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Investigaton of Ground Water Potentiality in Obasanjo Quarters Damaturu, Yobe State

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Abstract: Groundwater is the most utilized source of domestic potable water in Damaturu metropolis of Yobe State, Nigeria as a result of the paucity of surface water resources, which, due to climate variability, population increase and higher anthropogenic activities, are depleting over time. This study, therefore, assessed the groundwater potential of Obasanjo Quarters, Damaturu for zoning appropriate areas for sustainable borehole siting. A total of Seven (7) Vertical Electrical Sounding (VES) lines, performed using the Schlumberger array, were used to characterize subsurface geoelectric layers in the study area and to delineate aquiferous targets. Interpreted resistivity data shows several geoelectric layers, mainly inter-bedded sands, clays, silt and sandy clay lenses characteristic of the Chad Formation with unconfined and confined aquifer conditions across many sounding points. This is supported by the curve types of K, KH and mainly A-types generated from the sounding data, which show good hydrogeological conditions across the study area. However, several VES points had low resistivity layer at depth of ~80 m to ~350 m and interpreted as saturated layers with high groundwater potential and suggested drilling depth of 90 ± 5 m to 350 ± 5 m. The study therefore confirms that Obasanjo Quarters has exploitable groundwater bearing formations, and therefore, can support domestic and municipal water supply. This result provides basis for informed drilling of boreholes and for sustainable groundwater management in Damaturu metropolis, where water table is on the decline and reported cases of borehole failures are rife in recent times.

I. INTRODUCTION

Groundwater refers to the subsurface water that occurs beneath the water level in soils and geologic formations that are fully saturated and its flow is controlled by the force of gravity (Tijani, 2017).Groundwater is a mysterious nature's hidden treasure. Its exploration and exploitation have continued to remain an important issue due to its unalloyed needs. Though there are other sources of water, like streams, rivers, ponds, etc., none is as hygienic as groundwater because groundwater has an excellent natural microbiological quality and generally adequate chemical quality for most uses (Okpoli, 2017). Ground water is one of the most essential natural resources to support human health, economic development and ecological diversity. Due to its several inherent qualities (e.g. widespread and continuous availability, excellent natural quality, limited vulnerability, low development cost and drought reliability), it has become an important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries (Todd & Mays, 2005).

Groundwater is the water that occurs beneath the ground surface, filling the pore spaces between grains in sediments and sedimentary rocks, and filling cracks and crevices in other types of rock known as aquifers. Groundwater is quite pure and largely confined from surface pollutants as a result of their depth of storage and natural filtration through different subsurface layers. Thus, there is a need to undertake an all-inclusive investigation of groundwater potential in the area to identify suitable locations for groundwater exploitation to alleviate the challenges of potable water supply in the area. Groundwater is described as the water found beneath the surface of the earth in underground streams and aquifers (Anomohanran, 2011). The reason why groundwater has become more popular as a source of potable water is due to its availability and 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. Various researchers have employed different methods in exploring this very essential life sustaining resource.

The occurrence of groundwater otherwise aquifer is dependent on the geology, geomorphology and rainfall of an area. But rainfall ultimately controls the amount of groundwater recovered from wells in any given locality. In the Basement complex terrain, groundwater occurs in the weathered regolith, fissures and in fractures in the fresh crystalline rocks, exploited through boreholes, wells and contact springs.

The storage of groundwater is confined to fractures and fissures in the weathered zone of igneous, metamorphic and volcanic rocks, the thickness of which range from <10 - 60 m in arid and humid rain forest. The groundwater resources here are usually limited (Eduvie, 2006). The biggest water bearing units in Nigeria include: Chad, Kerri Kerri, Nsukka, Benin and Abeokuta Formations. This is because they are largely formed from sandstones, alluvial deposits and other related arenaceous sedimentary rocks.

