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Shallow Aquifer in Isihor Village of Edo State, Nigeria

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ABSTRACT

The need to prospect for shallow aquifer (water bearing formations) that will never dry up for a long time became inevitable because of acute water shortage engulfing the inhabitants of the area thus making life unbearable and hence creating economic hardship for the citizen of the area.

The existence of shallow aquifer in Isihor Village of Edo State, Nigeria was determined geophysically by the vertical electrical sounding (VES) of electrical resistivity method. This study revealed that Isihor Village is one of the most auriferous region in Edo State of Nigeria because the first four to five sub lithological layers consist of aquifer as further confirmed by nearby borehole log/driller's log lithology of the area. The existence of shallow aquifer in Isihor Village means that pure water industry can be sited in the area for portable water production because the aquifer will not dry up for a long time. This will however assist the community to solve unemployment problems.

Ten VES, fairly distributed in the area was carried out using Schlumberger array techniques based on six (06) points per decay operation to justify the study.

The geophysical results were used to determine the depth, thickness and resistivity of the recommended shallow unconfined aquifer. The shallow aquifer which is mainly sand and laterite in nature occur at a depth of about 53m below sea level. Its thickness varied from 0.5m to 27.0m while its resistivity varied from 1000hm-m to 6000 ohm-m.

Area of probable shallow thick aquifer have been identified for future drilling operation.

Keywords: *Existence, geophysical, vertical electrical sounding (VES), Isihor village, pure water.*

1. INTRODUCTION

The advantages of electrical resistivity method over other geoelectric methods can not be over emphasised as reported by other previous researchers (Clinton, 1995; Ezomo, 2010). The ability of the method to give detailed information in subsurface geology usually not obtained by other methods in prospecting for shallow aquifer or water bearing formations was presented in (Ezomo 2005-2010). Surface geophysical survey as an instrument in groundwater exploration, has the basic advantage of saving cost in borehole construction by locating water bearing formations before embarking upon drilling (Ezomo and Ifedili, 2005-2007).

Water is known to sustain life everywhere. No wonder that historically, early settlements were associated with proximity of surface water such as springs, running streams, rivers and the like. Water can therefore make or man the economy and life style of a nation or group of people. The necessity of obtaining portable water within an environment is pertinent. It is a major determinant of population growth. The advent of technological advancement has made the quest for water for domestic, industrial and agricultural consumption to drift from mere search for surface water (flowing or stagnant pools) to prospecting for steady reliable subsurface/ground water from boreholes (Ezomo and Ifedili, 2005-2007).

The study area which is Isihor Village in Edo State of Nigeria is underlined by Benin formation (Information Centre, 2010). Details of the geology and hydrogeology of the Benin formations have been documented (Kogbe, 1976). The area lies on latitude and longitude of about $6^0 25^1$N and $5^0 34^1$E respectively (Information Centre, 2010).

The topography of the area are plane surface which has the following rock types, top soil, laterite, clay, sandy clay and clean sand which is in close agreement with the Benin formation that ranges from miocent to recent. The inhabitant of these survey area earns their source of livelihood from farming and peti trading (Kogbe, 1976).

This research paper tends to estimate the thickness, depth below sea level of shallow aquifer or water bearing formation using electrical resistivity method of geophysical survey with the intention of setting up lucrative venture or pure water industry for the production of portable water, free from pollution.

2. MATERIALS AND METHODS

Schlumberger electrode configuration of vertical electrical sounding (VES) was employed for this research, full detail of the method have been documented (Ezomo 2005-2010).

Ten (10) VES, fairly distributed were conducted using the ABEM signal averaging system (SAS) 300 terranmeter and its 2000 booster.

Measurement were taken at increasing current electrodes distance such that the electric current passed into the earth's surface penetrates greater depths. The greatest current electrodes separation (AB) was 632m in a six (06) points per decade operation. The operational efficiency of six points per decade in subsurface geophysical study in groundwater exploration have been documented arising from electrical resistivity theoretical approach (Ezomo, 2005-2010).

There are different types of electrical resistivity theoretical approach based on electrodes array for interpreting resistivity data.

The techniques of data interpretation used involved seeking a solution to the inverse problem namely the determination of subsurface apparent resistivity distribution from surface measurements.

