

A Geo-Electric Survey of Potential Aquifer in some Parts of Amaigbo in Nwangele Local Government Area of Imo State, Using Vertical Electrical Sounding and Well Log Data.

ABSTRACT

The study is based on the determining the potential aquifers some parts of Amaigbo in Nwangele Local Government Area of Imo State, in Nigeria. The method employed was electrical resistivity survey which was carried out to study the subsurface layer with a view of determine the depth to the aquifer, thickness of an aquifer, and to determine the potential aquifer for groundwater exploration. Using Schlumberger array technique, Vertical Electric Sounding (VES), along with Self Potential well logging was carried out at six (6) VES stations in Amaigbo using the ABEM SAS 1000 terrameter and ABEM SAS 1000 logger respectively. The field data obtained have been analysed using the computer software (IP2win) which automatically interprets the apparent resistivity. The VES result revealed the heterogeneous nature of the subsurface geological sequence. Result from the Geo-electric section showed that the aquifer resistivity of the study ranges from $352\Omega m$ to $7514\Omega m$, with potential groundwater depths ranging from 45m to 119m which shows that the study area is extremely good for groundwater development. The data from the SP well logs correspond to the VES data obtained.

Keywords: Electrical Resistivity, Vertical Electrical Sounding, Amaigbo, SP Well Logs.

1 Introduction

Water is the oldest, fundamental and abundant natural resources to maintain the existence of all living things on earth. Water just like air is the naturally resource we cannot do without for survival. Water is essential for all commercial, domestic, industrial, land agricultural purposes. Sourcing of water started from tapping from rainfall and local stream, rivers and lakes, to digging of wells and drilling of boreholes. As life ages, there is continuous search and thirst for a better life, good health and of course, a secured source of water.

This aging of life comes with advancement in technology, that embolden the intent and quest for water for all purpose in life, drifting from ordinary search for water to prospecting for portable, clean, accessible, secured source of water (Odong, 2013).

The sources include groundwater or subsurface water source, surface Water, precipitation or rain water.

Surface water such like river, lakes, streams was the first choice of man as a source of water, but with recent cases of pollution being inadvertently introduced by man through industrialization, urbanization, improper waste disposal and agricultural malpractices pose challenges for this type of water supply system (Bernard, 2003).

The subsurface or ground water is the portion of atmospheric precipitation that has percolated into the earth trapped under the surface of the ground in the tiny pore spaces between rocks, sand, and gravel. This makes

water to be trapped almost everywhere beneath the earth's surface, not just from a single widespread aquifer but in millions of aquifer system.

Over the years, a lot of different geophysical methods have been used to exploit the groundwater which is in abundance. This method includes Gravity, Seismic, Electrical Resistivity, Magnetic Resonance and magnetotelluric methods (Todd, 2004; Majumdar and Das, 2011). The method to be adopted is a function to depth of investigation and cost effect.

However, the most frequent used is Electrical Resistivity and specifically Vertical Electric Sounding (Molue, and Emegbetere, 2005, Anomohanran, 2011).

Vertical Electrical Sounding (VES) which is extensively used to for the location of aquifers (Keller and Frischknecht, 1966; Zhody et al., 1974), can also be used to determine other hydraulic parameters of an aquifer.

must be carried out, on the surface before drilling, sinking or construction of a functional borehole. There have been a thorough researches by several researchers and geophysicist including Onwumesi et al., (1991), confirming the effectiveness and efficacy of vertical electrical sounding for groundwater prospecting, containment plumb predication and freshwater and saline water boundary predication.

1.2 Aim of Study

The aim of study is to carry out a geo-electric survey to determine the potential aquifers in parts of Amaigbo, Nwangele local government area of Imo state using vertical electrical sounding and well log data.

1.3 Objectives of the Study

The objectives of the study are to carry a resistivity survey of the study area so to obtain the VES Curves using the IP2Win Software which will help to determine the depth and thickness of the aquifer. And most importantly to obtain SP well log data of some uncased boreholes near our VES point stations.

