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The Geo-Electric Resistivity Survey in Jalingo, Yorro and Zing Local Government Areas of Northern Taraba State, Nigeria

Nyagba B.B, Ahile J. A., Hiar G. N., Drambi J.S., Abdul I.

***Abstract*— The Geo-Electric Resistivity Survey in Jalingo, Yorro and Zing Local Government Areas of Northern Taraba State, Nigeria was carried with the aim to tackle water scarcity problem from the source. Sixty pilot investigation structured questionnaires were administered to persons of sixty years and above of age, in order to have knowledge of water sources 102 years ago, how these sources are changing overtime, the factors responsible for these changes and to use this result as a prerequisite to the vertical Electrical sounding(VES) or schlumberger array method in the area. This research has shown that for the period of 102 years ago of human settlement within the three Local Government Areas, 210 water sources existed out of which 94 sources depleted constituting 44.7%. It is the surface water source that suffered the most loses due to: human activities, global warming, increasing in population, negligence, pollution, development, and hence necessitating the need for ground water exploration so as to Compplement these loses. VES method was then chosen with the aim to achieve the following objectives: To determine and analyzed aquifer properties in terms of apparent resistivity, thickness, depth to the sub surface of the units in the study area and to delineate the water bearing zones. Fifteen VES were carried out using Schlumberger configuration with maximum current electrode spacing of 200 m, that was herald by reconnaissance study using two brass rods and the centre of array of each VES station was located. Using ABEM SAS 300 system Terrameter , data obtained was analyzed using Interpex IXI-D. It was found that in the study areas two curve types, the H-and the A-types were obtained. The H-curve types dominate with 93.3% and the A-curve type is 6.7%. It is also underlain by rock materials whose layer ranges from two to three. Geo-electric parameters; low apparent resistivity and large thickness favoured presence of availability of ground water in light of this all VES points in Jalingo and Yorro Local Government Areas are favorable for ground water exploration while four in Zing are favorable with VES 15 un suitable.**

***Index Terms*— Electrode array,geo-electrical, resistivity, source of water, VES, water.**

Nyagba B.B1, Department of Basic Science College of Agriculture, P.M. B 2015 Jalingo, Taraba State of Nigeria.
Ahile J. A., Department of Physics, Modibbo Adama University of Technology P.M.B 2076 Yola Adamawa state,
Hiar G. N., Department of Physics, Modibbo Adama University of Technology P.M.B 2076 Yola Adamawa state
Drambi J.S., Department of Physics, Modibbo Adama University of Technology P.M.B 2076 Yola Adamawa state,
Abdul I., Department of Physics, Modibbo Adama University of Technology P.M.B 2076 Yola Adamawa state.

I. Introduction

Water is defined as a chemical compound made up of hydrogen and oxygen in the ratio of 2:1 with chemical formula H2O. In the planet earth, the part that is made up of water collectively is called the hydrosphere; it refers to the water masses including rivers, seas and oceans. It occupies 70% of the total earth crust by volume. It holds water in form of solid, liquid and gaseous states. Water on the earth system is found in the atmosphere, surface of the earth and beneath; are known as atmospheric-, surfaces – and ground-water respectively.

Hydrologic cycle is a vast and complex system which circulates water over the whole planet earth, which both starts and ends up in the ocean. Energy from the sun powered the system causing water to evaporate from the surface of the world's oceans which then vapourises to form large masses of clouds, when condition is favourable, water precipitates falling back to earth surface again as rain, hail, sleet or snow.

Some of the water fall on the land collect to form streams and rivers which eventually flow back into the seas and oceans from where the process start up again. Not all the rain fall contributes to the flown of streams and rivers in the same way, some of it returns to the atmosphere as evaporation from oceans, ground surfaces and transpiration from the plants. The reason why groundwater has become more popular as a source of potable water in Nigeria is due to its quality when compared to other water sources. It is known to be free most times from pollutants and hence requires little or no decontamination before use.

Lawrence and Ojo (2012) noted that groundwater is most generally free from odor, color and has very low dissolved solid. It is also not usually affected by natural factors such as drought. The search for ground water has become imperative in human history. This is due to the fact that government and well-to-do individuals are unable to meet the over increasing water demand; inhabitants have to look for alternative means of portable water supply.