Kernel function represents a very good solution to the inverse problem. It describes the apparent resistivity measurements in terms of subsurface lithological variation with depths. The function assumes the earth to be locally horizontally stratified, inhomogeneous and isotropic layers, and unlike apparent resistivity function, it does not depend on electrode configuration. It cannot be measured in the field but has to be obtained from the transformation of measured apparent resistivities. The kernel function utilised in this work have been documented in (Ezomo, 2010), if the observed apparent resistivity is such that

$$\ell_a(r)=r^2\int_o^\infty \lambda T(\lambda)J\,(\lambda r)d\lambda \qquad (1)$$

Where the kernel function is given as:

$$T(\lambda) = \int_o^\infty \frac{1}{r}\ell\,(r)J(\lambda r)d\lambda \qquad (2)$$ ‘(Ezomo, 2010)

J_1 represent Bessel function of first order, first kind and $T(\lambda)$ is the transformed resistivity data.

However, when the earth is approximately composed of horizontally stratified isotropic, and homogenous media such that the change of resistivity is a function of depth, the Schlumberger configuration is the most widely used array and may provide useful information in solving groundwater problems. A vital aspect of the Schlumberger is the less sensitivity of the array to the effect of near surface lateral heterogeneities and easy recognition of their effects (Ezomo, 2005).

In electrical resistivity sounding, four electrodes are earthed along a straight line in the order AMNB, where A and B are the current electrodes, M and N, the potential electrodes. The calculated apparent resistivity (ℓ_a) according to Schlumberger array condition of AB≥5M N is

$$\ell_a = \pi\left(\frac{\frac{(AB)^2}{4} - \frac{(MN)^2}{4}}{MN}\right)\frac{\Delta V}{I} \qquad (3)$$

AB = Current electrodes spacing in metre

MN = potential electrodes spacing in metre

ΔV = Potential difference in volts, I=electric current in Amperes, π= 22/7

3. RESULTS

The result of the vertical electrical sounding (VES) based on electrical resistivity method obtained from geophysical survey is a function of apparent resistivity (ℓ_a) and current electrode separation. This produced the computer iterated sounding curves shown in figures 1-6 and its associated lithologies shown in tables 1-6.

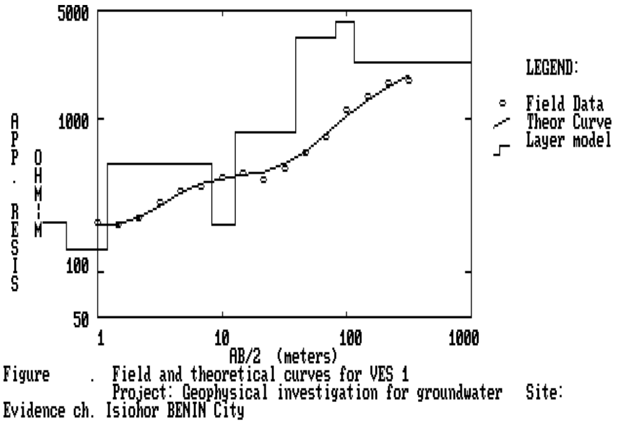

Fig 1: Iterated Sounding Curve
For VES Station 1

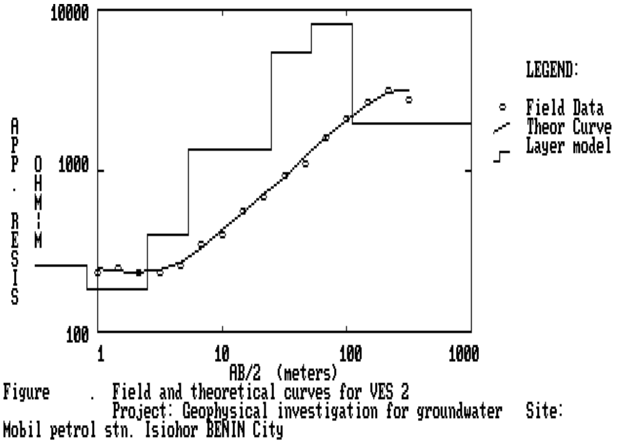

Fig 2: Iterated Sounding Curve
For VES Station 2

Table 1: Lithology for VES station 1

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	209.00	0.56	0.56	Top soil
2	138.99	0.64	1.20	Top soil
3	500.89	7.01	8.21	Laterite
4	198.55	4.61	12.82	Clay soil
5	813.00	26.01	38.83	Laterite
6	3361.00	41.93	80.76	Sandy soil
7	4303.00	34.33	115.09	Sandy soil
8	2336.00	Infinity	Infinity	Clean sand

Table 2: Lithology for VES station 2

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	256.50	0.82	0.82	Top soil
2	181.00	1.62	2.51	Top soil
3	394.00	2.85	5.36	Laterite
4	1376.00	19.35	24.71	Sandy clay
5	5416.00	27.06	51.77	Sandy soil
6	8048.00	58.06	109.83	Clean sand
7	1990.00	Infinity	Infinity	Clean sand