Groundwater conditions at a location are mainly described through the distribution of permeable layers (like sand, gravel, fractured rock) and impermeable or low-permeable layers (like clay, till, solid rock) in the subsurface. Groundwater has become immensely important for different water supply purposes in urban and rural areas of both the developed and developing countries. However, groundwater exploration in hard rock terrain is a very challenging and difficult task, if the promising groundwater zones are associated with fractured and fissured media. In such an environment, the groundwater potentiality depends mainly on the thickness of the weathered/ fractured layer overlying the basement. Most groundwater projects recorded in basement complex aquifers have revealed geophysical survey as a compulsory perquisite to any successful water well drilling project. The electrical resistivity method involving the vertical electrical sounding, (VES) technique is extensively gaining application in environmental, groundwater and engineering geophysical investigations.

The growth in the population of the people in most cities and towns in Nigeria and the associated expansion in industrial activities has placed enormous pressure on the available water resources. Damaturu is located in the semi-arid region of Nigeria where there is scarcity of rivers and streams. The people in Damaturu and its environments depend heavily on groundwater for their domestic and industrial water supply. The demand for quality drinking water is increasing and its availability is strongly affected by climate change. Research reports have shown that groundwater table and its recharge ability are declining due to climate variability (Chartzoulakis et al., 2001; Tsagarakis et al., 2001; Agada and Yakubu, 2022).

In a semi-arid region area such as Damaturu where precipitation remains the main groundwater recharge, the fluctuation in the amount of annual precipitation in the area has affected both the groundwater water-table, quantity and quality (Agada and Yakubu, 2022). Extreme weather events such as droughts and heat wave which are prevalent in semi-arid regions are known to influence the lowering of water table. As a result of climate change, water availability is limited by climate variability (Agada and Yakubu, 2022). Due to climatic variability, the demand for irrigation water has become very high in semi-arid regions and the need to use groundwater for irrigation purposes has also become exceedingly necessary. Ishaku et al. (2013) evaluated the groundwater potential in Bida Basin of North-Central Nigeria, and their results showed that the area is composed of topsoil, sand, clay, sandstones and sandy-clay layers. The groundwater bearing formation in the area has a thickness which varies from 35-50 m. The aquifer in the area is sandstone which is the fourth layer.

Agada et al. (2020) investigated groundwater potential in Gashua Northeast Nigeria. They observed that the area is made up of five (5) geologic layers which are: Topsoil, clay, sand, sandy-clay and sand. Amadi et al. (2013) evaluated the groundwater potential in some parts of Paiko, north-central Nigeria. The results of their study indicated that the area is composed of three geologic layers, which are: The topsoil, whose resistivity ranges from 0.9 m to 3.5 m. This topsoil is underlain by a weathered/fractured basement whose resistivity values ranges from 1.6 m to 29.0 m. The last geologic layer in their study area was the basement complex whose resistivity ranged from 900 to 2800 Ωm, extending to an infinite depth.

Egwebe et al. (2004) investigated the aquifer potential at Ivbiaro, Ebesse in Edo State, using the geo-electrical direct current resistivity technique. The interpretation of their data yielded a depth of 96-147 m to the aquifer (sand) within the sand/shale sequence of the Mamu Formation.

Amadi et al. (2011) evaluated the groundwater potential of Pompo Village in the neighborhood of Gidan-kwano Campus of Federal University of Technology, Minna, using electrical resistivity method. Five (5) out of the twelve (12) VES showed good groundwater potential in the study area. Electrical resistivity survey method has proven to be very effective for groundwater exploration (Obiora et al., 2017; Agada et al., 2020).