Jalingo, Yorro andZing Local Government Areas of Northern Taraba State, Nigeria are known to have persistence water scarcity problem that need to be tackled urgently. Although there are other sources of water such as pit water sources, streams, rivers, open hand-dogged wells, hand pumped and motorized boreholes, these are grossly inadequate for the teaming population. To tackle this problem this research paper has chosen two methods: administering plot investigation structure questionnaires method and vertical electrical sounding(VES) method in which five (5) locations in each of the local government areas were carried out to study the ground water potentials. The vertical electrical sounding method for the study was chosen because of its excellent vertical resolution and good depth sensitivity, simple instrumentation, easy field logistics and relatively economical, (Zhody et al, 1974).

II. STUDY AREA

The study areas comprise of Jalingo, Yorro and Zing local government Areas in the northern Taraba state, Nigeria. It lies between latitudes 8^0 34' 0"N to 9^0 10' 0"N and longitudes 11^0 12' 0"E to 11^0 54' 0"E as shown in Figure 1.

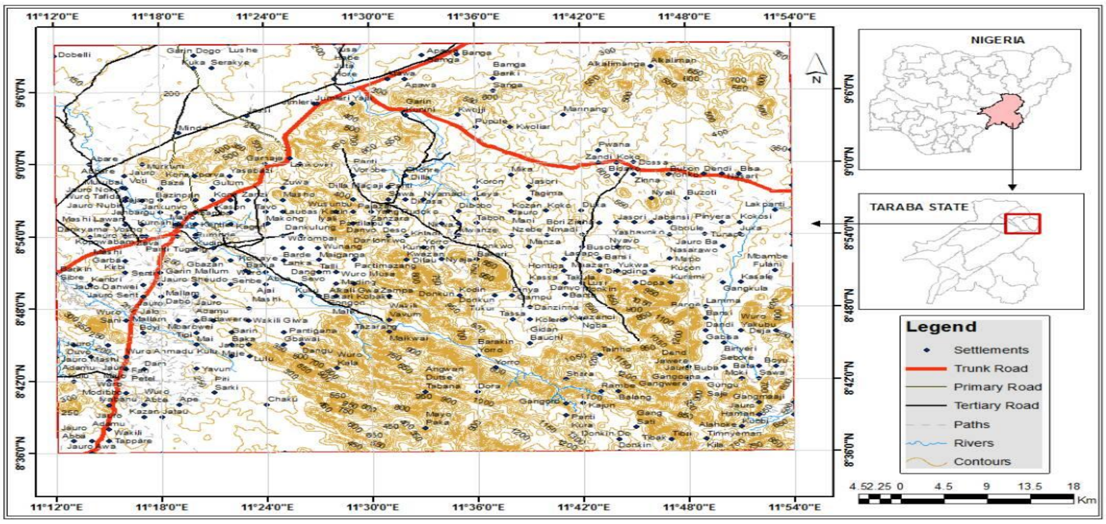

Figure 1: Topographic map of the study area (GSN, 2006)

III. GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

The Taraba State area is made up of both the Basement complex and the Sedimentary Basin. Generally, the Basement complex of Nigeria comprises of:-The Basement complex of North Western Nigeria, the Basement complex of Southern Nigeria, and that of North Eastern Nigeria while Sedimentary Basin comprises of the Sokoto (Illumedeen) basin, the Chad Basin, the Niger-Benue Trough and the Dahomy Basin. However, Jalingo, Yorro and Zing Local Government areas fall under Taraba area which is part of the Basement complex of North Eastern Nigeria and Sedimentary Basin of the Benue Trough. This block is known to be composed of the migmatite-gneisses-quartzite complex of which have been intruded by intensive bodies of Pan Africa granites. Meta sedimentary belts are conspicuously absent in this block. Only relics of the meta sedimentary are found as xenoliths (Carter *et al* 1963). The geologic formations of the study areas are shown in figure 2.

