478.7	7195.6	-	0.66	16.88	37.67	-	0.66	17.540	55.21		12.83

Table 2b: Summary of the results of the interpreted VES curves points

VES Location No/Name	LONG. CONDUCTANCE OF LAYERS (Siemens)				TRANS. RESISTANCE OF LAYERS (Ohms)			
	σ_1	σ_2	σ_3	σ_4	Ω_1	Ω_2	Ω_3	Ω_4
01 Ozuzu	0.003	0.003	0.033	-	665.9	1296085.4	20802.8	
02 Umudike	0.007	0.049	0.128	-	946.0	4700.0	328325.2	-
03 Orwu	0.001	0.004	0.014	-	8504.9	13540.7	425432.6	-
04 Akpoku	0.0030	0.008	0.041	-	1305.5	51193.8	34856.1	-
05 Elele	0.006	0.022	-	-	40.0	132145.0	-	-
06 Amaji	0.002	0.005	0.022	0.309	2805.0	3125.3	138190.6	299747.4
07 Egwi	0.001	0.001	0.016	-	65.3	41782.4	61682.8	-
08 Ikwerengwo	0.003	0.006	-	-	1554.0	300204.1	-	-
09 Umuanyagu	0.001	0.003	0.003	-	8608.9	3824.6	192455.0	-
10 Odagwa	0.002	0.004	0.101	-	6621.4	110565.7	34363.4	-
11 Okehi	0.000	0.005	0.015	-	1282.8	6672.5	236728.7	-
12 Umuaturu	0.002	0.77	0.032	-	18.7	6413.5	18764.0	-
13 Igbodo	0.002	0.018	0.020	-	1551.6	2967.0	377546.8	-
14 Umuola	0.001	0.001	0.99	-	491.1	25768.4	156207.5	-
15 Egbu	0.001	0.007	0.79	-	338.9	39120.3	18031.9	-

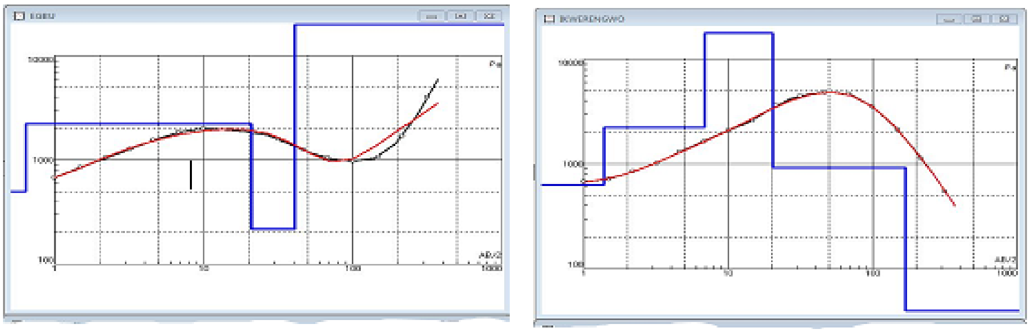

Figure 4: Typical field curves for VES data at Egbu and Ikwerengwo

Table 3: Water table distribution across the study area

VES Location	Coordinates		Static water level
No/Name	Easting	Northing	(m)
01 Ozuzu	508894	126213	20
02 Umudike	530776	115952	25
03 Orwu	504490	134095	18
04 Akpoku	509704	128847	20
05 Elele	505325	120650	22
06 Amaji	528550	15468	27
07 Egwi	511758	112492	15
08 Ikwerengwo	514114	102820	24
09 Umuanyagu	517678	104599	25
10 Odagwa	520748	110518	16
11 Okehi	520210	125717	25
12 Umuaturu	514818	126240	18
13 Igbodo	521710	136587	26
14 Umuola/Obibi	516141	116814	20
15 Egbu	500841	134222	21
16 Umuagwu Eberi	529131	124821	28
17 Umuoye	507666	137593	23
18 Isu	509933	126754	18
19 Obite	514742	133792	23
20 Ulakwo	514382	117396	25
21 Afara	514545	121042	22
22 Umuechem	507481	106342	23