Muhammed et al. (2008) delineated the auriferous units in the central part of Minna by using electrical resistivity method; they were able to determine the depth to the groundwater and the thickness of the aquifer in their study area. Their results showed that the area was composed of four geological formations and the auriferous unit have resistivity value of 120-900 Ωm and an average thickness of 25 m - 30 m. Agada and Yakubu, (2022) reported that some groundwater from Pompomari area of Damaturu is contaminated and could be responsible for the prevailing health complications associated with the consumption of contaminated water in the area. The increasing demand of groundwater for domestic, agricultural and industrial purposes has made groundwater resources management a very important tool for sustainable development. Some boreholes in Damaturu have not been able to supply water throughout the year due to failures associated with improper sitting and reduction in groundwater table. Accessibility to quality drinking water in New Jerusalem area of Damaturu has been limited due to population growth and industrial expansion.

In view of these constraints, there is a need for more groundwater exploration in New Jerusalem area of Damaturu Metropolis to supplement the available groundwater data at the Rural Water Supply and Sanitation Agency (RUWASA) Damaturu, Yobe State. The existing data could no longer provide reliable information as the number of borehole failure across the study area and other parts of Damaturu metropolis is increasing. The estimated 60 m drilling depth for boreholes in the New Jerusalem area of Damaturu is no longer sustainable due to the decline in groundwater table, low borehole yields and reports of water pollution related infections. In view of these prevailing conditions in the study area, this study is focused on evaluating the groundwater potential in New Jerusalem for efficient groundwater management in order to sustain adequate water supply to the metropolis.

The results of this research will serve as a guide to groundwater exploration in the study area and Damaturu at large. Water remains one of the vital elements in life. It is very much vital to human existence. It is one natural resource that is not only essential for the survival of mankind but also for the survival of the natural environment. The availability of water has played a key role in the development of all civilizations. Indeed, especially in the ancient times, water scarcity prevented the development of settlements. Social welfare and economic development may also be hampered in the absence of reliable water supplies. This is particularly true of sub-Sahara and Sahara countries, such as Nigeria, where water resources are extremely limited and highly valued as a social and economic good. It has been observed that more than two billion people worldwide depend on groundwater for their daily water supply, and a large proportion of the world's agricultural and industrial water requirements are supplied by groundwater. Higher agricultural use of water has been in the aspect of irrigation of farmlands.

II. STUDY AREA AND METHOD

A. Study Area

The study area is location north-eastern Nigeria is at Obasanjo Quaters Damaturu, yobe state. The site is easy to access by all means. It is located in the Chad Basin and it has a semi-arid climate characterized by a long dry season and short rainy season. The duration for the rainfall last for about three to four months and the annual rainfall ranges from 500-1000mm and the rainy season is from June to September (Agada et al., 2011). Damaturu has an estimated population of 69, 952 people in 2010 according to the National Population Census. Damaturu is located within the Chad Basin. The Chad basin extends to five countries in Africa, namely Chad, Nigeria, Cameroon, Central Africa Republic and Niger. The Chad Basin covers parts of Borno State, Yobe State, and Jigawa state (Agada et al., 2020). In Nigeria, about ten percent of the Chad basin lies in the north-eastern part of Nigeria. The Chad formation is composed of inter-bedded sands, clays, silts and discontinuous sandy clay lenses which give aquifer characteristics ranging from unconfined, through semi-confined to confined types (Adegoke, 1985; Goni et al., 2000; Bura et al., 2018).