1.4 Justification of the Study

With the surging human population in Amaigbo, there has been an ever-increasing demand for portable water in the area. Groundwater can be extensively used to supplement surface water and other sources of water thereby subjecting it to over exploitation by indiscriminate drilling of boreholes which consequently resulting to borehole failure and deterioration of groundwater in the area.

The cases of borehole drilling failures, contamination and abandonment reported in parts of Amaigbo have made this study imperative, to assist water resource planners, developers or geophysicist to accurately gauge the yield of the borehole in the area as to optimize the sinking of functional boreholes in the future.

1.5 The Study Area

The study area, Amaigbo is in Orlu senatorial zone of Imo State of south-eastern region of Nigeria. It lies within latitudes $5^{\circ} 43' 48''$ N and longitudes $7^{\circ} 6' 54''$ E.

1.6 Literature Review

The ever-increasing demand for water supplies is making groundwater exploration to gain importance. According to World Health Organization (WHO), 10% of the world is already affected by chronic water scarcity and this is likely to rise by 2030. The water scarcity experienced led to the search for more portable water aside the surface water sources. Although boreholes have been drilled in various parts of Imo River Basin, there have not been any systematic and comprehensive studies to establish the nature and distribution of the aquifers beneath the basin (Egboka and Uma 1985).

A lot of studies (Iduma and Abam, 2010; Ahiarakwem and Ejimadu, 2002; Ezeigbo, 1989; Uma, 1984; and Etu-Efeotor and Odigi, 1983) have been carried out on some aspects of the hydrogeology of Southeastern Nigeria of which the study area is a part; the flow potential of the groundwater resources in the area is yet to be studied. This must have been one of the reasons for numerous water borehole drilling failures encountered in the area.

Uma (1984), carried out a study on the groundwater resources of Imo River Basin using hydrological data from existing boreholes. He concluded that three (3) aquifer systems (shallow, middle and deep) occur in the area as confined, unconfined and semi-confined forms. The study was aimed at evaluating the aquifer parameters, mapping our prospective aquifer zones through the study of subsurface lithologies and causes of subsurface water exploitation failures as well as assessing the pollution potentials of the aquifers through borehole logs and water chemistry analysis.

Recently due to advancement in technology and rise in population leading to the need for sustainable subsurface water source. since the surface water has been polluted as a result of massive population explosion due to migrations, and improper land use cases of water exploitation, borehole failures and borehole abandonment have been reported by Offodile (1983).

A study was carried out to examine the nature of underground water aquifer, causes of water exploitation, aquifer pollution cases and problems. There exist a lot of studies on the different aspects of the geology of the region, some of which includes the works of Etuefeotor and Ogidi (1983) and Uma (1984). The observed that the sedimentary sequence of the area are known to contain several aquiferous units. They also observed that the conductivity and storage potentials are not fully known.

The integration of aquifer parameters gotten from existing borehole data as well as surface resistivity parameters derived from surface resistivity measurements has proven to be highly effective in hydrogeophysical studies carried out by Amaechi et al., (2017), yet, there is no design management structure for prevention of water exploitation, pollution, borehole abandonment or borehole failure.

The search for groundwater faces a lot of uncertainties to minimize and to avoid failures, it is pertinent that the right exploration is utilized in the delineation of subsurface water.

2 Research Methodology

The longitude, latitude, elevation of the survey area was determined using the Global Positioning System (GPS) was first determined. We used the Schlumberger Configuration for our VES. The hammer was used to hit the electrode inside the ground as the current charge (I) was induced using the 12V battery through the input electrode and the potential difference (V) was determined using the output electrodes, displayed on the terrameter.

Potential electrodes (output electrodes) are installed at the centre of electrode array with small separation measured with a tape, which is typically less than one-fifth of the distance spacing of the current electrodes. The potential electrode remains constant while the current electrodes are increased in distance in the same position during the survey until the observed voltage becomes too small to measure. A spacing of 3m distance apart was maintained throughout the investigation for the six (6) VES point stations.