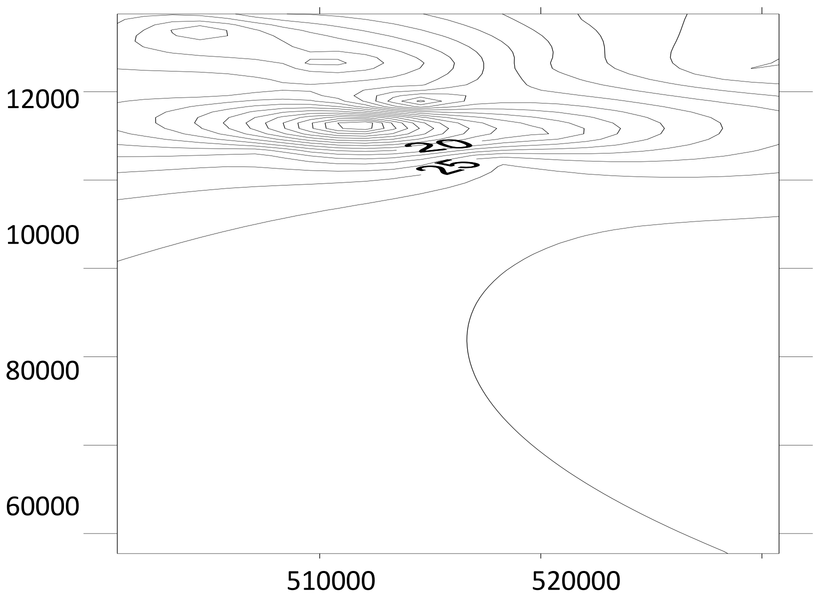

Figure 5: Contour map of water level distribution in the study area (Surfur 8).

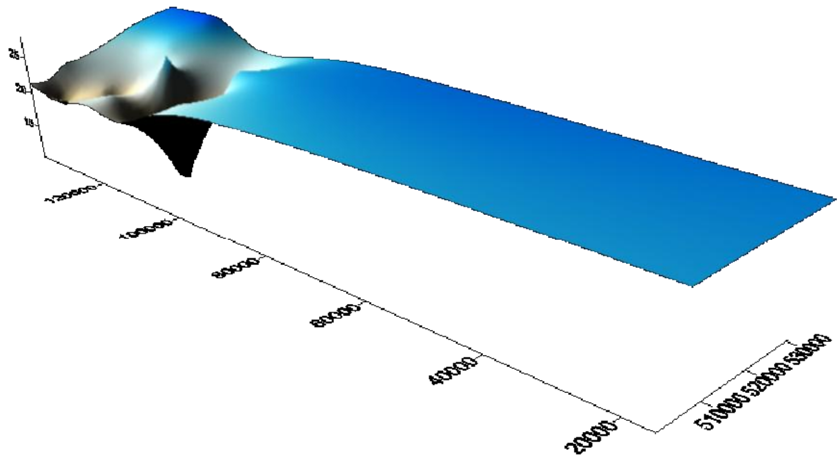

Figure 6: Surface map of water level distribution in the study area

Results and Discussion

The computer iterated results of the VES data are presented in Tables 1, while the plotted results of apparent resistivity against its corresponding current electrode spacing (AB/2) are presented in Fig. 4. In Table 1, VES 05 and 08 revealed three layer curves while four layer curves were delineated in VES 03, 09, 11 and 13), VES 02 and 12, VES 14 and VES 01, 04, 07, 10 and 15. Five layers curve was revealed at Amaji (VES 06) located at theNortheast part of Rivers State. The thickness of the layers ranged from 0.19m to 309.43m. From records of existing geologic information, the area studied is underlain at the top by clayey to lateritic topsoil, overlying sandylayer. Beneath the latter is the aquifer which is essentially sands of varying texture of grained sands, medium coarse and coarse sands characteristic of Benin Formation. The prolific aquifer zones extend from overburden layers of medium to coarse sands with appreciable thicknesses as shown in Table 2. In the southern part comprising (Odagwa, Egwi, Ikwerrengwo and Umuanyagu), the resistivity values (Table 2) show a reasonably permeable layer surrounded by high resistance rock formations.