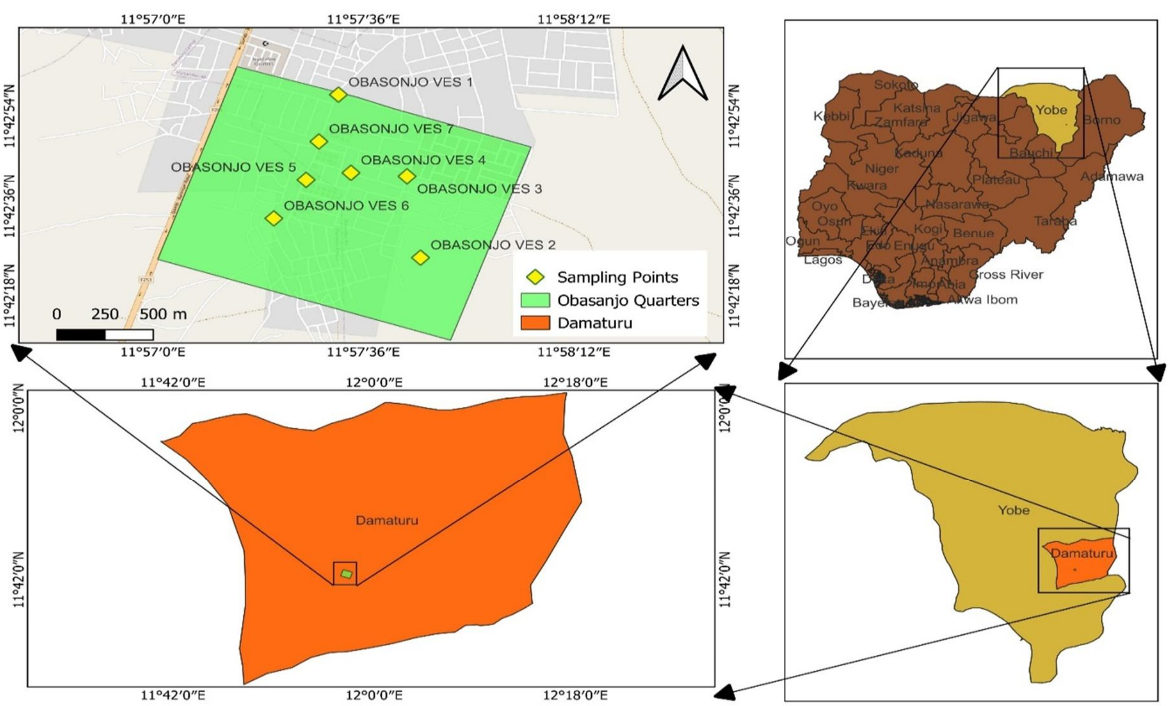


Fig. 1 Study Area Map

1) Climate and Vegetation of Damaturu

Damaturu local government area has hot and dry climatic features. The hottest month is March, April, and may with temperature ranging from 390c-420c. The period of rainy season in the town is 120days, annual rainfall ranges from 500mm-1000mm and the rainy season is normally from June-September and some times of to October. The vegetation of Damaturu is classified as Sudano-Sahelian savannah.

2) Relief and Drainage

Damaturu is part of the open plain developed on young sedimentary rocks of Chad formation, which is made up of clay and horizons the basin averages depression is between 45-75 meters and separated from Benue valley by Biu plateau. The topography of the town is flat with open valleys running on a north –south west axis through the town during the rainy season this act as stormy water drainage flowing to the north – east (El-idrisi,2000). Water divided is found about few meters below in the area.

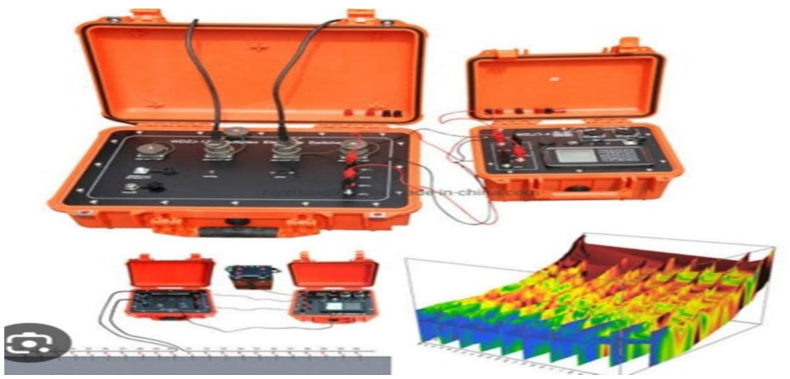
B. Method

In the course of my research work, geological survey will be conducted concurrently by the use of electrical resistivity machine in other to determine the resistivity of each rock layer beneath the earth surface. The electrical resistivity consists of schlumberger array type, Where four electrodes will be placed in the ground, two current electrodes (AB/2) and the other two will be the potential (MN/2), by vertical movement of the current electrode. I will be able to take the variations in the resistivity of the ground. Because the more widely you move the current electrode, the deeper you go horizontally.