The resistance (R) was determined using the Ohm's law, that is, $R = V/I$. The Resistance (R) was multiplied by the Geometric factor (G) to determine the apparent resistivity (ρ). To plot the apparent resistivity (ρ) against $AB/2$, which is further computed using the IP2win software to generate the sounding curves.

3 Results and Discussion

3.1 Results

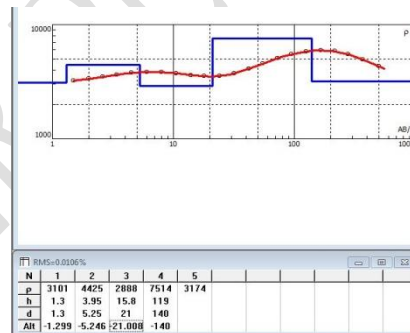


Figure 1: Resistivity curve and geo-electric section of Umuanu

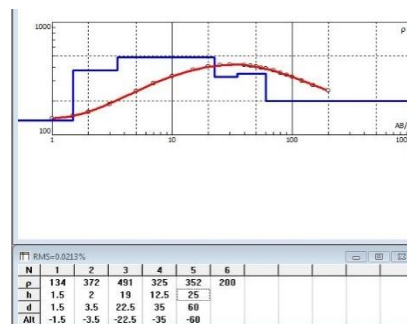


Figure 2: Resistivity curve and geo-electric section of Umuleke

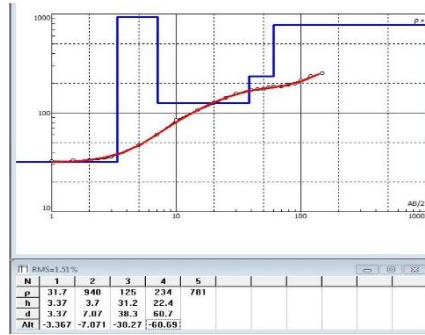


Figure 3: Resistivity curve and geo-electric section of Amaju

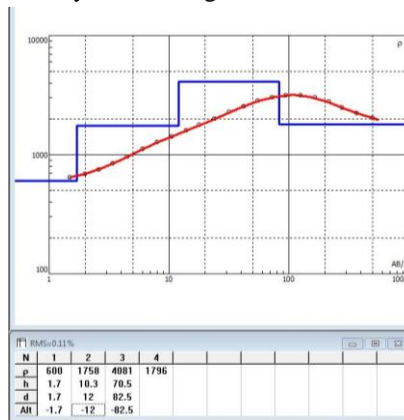


Figure 4: Resistivity curve and geo-electric section of Umudurumba

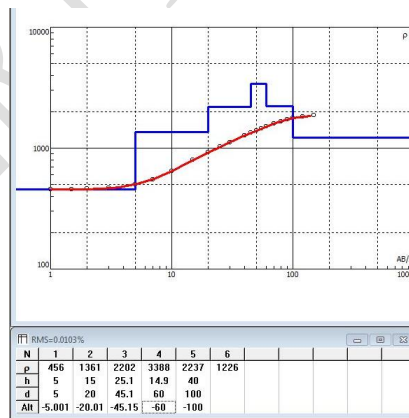


Figure 5: Resistivity curve and geo-electric section of Umudike

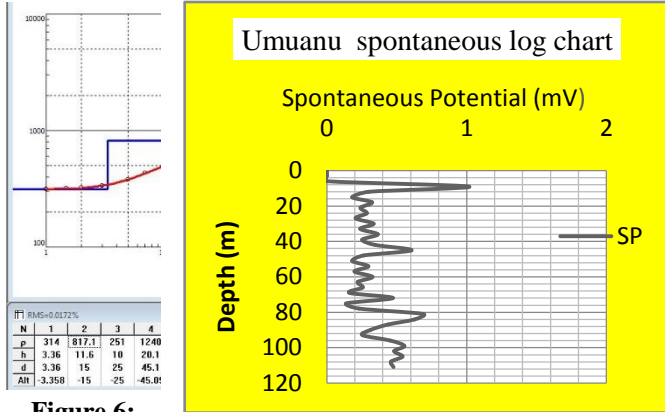
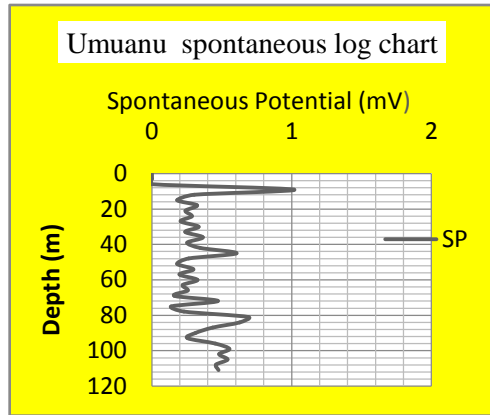


Figure 6:



Resistivity curve and geo-electric section of

Umuchoke

These are borehole charts represented near each VES point stations are listed below