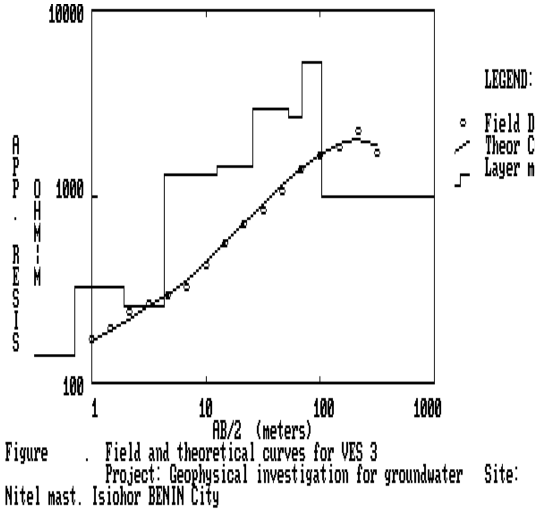

Fig 3: Iterated Sounding Curve
for VES Station 3

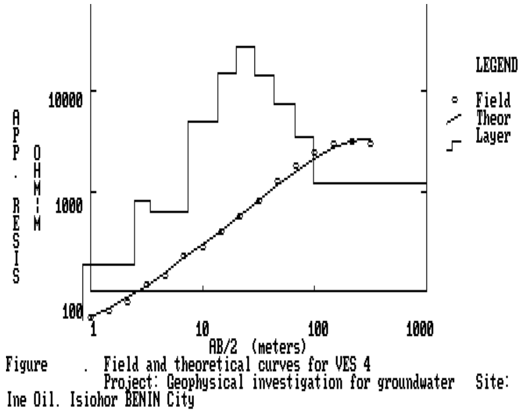

Fig 4: Iterated Sounding Curve
for VES Station 4

Table 3: Lithology for VES station 3

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	141.00	0.71	0.71	Top soil
2	324.00	1.21	1.92	Laterite
3	260.00	2.36	4.28	Clayey soil
4	1310.00	8.20	12.48	Sand clay
5	1455.00	13.24	25.72	Sandy soil
6	2907.00	27.06	52.78	Sandy soil
7	2664.00	16.10	68.88	Sandy soil
8	5250.00	34.33	103.21	Clean sand
9	1009.00	Infinity	Infinity	Clean sand

Table 4: Lithology for VES station 4

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	42.67	0.86	0.86	Top soil
2	186.12	1.59	2.45	Top soil
3	788.70	0.98	3.43	Laterite
4	621.11	3.99	7.42	Laterite
5	4994.23	6.22	13.64	Laterite
6	15,452.86	6.40	20.04	Loose sand
7	28014.02	8.87	28.91	Loose sand
8	14,199.97	14.49	43.40	Loose sand
9	7630.89	23.73	67.13	Clean sand
10	3512.61	30.90	98.03	Sandy soil
11	1202.12	Infinity	Infinity	Clean sand