Figures 5 and 6 show the contour mapof water distribution of the area conducted during the dry season. Water table in the area is fairly deep compared with the existing records in the State, with deepest at Omuma LGA. The water table distribution across the entire areas of study ranges from 15m to 28m which is the highest from available records in Rivers State [11]. The contour lines are characterized by isolated closures as presented by the surfur 8 software used for the interpretation, typical of discontinuous basement aquifer system. The closely packed contour lines observed indicates steeps or valleys as the sparsely distributed lines depict ridges or elevations.

Conclusion

Geoelectrical investigation using the DC electrical resistivity method conducted in the area has shown that groundwater potential is very high throughout the study area. The area is basically underlain by top clayey to lateritic topsoil, overlying sandy layer that favors prolific aquifer yield. Beneath the latter is the aquifer which is essentially sands of varying texture. The aquifer has shown to extend to about 100m beneath the subsurface. The water level distribution contour map is a useful guide for geoelectric study as reconnaissance survey for locating new wells.

References

[1]. Allen J. R. L., (1965) "Late Quaternary Niger Delta and Adjacent Areas: Sedimentary Environments and Lithofacies," *American Association of Petroleum Geologists Bulletin*, 49 (5), 1965, pp. 549-600.

[2]. Amechi, B.U and Horsfall, J.O (2015). Well design, construction and downhole logs for prolific fresh water aquifer delineation at the Rivers State University of Science and Technology, Nkpolu. Port Harcourt. Nigeria. *World Journal of Applied Science and Technology, 7 (2) (2015).*

[3]. Dobrin, M.B. (1976): Introduction to Geophysical Prospecting. *McGraw-Hill, New York.*

[4]. Ekine AS, Osobonye GT (1996). "Surface Geoelectric Sounding for the determination of Aquifer Characteristics in parts of Bonny Local Government Area of River State". Niger. J. Phys. 85: 93-97.

[5]. Offodile, M.E. (1984). An approach to groundwater study and development in Nig. *Macom Services* Ltd. Nig.

[6]. Okwueze, E.E. (1996) "Preliminary Findings of the Groundwater Potentials from a Regional Geoleectric Survey of the Obudu Basement Area, Nig.Global J.Pure Appl. Sci. 2(2): 201 – 211

[7]. Onuoha, K. M. and. Mbazi, F. C. C (1988). Aquifer Transmissvity from Electrical Sounding Data: The Case of the Ajali Sandstone Aquifers South-West Enugu, Nigeria," In: *C. O. Ofoegbu, Ed., Groundwater and Mineral Resources of Nigeria*, F. Vieweg, Braunschweig/Wiesbaden, 1988, pp. 17-30.

[8]. Oseji, et al (2009). Geoelectric Investigation of Groundwater Resources and Aquifer Characteristics in Utagba-Oge Kingdom Ndokwa Land Area of Delta State, Nigeria. J. of Environ. Chemistry and Ecotoxicology. Vol.2 (3), pp.38 - 46

[9]. Oyedele K.F (2001) Geoelectric Investigation of Groundwater resources at Onibode area, near Abeokuta South-West Nigeria, PP. 501 -504.

[10]. Parasnis, D. S. (1986) Principles of Applied Geophysics, *Chapman and Hall, London*, UK, 5^{th} edition, 1986.

[11]. Rivers State Water Board Report 1986

[12]. Telford, W, M., Geldert, L. P., Sheriff, R. E., and Keys, D. A., (1990) Applied Geophysics, *Cambridge University Press*, England, 1990.

[13]. Uma, K.O and Egbuka, B.C.E (1985). Water Resources of Owerri and its environs, Imo State Nigeria. Nig. J. Min. Geol. 22, pp57 – 63.