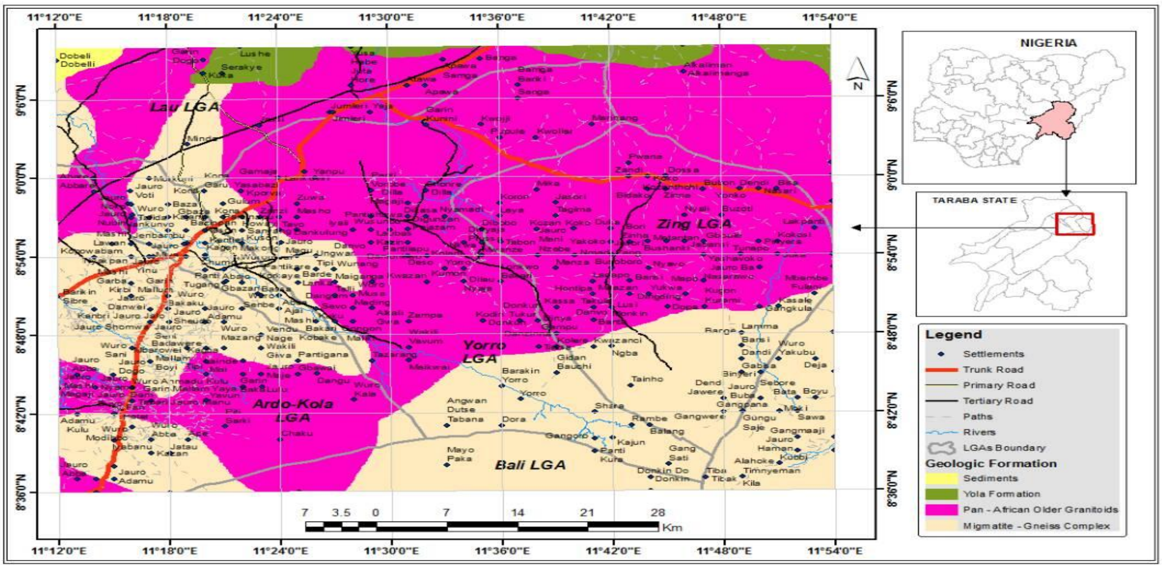

Figure 2: The Geologic map showing geologic formations of the study area (GSN, 2006).

IV. MATERIALS AND METHODS

The materials used during this work include ABEM Terrameter SAS 300 system, pilot investigation structured questionnaires, two brass rods, Interpex IXI-D software, Hammer, water and two trained technical personnel.

Two methods were adopted in this research work which includes: Reconnaissance survey i.e. distribution of pilot investigation questionnaires so as to ascertain the water scarcity problem from the source in the areas and subsequently a geo-physical survey using VES for the data acquisition.

The Schlumberger electrode configuration was used, with maximum current electrode separation (AB/2) of 100m. The instrument, in this array measures vertical changes in ground resistivity with depth.

This is the preferred way to locate vertical layers and aquifers thicknesses. The principle of the resistivity methods is that an electric current is passed into the ground through two current electrodes and the resulting potential difference is measured across two potential electrodes. The resulting potential difference and the current effect is displayed by the digital resistivity equipment as a ground resistance called resistivity. The electrode spacing is progressively increased, keeping the center point of the electrode array fixed. At small electrode spacing, the apparent resistivity is nearly the resistivity of the surface material, but as the current electrodes spacing increase the current penetrates deeper within the subsurface and so the apparent resistivity reflects the resistivity of the deeper layers as well. The apparent resistivity values are obtained by multiplying the measured ground resistance with an appropriate geometric factor to and obtained the apparent resistivity. The result was interpreted using Interpex IXI-D computer geo-electric interpretational software.

V. RESULTS AND DISCUSSION

a. Sources of Water

Sixty questionnaires were administered, twenty in each of the three local government areas in the study areas. It was found that 100, 73 and 37 sources were in existence within Jalingo, Yorro and Zing respectively totaled up to 210, while those depleted were 28, 26 and 20 in the respective local government areas also totaled up to 94, that constituted 44.7% as shown in table1. The factors responsible for the changes are:

Climate change, Human activities, increases in population, pollution, Negligence and development. It was observed that surface sources that suffered most losses, hence necessitating for the ground water exploration in the areas to Complement those losses. Therefore, VES was chosen as the exploration method to tackle the problem.

Table 1: Sources of water in the study area as over 102 years ago

	Sources of Water in existence in Jalingo					sources of water depleted				% depleted
Location	**PWS**	**SRWS**	**HDW**	**BH**	**Total**	**DU**	**GE**	**Others**	**Total**	
Magami	15	4	10	20	49	13	5	5	23	46.94
Golong Mile Six	5	4	1	4	14	5	-	-	5	35.70
Turaki	10	2	2	3	17	-	10	1	11	64.71
Shavong	8	3	-	1	12	2	3	1	6	50.00
Kpanti-Tanyoh	3	2	-	3	8	-	3	-	3	37.50
	Sources of Water in existence in Yorro					**sources of water depleted**				**% depleted**
Location	**PWS**	**SRWS**	**HDW**	**BH**	**Total**	**DU**	**GE**	**Others**	**Total**	
Kada-Bazing	6	1	3	4	14	1	2	1	4	28.57
Dan-Zang	12	2	-	3	17	-	5	-	5	29.41
Pupule-Mikka	9	1	3	3	16	3	1	1	5	32.00
Pa-Larang	9	2	1	2	14	3	2	1	6	42,86
Malale	6	3	2	1	12	3	2	1	6	50.00
	Sources of Water in existence in Zing					**sources of water depleted**				**% depleted**
Location	**PWS**	**SRWS**	**HDW**	**BH**	**Total**	**DU**	**GE**	**Others**	**Total**	
Bubong	7	2	1	4	14	5	1	-	6	42.86
Dan-Lappa	3	1	1	2	7	2	1	1	4	57.14
Dan-Jaseri	3	1	1	2	7	1	2	1	4	57.14
Yelwa	2	1	1	1	5	1	1	1	3	60.00
Lugere	1	1	1	1	4	1	1	1	3	75.00