The schlumberger array type will be used in doing the survey with the following materials:

1) Field Equipment and Their Uses

a) Terrameter: is a compiling machine that computes and display the result of the sub surface resistivity at every electrodes spacing. The type of terrameter used is Mc OHM-EL terrameter.

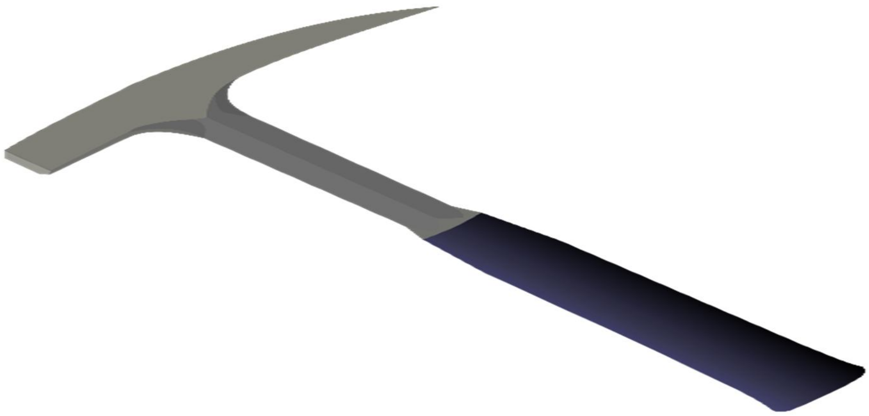


b) Electrodes (currents and potential electrodes): This are means through which current is passed into the ground and potential difference is measured respectively.

c) Measuring tape: Is a tape laid on the ground and on both side of the terrameter, to provide distance measurement on where to dig electrodes during spacing.

d) Battery: its source of energy for terrameter to work.

e) Hammer: used to dig electrodes to an appropriate depth.



f) Reel: (red and black wire): This contains wire round the device. It provides a means of connection between electrodes and terrameter. The wires are threaded onto the terrameter, and clipped on the electrodes as appropriate.

g) Global positioning system (GPS): This is used to find the coordinate of the proposed site and in making the community map identifying the site.

2) Data and Data Acquisition Procedure

In the process of collecting my data, the resistivity survey method was used by taking values using the necessary instrument by carrying out geophysical survey. Using the resistivity meter model McOHM-EL 2119, the electrode and all other instrument were arrangement accordingly. The resistivity meter was at the center connected with the battery, the reels wire was also connected together the electrodes. The potential electrode MN/2 was placed with a spacing of 0.25 where the current AB/2 at 1. The variation in the resistivity values was recorded for a total distance of 500m horizontally. When the equipment's were set up as required, terrameter is switch on. ENTER bottom on the terrameter was pressed and the result was displayed. The current electrodes are then continued to be moved outward along the measuring tape, with the potential electrodes kept fixed to obtain more information of the sub surface. The field procedure consists of expanding the current electrodes 'AB' while keeping the potential electrode 'MN' relatively fixed.

For each reading current was sent into the ground through A and B which setup the measured potential differences between the potential electrodes M and N the magnitudes of the potential difference developed is a measure of the electrical resistance ground between probes. The resistance is in turn a function of the geometrical configuration of the electrodes and the electrical parameters of the ground.

The following spacing intervals are used in obtaining the values of AB/2 and MN from the electrode spacing. For AB/2, the distances of current electrodes are kept at 1, 2, 2, 4, 6, 6, 8, 10, 10, 15, 20, 20, 30, 40, 40, 50, 60, 60, 80, 100, 100, 150, 200, 200, 250, 300, 300, 350, 400, and 500. The corresponding distances of MN at the above AB/2 distances are 0.25, 0.25, 0.5, 0.5, 1, 1, 1, 2, 2, 2, 4, 4, 4, 8, 8, 8, 12, 12, 12, 20, 20, 20, 30, 30, 30, 40, 40, 40, and 40.