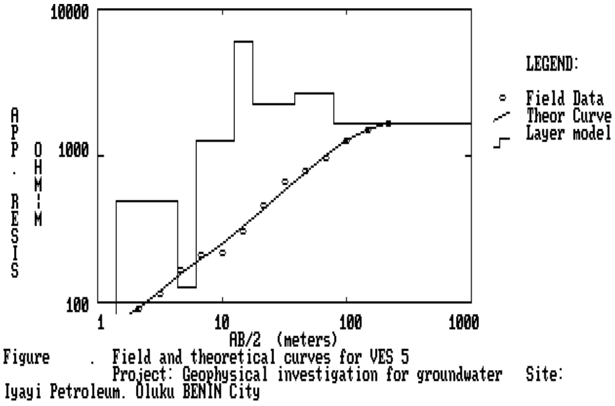

Fig 5: Iterated Sounding Curve for VES Station 5

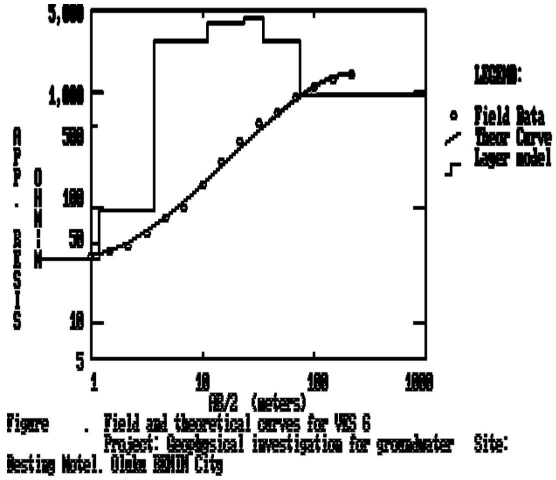

Fig 6: Iterated Sounding Curve for VES Station 6

Table 5: Lithology for VES station 5

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	61.30	1.40	1.40	Top soil
2	496.00	2.98	4.38	Laterite
3	125.00	1.78	6.16	Clayey soil
4	1285.00	6.42	12.58	Laterite
5	60.00	5.10	17.68	Sandy soil
6	2259.00	20.37	38.05	Sandy soil
7	2635.74	39.83	77.88	Sandy soil
8	1662.12	Infinity	Infinity	Clean sand

Table 6: Lithology for VES station 6

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	31.73	0.25	0.25	Top soil
2	37.00	0.92	1.17	Top soil
3	94.00	2.48	3.65	Top soil
4	27340.30	7.42	11.07	Laterite
5	3850.35	12.58	23.65	Laterite
6	4384.00	10.95	34.60	Laterite
7	2786.40	39.83	74.43	Laterite
8	933.16	Infinity	Infinity	Clean sand

4. DISCUSSION

Computer iteration techniques were employed by using software IP12WIN to exhibit all the models of the lithologies. The lithologies or rock types of the different layers were then confirmed by using nearby borehole/driller's log of the area (Isihor bore hole log, 2010). We usually harmonise bore-hole driller's log of the area with standard table of electrical resistivities of some rocks and soil for Benin formation for the purpose of interpretation because it is possible for different rock types to have the same range of resistivity (Okwueze and Akpotu, 1979) which usually make electrical resistivity data ambiguous to interpret.

By integrating the resistivity results with the bore hole/driller's log lithology, resistivity interpretation for the VES stations 1 – 6 lithologies shown in tables 1-6 was obtained.

Shallow aquifer (aquifer occurring at shallow depth) exist in all the VES stations because the first five sub lithological layers consist of top soil, laterite clayey sand, and clean sand which are all aquifer. Hence, the area of study is auriferous.

In VES station one (1), aquifer such as top soil, laterite, clayey sand, sandy clay and sandy soil occur at shallow depths of about 0.56m, 1.20m, 8.20m, 12.82m and 38.83m respectively below sea level.

In VES station two (2), aquifer such as top soil, laterite, clayey sand, clean sand occur at shallow depths of about 0.82m, 2.51m, 5.36m, 24.71m and 51.77m respectively below sea level.

In VES station three (3), aquifer such as top soil, laterite, clayey sand and clean sand occur at shallow depths of about 0.7/m, 1.92m, 25.72m and 52.78m respectively below sea level.

In VES station four (4), aquifer such as clay, top soil, laterite, sandy soil and loose sand occur at shallow depths of about 0.86m, 2.45m, 7.42m, 13.64m and 43.40m respectively below sea level.

In VES station five (5), aquifer such as clay, laterite, clayey soil, sandy clay and sandy soil occur at shallow depths of about 1.40m, 438m, 6.16m, 12.58m and 17.68m respectively below sea level.

In VES station six (6), aquifer such as clay, laterite, sandy soil and clean sand occur at shallow depths of about 3.65m 23.65m, 34.60m and 74.43m respectively below sea level.

Close examination of all the VES stations revealed the following sublithological layers; top soil, clay/mart, laterite, sandy clay, sandy soil, loose soil/sand and clean sand which are aquifer occurring at shallow depths. This is in close agreement with the Benin formation in relation to the research area, which again is in close agreement with the bore hole/driller's log of the area (Isihor Bore Hole Log, 2010).

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5. CONCLUSION/ RECOMMENDATION

Vertical Electrical Sounding (VES) techniques has proved useful and successful in the exploration of groundwater arising from shallow aquifer. The recommended shallow aquifer which is present in VES stations 1-3 is mainly sand and laterite in nature occurring at a depth of about 53m below sea level. Its thickness varied from about 0.5m to 27.0m while its resistivity varied from 100 ohm – m to 6000 ohm-m. Hence, the aquifer occurring at shallow depth is recommended for water production because it will not dry up for a long time if sinking of bore-hole operation is handed by a competent geologist. This therefore, permits the citing of pure water industry in the area for the production of portable water free from pollution to solve the major problem of acute water shortage in most of the town.

The implication of the results is that it will curb to some extent, the unemployment problem engulfing the youth of the area by virtue of citation of pure water industry/factory in the area where this youth will be gainfully employed.

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