PWS = Pit Water source, SRWS = Streams and Rivers, HDW = Hand-Dug Well, BH = Borehole, DU = Dried Up and GE = Gone Extinct

b. Apparent resistivity

Fifteen VES were carried, five each from Jalingo, Yorro and Zing Local Government Areas. The apparent resistivity field values for each VES was recorded in field record sheets. These values were multiplied by schlumberger geometric factor, K="a2/b , and apparent resistivity values for each VES point location were computed as shown in tables 2a, 2b and 2c.

Table 2(a): Apparent resistivity value for Jalingo VES Stations

S/N	AB/2(m)	VES 1		VES 2		VES 3		VES 4		VES 5	
		ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)
1	1.00	26.10	196.80	59.90	451.65	25.30	190.76	89.50	674.83	94.70	714.04
2	1.45	12.09	195.86	25.00	405.00	11.76	190.51	26.40	427.68	35.10	568.62
3	2.15	4.96	178.56	10.43	375.48	3.82	137.52	7.99	287.64	12.21	439.56
4	3.15	1.83	141.93	3.01	233.58	0.65	50.053	2.33	180.81	4.55	353.08
5	4.65	0.70	118.31	1.02	172.21	0.08	14.20	0.95	161.03	1.58	267.64
6	6.80	0.22	81.31	0.44	159.72	0.02	7.30	0.49	176.78	0.78	282.41
7	6.80	1.49	71.27	3.35	1601.30	0.20	9.46	4.41	210.80	3.09	147.70
8	10.0	0.47	50.80	1.26	134.11	0.05	5.66	2.24	237.66	2.42	256.76
9	14.5	0.193	43.47	0.55	124.65	0.03	6.89	1.24	279.45	1.28	288.45
10	21.5	0.11	53.04	0.26	130.97	0.02	9.91	0.92	456.67	0.71	355.57
11	31.5	0.07	69.96	0.14	145.93	0.02	15.99	0.42	453.88	0.42	445.29
12	31.5	0.32	68.99	0.71	154.83	0.04	8.85	1.92	420.70	2.13	466.47
13	46.5	0.20	96.77	0.37	181.90	0.04	20.44	1.14	556.97	1.14	556.48
14	68.0	0.12	120.93	0.22	229.37	0.05	54.44	0.66	694.45	0.58	608.83
15	100.0	0.08	185.30	0.13	289.90	0.06	142.54	0.33	751.77	0.29	666.71

Table 2(b): Apparent resistivity value for Yorro VES Stations

S/N	AB/2(m)	VES 6		VES 7		VES 8		VES 9		VES 10	
		ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)
1	1.00	99.50	750.23	56.00	422.24	44.20	333.27	8.93	67.33	84.80	6639.39
2	1.45	44.50	720.90	28.90	268.18	16.12	261.14	2.36	38.23	45.00	729.00
3	2.15	12.74	458.64	6.46	232.56	5.98	215.28	0.60	21.50	21.40	770.40
4	3.15	5.32	412.83	3.09	240.25	2.21	171.50	0.13	9.70	9.90	768.24
5	4.65	2.00	339.00	1.28	216.32	0.49	82.72	0.04	6.03	3.03	513.59
6	6.80	0.66	239.94	0.89	321.40	0.13	46.61	0.02	5.80	0.88	317.99
7	6.80	5.88	281.06	3.22	153.92	1.05	50.38	0.13	6.20	7.89	377.14
8	10.0	2.29	242.96	0.91	96.88	0.41	43.93	0.10	5.80	2.38	252.52
9	14.5	0.80	178.88	0.47	106.65	0.24	54.45	0.30	70.20	1.09	244.58
10	21.5	0.35	172.31	0.24	176.29	0.14	71.46	0.02	9.40	0.49	238.63
11	31.5	0.19	202.80	0.14	148.50	0.08	87.56	0.01	13.50	0.25	268.25
12	31.5	1.05	229.95	0.57	144.98	0.44	96.36	0.05	11.90	1.57	343.61
13	46.5	0.54	264.55	0.33	163.03	0.25	121.76	0.03	18.80	0.84	411.25
14	68.0	0.28	299.13	0.22	234.23	0.15	157.49	0.02	28.10	0.45	475.65
15	100.0	0.16	372.44	0.14	322.80	0.07	171.05	0.01	42.07	0.21	482.79