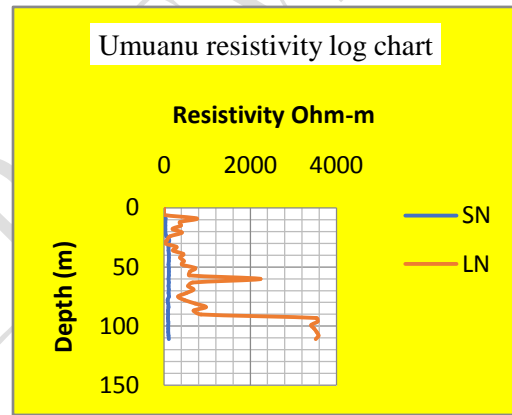


Figure 7: Umuanu log Chart

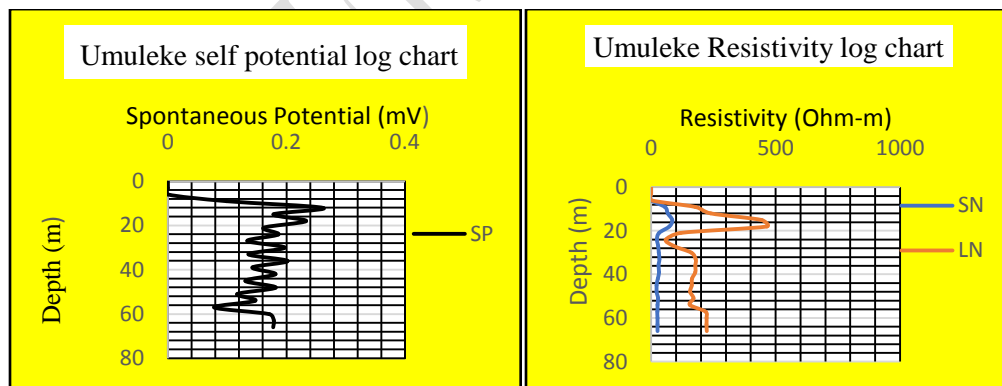


Figure 8: Umuleke log Chart

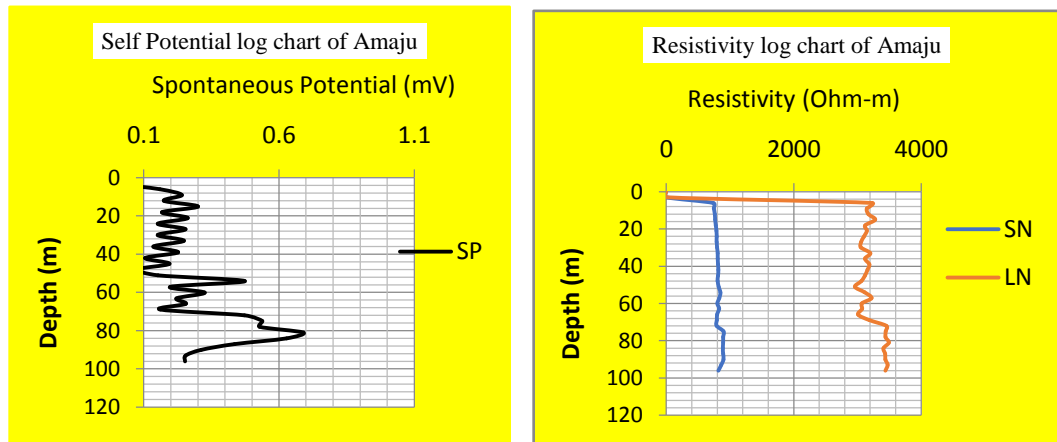


Figure 9: Amaju log Chart

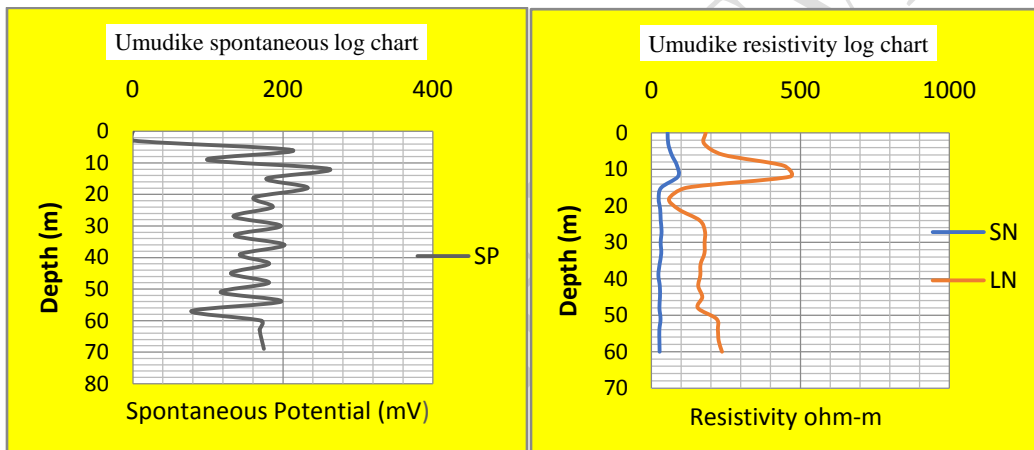


Figure 10: Umudike log Chart

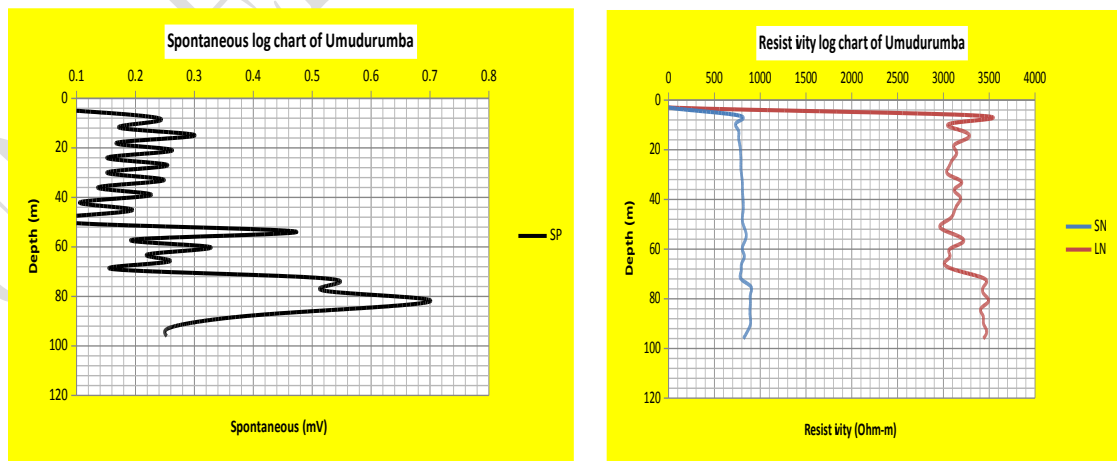


Figure 11: Umudurumba log Chart

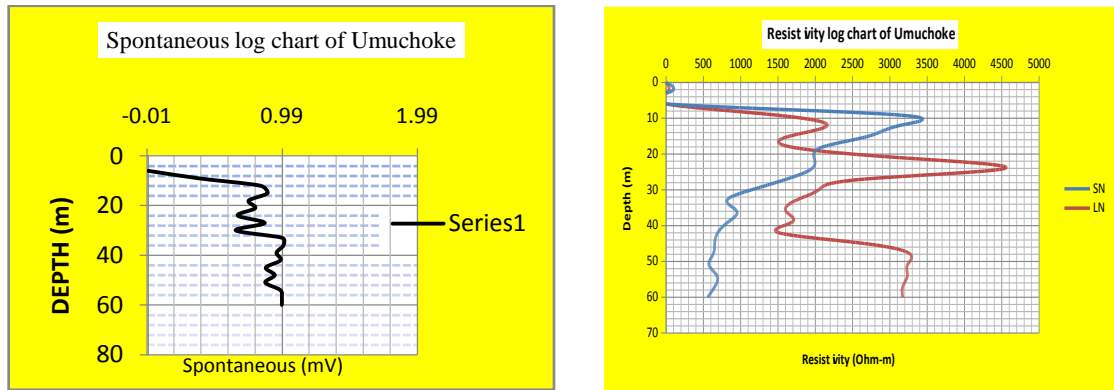


Figure 12: Umuchoke log Chart

3.2 Discussion

This chapter intends to give an elaboration of the geo-electric curves, the types of curves encountered in the area, the depth to potential aquifer in the study area as well as correction of the vertical electrical sounding result with the geophysical well logging result obtained from the research area.

3.2.1 VES Implications of Umuanu

Figure 1, shows the Vertical electrical sounding result from Umuanu community reveals five layered subsurface formation with varying resistivity values of $288\Omega