As AB became larger, the potential setup between electrode exceeded the measuring capabilities of the instrument due to the fact that the field at the center of the configuration varies inversely as the square of the length of the configuration 'AB' when the situation occurred, a new value typically about three times larger than the preceding value was established for 'MN'.

III. RESULTS AND DISCUSSION

Table 1 summarizes the results of physical parameters obtained from the VES collected from Obasonjo Quaters. The physical parameters are, coordinates and elevation, electrode maximum spacing and date of survey are all recorded.

Table 1 Physical parameters

S/N	VES NO.	COORDINATE	ELEVATION	ELECTRODE MAXIMUM SPACING (AB/2)	ELECTRODE MAXIMUM SPACING (MN)
1	OBASONJO VES 1	11.57'31.76064E 11.42'58.31604N	367	500	40
2	OBASONJO VES 2	11.57'45.80604E 11.42'25.6418N	366	500	40
3	OBASONJO VES 3	11.57'43.49592''E 11.42'41.99814''N	366	500	40
4	OBASONJO VES 4	11.57'33.9''E 11.42'42.7''N	369	500	40
5	OBASONJO VES 5	11.57'2622132''E 11.42'41.29308''N	368	500	40
6	OBASONJO VES 6	11.57'20.7E 11.42'33.6''N	370	500	40
7	OBASONJO VES 7	11.57'28.41444''E 11.42'48.9564''N	366	500	40

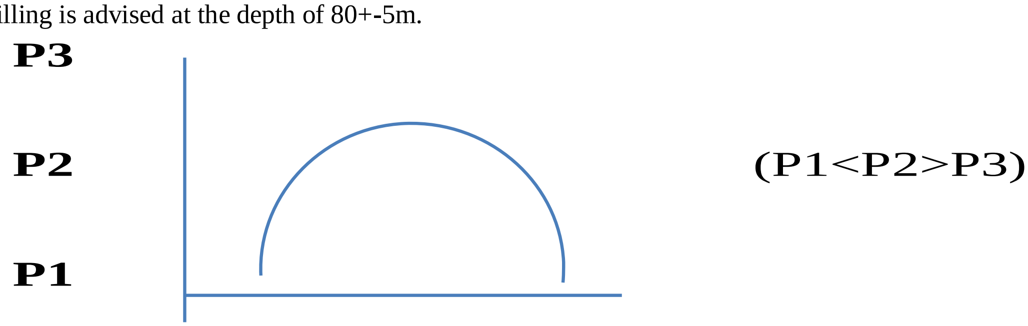
A. Graphical Presentation of Vertical Electrical Sounding (VES) and Layered Model

The data obtained from the site were interpreted using IX1D inversion computer interpretation software. These are interactive sounding data models in terms of a layered earth (1D) models. These are graphically presented in plate style format, apparent (ρ) in Ohms-meter against AB/2 meters.The field data were plotted showing the following information viz resistivity, thickness, depth, and type of configuration.

Discussion of Graphical Presentation of Vertical Electrical Sounding (VES) And Layered Model

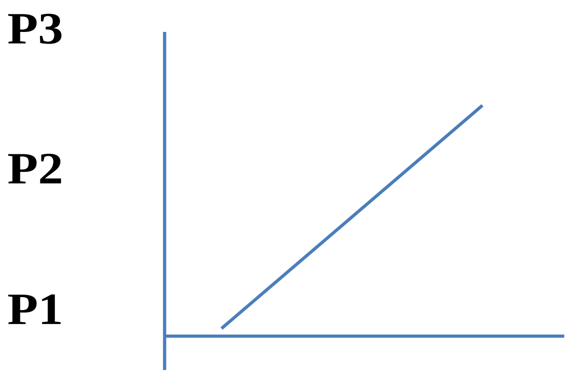
1) Obasonjo (VES) 1

Six main geoelectric layers were revealed through the investigation, with a k – curve type (P1<P2>P3). Shows that the lowest resistivity is located in the 4 layer. And it has a high groundwater potential in this VES. There is an indication zone of saturation at100 m, the drilling is advised at the depth of 80+-5m.