Table 2(c): Apparent resistivity value for Zing VES Stations

S/N	AB/2(m)	VES 11		VES 12		VES 13		VES 14		VES 15	
		ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm)	ρ (Ωm)	ρ_a (Ωm
1	1.00	14.93	112.57	64.40	438.00	18.28	137.80	27.00	203.58	1.60	12.00
2	1.45	6.63	107.41	19.62	317.80	7.21	116.80	8.43	136.60	0.70	11.00
3	2.15	3.49	125.64	4.55	163.80	2.81	101.16	2.16	77.76	0.30	10.41
4	3.15	1.87	144.81	1.03	79.62	1.05	81.64	0.56	43.53	0.20	12.21
5	4.65	0.25	43.036	0.32	54.80	0.40	68.00	0.19	31.71	0.10	13.60
6	6.80	0.23	83.85	0.30	99.83	0.20	56.60	0.05	16.90	0.10	16.30
7	6.80	1.79	94.88	0.80	39.53	1.30	64.00	0.36	17.40	0.41	19.60
8	10.0	0.63	67.27	0.70	78.62	0.60	62.18	0.16	17.10	0.20	23.02
9	14.5	0.21	70.65	0.50	105.08	0.31	70.65	0.09	19.60	0.10	30.20
10	21.5	0.80	41.93	0.20	86.65	0.02	85.10	0.06	29.70	0.10	39.34
11	31.5	0.04	46.03	0.10	79.40	0.10	111.60	0.04	45.06	0.10	55.70
12	31.5	0.31	67.23	0.030	64.00	0.52	113.00	0.40	76.00	0.30	56.30
13	46.5	0.18	89.00	0.10	37.16	0.30	159.90	0.21	103.20	0.20	79.80
14	68.0	0.12	125.68	0.20	169.12	0.21	223.03	0.15	161.62	0.10	120.60
15	100.0	0.07	162.08	0.10	285.02	0.12	278.20	0.20	338.00	0.10	198.63

c. Geo-electric Parameters.

The apparent resistivity values for each of the fifteen VES stations were plotted against half the current electrodes spacing using bi-logarithmic scale and interpex IXI-D undergoes modeling program and iteration process until smooth layered model were obtained then compared to H-,K-,A-,Q- curve types. The H-,Q- curve type or their combinations, with other curve types exhibit the most probable existence of aquifers hence availability for the existence of ground water. In the study areas H-and A- curve types were obtained with the H-curve types dominating: Five H-Curve types in Jalingo, five in Yorro and four in Zing. This constituted 93.3%. It was found that only one A-curve type found in Zing Local Government Area i.e. VES 15 that constituted 6.7%. The interpretation of the fifteen VES station in the study areas also revealed that the areas are underlained by rock materials whose layers varies from two to three. All the five VES stations in Jalingo and Yorro Local Government Areas are underlained by rock materials with three layers while for VES stations in Zing with one i.e. VES 15 is underlained by rock material with two layers. From the study it was found that three layered VES stations dominante with fourteen constituting 93.3% while two layered 6.7%.

VI. CONCLUSION AND RECOMMENDATION

The pilot investigation structured questionnaire has assisted to identify sources of water existing over 102years ago of the period of human settlement in the study areas. Out of the total source of water (210) about 94 constituting 44.7% are depleted or lost to the nature which may be due to human activities, climate change, pollution, neglecgence, development and increase in population.. It was also observed that the surface water sources were more affected than the ground water sources.

The geo-physical method used in the paper has greatly assisted in evaluating ground water potentials in Jalingo, Yorro and Zing Local Government Areas. The geo-electric parameters that favour presence of ground water are low apparent resistivity, large thickness and weathered or fractured geo-electric section. In light of this statement the VES stations for drilling sites in the study areas: For Jalingo Local Government Area all VES stations are suitable, Yorro Local Government Area all are also suitable and Zing Local Government Area with the exception of Lugere (VES 15), the rest are suitable sites for borehall drilling.

Government, NGO'S and Wealthy individuals should ensure the effective implementation of Land use laws to avoid devastation so as to preserve nature's gift to the world.

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