m$ to $7514\Omega m$ and thickness range of 1.3m to 119m. The first layer which cover top soil of the Earth material and has a resistivity value of $3101\Omega m$ and 1.3m thick. The second layer with a resistivity value of $4425\Omega m$ and $3.95m$ thick indicates a consolidated layer and it is interpreted as unsaturated lateritic sand. The third layer of the formation with resistivity value of $2888\Omega m$ consist of dry-sand mixed with gravel. The fourth layer with resistivity value of $7514\Omega m$ reveals a saturated sand mixed with gravelly material that can hold and transmit water. The last layer whose bottom was not determined has a resistivity value of $3174\Omega m$ which is interpreted as saturated fine-sand with undefined depth and thickness.

3.2.2 VES Implications of Umuleke

Result of this location shows six Geo-electric units as observed in Figure 2 and shown in (Table 2). The survey is displayed with resistivity range of $200\Omega m$ to $491\Omega m$ and thickness range of 1.5m to 25m. The first layer consist loose top soil of the Earth material and has a resistivity value of $134\Omega m$ and 1.5m thick. The second layer has resistivity value of $372\Omega m$ with layer thickness of 2m and is interpreted as lateritic sand formation. The third layer of the formation has resistivity value of $491\Omega m$ and is interpreted as consolidated lateritic sand. The fourth layer of Umuleke geoelectric section with resistivity value of $325\Omega m$ with thickness of 12.5m is interpreted as partially saturated sand material. The fifth layer has a resistivity value of $352\Omega m$ and

25m thick. The high resistivity indicates that the layer is made up of non-conductive material and it is interpreted as water saturated coarse-sand which is the potential aquifer unit of interest. The last layer whose bottom was not determined has a resistivity value of 200Ωm.