2) Obasonjo (VES) 2

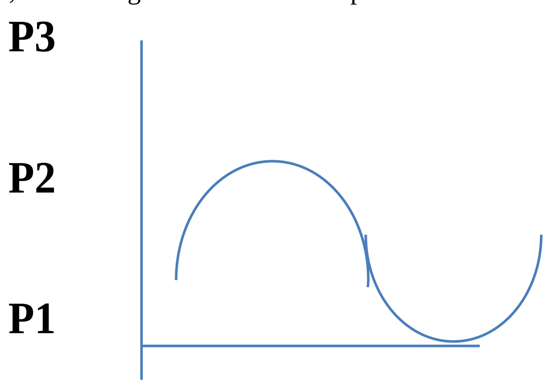
Six main-geoelectric layers were revealed through the investigation, with an A – curve type (P1<P2<P3). Shows that the lowest resistivity located in the 3 layer. And it has a high groundwater potential in this VES. There is an indication zone of saturation at 80 m, the drilling is advised at the depth of 75+-5 m.



(P1<P2<P3)

3) Obasonjo (VES) 3

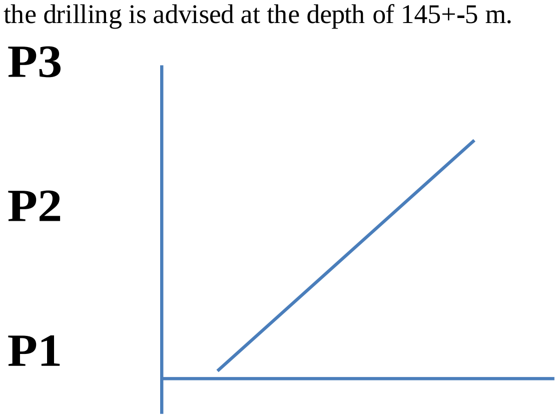
Five main-geoelectric layers were revealed through the investigation, with a kH – curve type (P1<P2>P3) (P1>P2<P3). Shows that the lowest resistivity located in the 4[Th] layer. And it has a high groundwater potential in this VES. There is an indication zone of saturation at 150m, the drilling is advised at the depth of 145+- 5m.



(P1<P2>P3, P1>P2<P3)

4) Obasonjo (ves) 4

Four main-geoelectric layers were revealed through the investigation, with an A– curve type (P1<P2<P3). Shows that the lowest resistivity located in the 2 and 4 layer. And it has a high groundwater potential in this VES. There is an indication zone of saturation at 150 and 300m, the drilling is advised at the depth of 145+-5 m.



(P1<P2<P3)