3.2.3 VES Implications of Amaju

This location shows five-Geo-electric units as seen in the curve in Figure 3. The location is shown with resistivity variation of 31.7Ωm to 940Ωm and thickness range of 3.37m to 22.4m. The first layer which is mostly top soil of the Earth material and has a resistivity value of 31.7Ωm and 3.37m thick. The second layer has resistivity value of 940Ωm with layer thickness of 3.7m and is made up lateritic sand. The third layer with resistivity and thickness of 125Ωm and 31.2m is interpreted as partially saturated fine-sand formation. The fourth layer has a rise in resistivity value of 234Ωm with thickness of 22.4m which indicates layer of low conductivity; hence, it is interpreted as water saturated sands which is the potential aquifer unit. The last layer whose underneath was not determined has a resistivity value of 781Ωm.

3.2.4 VES Implications of Umudike

There are evident six geo-electric units sounding encountered in this location Figure 4. The sounding has a resistivity range of 456Ωm to 3388Ωm with average thickness range of 5m to 40m. The first layer is about 5m thick, which is the top soil that is made up of blackish earth origin with resistivity of 456Ωm. The second and the third layer with layer thickness of 15m and 25.1m and resistivity values 1361Ωm and 2202Ωm is interpreted to contain unsaturated dry lateritic sand and coarse sand formation. The fourth and the fifth layer which has resistivity value of 3388Ωm and 2237Ωm with thickness of 14.9m and 40m are seen as water saturated sand which are the prospective aquifer unit. The sixth layer whose base could not be recognized has

3.2.5 VES Implications of Umudurumba

Six geo-electric units sounding are encountered in this location Figure 5. The sounding has a resistivity range of 134Ωm to 491Ωm with varying thickness range of 1.5m to 25m. The first layer is about 1.5m thick, which is the top soil that is made up of earth origin with resistivity of 134Ωm. The second and the third layer has varying resistivity value of 372 Ωm and 491 Ωm with varying thickness of 2m and 19m, is interpreted to contain unsaturated fine-sand formation. The fourth and the fifth layer has resistivity value of 325Ωm and 352Ωm respectively with thickness of 12.5m and 25m seen as water saturated sand which is the prospective aquifer unit. The sixth layer whose base could not be defined has a resistivity 200Ωm. a resistivity 1226Ωm.

3.2.6 VES Implications of Umuchoke

Geo-electric section result of this survey area indicates six subsurface units as seen in Figure 6. The survey is displayed with resistivity range of 314Ωm to 2723Ωm and thickness range of 3.36m to 14.9m. The first layer

consists loose top soil of the Earth material and has a resistivity value of $314\Omega m$ and 3.36m thick. The second and the third layer has resistivity value of $817.1\Omega m$ and $25\Omega m$ with layer thickness of 11.6m and 10m is interpreted as lateritic and fine -sand formation. The fourth and the fifth layer has a resistivity value of $1240\Omega m$ and $2723\Omega m$ with thickness value of 20.1m and $14.9m$ thick. The resistivity indicates that the layer is made up of non- conductive material and it is interpreted as water saturated coarse-sand which is the potential aquifer unit of interest. The last layer whose bottom was not establish has a resistivity value of $1696\Omega m$.

3.2.7 Geophysical Log Chart of Umuanu

Figure 7 display the geophysical log chart of Umuanu. The borehole was logged and drilled to depth of 119m. From the figure, it is marked that there are pockets of aquifers interval encountered during logging process considering the short and long normal which give more responsible information on freshwater interval composition. A look at the Long Normal Resistivity curve shows that fresh water column occurs at depths of 58m to 62m, and 90m to 117m.

3.2.8 Geophysical Log Chart of Umuleke

Figure 8 shows the well-log chart carried out in Umuleke community. The borehole was logged and drilled to depth of 69m. From the figure, it is obvious that pockets of fresh water aquifers are encountered during logging process considering the short and long normal give more reliable information on the aquifer composition. A look at the Long Normal Resistivity curve shows that there is sand/ clay intercalation between depth of 19m-20m and 20m to 32m. Yet, freshwater interval occurs at depth between 55m to 69m as shown in the log chart

3.2.9 Geophysical Log Chart of Amaju

Amaju Geophysical log chart is shown in and Figure 9. The figure consists of borehole logged to depth of 98m. The log chart displays intercalation of clay and sand formation at depth between 58m and 60m with aquifer depth interval 68m to 98m. The aquifer depth section contains medium to coarse sand formation as shown in the kick of the long normal resistivity signature to the right hence, the well section can yield portable ground water for economic purpose.

3.2.10 Geophysical Log Chart of Umudike

Geophysical well log chart of Umudike is shown in Figure 10 with the aquifer depth summary in table 1. The spontaneous potential log and the resistivity log chart curve indicate a conductive clay formation from the depth of 12m to 21m with fine-sand and clay intercalation between depth of 21m to 48m. Underneath this depth is a clay formation which occurs from 48m through depth of 52m while the aquifer depth starts from depth of 52m

3.2.11 Geophysical Log Chart of Umuduramba

Umudurumba log chart is shown in Figure 11 with drilled depth and logged depth of 96m. The log chart shows a thick clay boundary with the resistivity and spontaneous log kicking to the left from the depth of 58m to 72m. Nevertheless, the aquifer interval starts from 72m through the depth of 96m.

to the log depth of 60m.

3.2.12 Geophysical Log Chart of Umuchoke

Figure 12, shows the result from the chart of Umuchoke. It is seen from the chart that a conductor casing was used to prevent collapse of saturated topsoil during drilling and as such, the log chart starts at 9m. However, from the chart, the aquifer interval starts from 42-60m. Table 1 shows the summary of the logging for aquifer depth.

3.3 Correlation Between VES and Geophysical Well Logging

Result of depth to aquifer in the study area from the vertical electrical sounding corresponds to the aquifer depth obtained from the geophysical well logging result. Result of the Geophysical well logging validate the electrical resistivity survey carried out in the study area which is an approximation confirming the best interval for screen placement for the borehole drilled within the area for optimal yield and good groundwater development.

This section may each be divided by subheadings or may be combined. A combined Results and Discussion section is often appropriate. This should explore the significance of the results of the work, don't repeat them. Avoid extensive citations and discussion of published literature only, instead discuss recent literature for comparing your work to highlight novelty of the work in view of recent development and challenges in the field.

4 Conclusions

This research was aimed at investigating the aquifer potential in parts of Amaigbo in Nwangele Local Government area of Imo State with the vertical electrical sounding technique using the Schlumberger method and with geophysical well log data. The result obtained from the field data shows the Geo-electric parameters which include: aquifer depth, aquifer thickness, and aquifer resistivity of the study area. The aquifer depth and resistivity values at different depth were used to identify the potential depth of the aquiferous layers. Also, result obtained from the long normal resistivity log and the spontaneous potential log charts were used to identify the aquifer section of the drilled borehole located close to the survey area. From the result obtained the following conclusions are drawn.

The result of the vertical electrical sounding result obtained from the resistivity curve obtained from the study area indicates three to four geo-electric layers with KHK, KHA, AK, AKQ, KHAK, and AKHK curve-type.

Result from the sounding resistivity logs showed that the aquifer resistivity of the study ranges from $352\Omega m$ to $7514\Omega m$, which confirms the range of fresh water resistivity.

Result from the survey and the geophysical well logging revealed that the potential aquifer within the study area lies between depths of 45m to 119m which shows that the study area is extremely good for groundwater development.

5 Declarations

5.1 Study Limitations

So far there was no study limitation that affected the outcome of this research.

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