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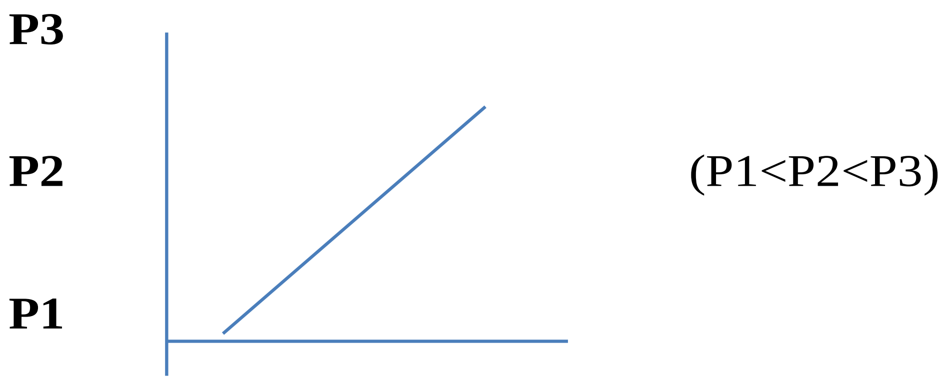
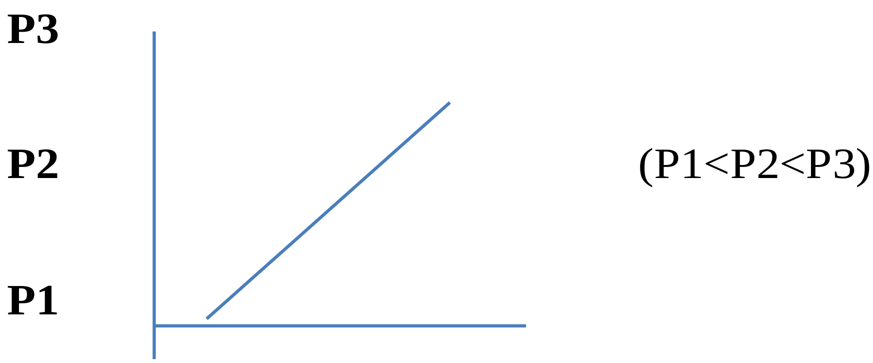
5) Obasonjo (VES) 5

Four main-geoelectric layers were revealed through the investigation, with an A – curve type (P1<P2<P3). Shows that the lowest resistivity located in the 3rd and 4th layer. And it has a high groundwater potential in this VES. There is an indication zone of saturation at the depth of 80 and 350 m, the drilling is advised at the depth of 78 or 350 +-5m.



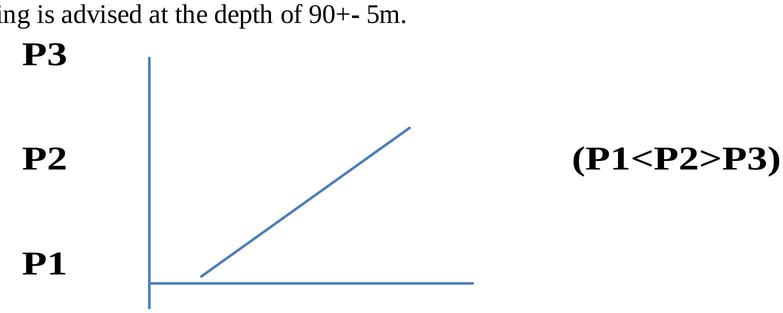
6) Obasonjo (VES) 6

Three main-geoelectric layers were revealed through the investigation, with an A – curve type (P1<P2<P3). Shows that the lowest resistivity located in the 2 layer. And it has a high groundwater potential in this VES. There is an indication zone of saturation at 150 to 300m, the drilling is advised at the depth of 140+-5m.



7) Obasonjo (ves) 7

Four main-geoelectric layers were revealed through the investigation, with a A – curve type (P1<P2<P3). Shows that the lowest resistivity located in the 3 layer. And it has a high groundwater potential in this VES. There is an indication zone of saturation at 100m and 300m, the drilling is advised at the depth of 90+- 5m.



IV. CONCLUSION

The geophysical investigation conducted in obasonjo quarters has successfully delineated areas with significant groundwater potential. Through the application of methods such as electrical resistivity sounding, we identified subsurface layers with promising aquifer characteristics. This finding is crucial for guiding future groundwater exploration and borehole drilling in the region. The study revealed that certain zones within the study area exhibit higher groundwater potential, particularly in regions of lower resistivity values, which correspond to saturated subsurface formations. These areas are likely to provide a reliable source of groundwater, essential for supporting the water needs of Obasanjo area growing population and other activities.The effectiveness of the geophysical method employed was validated by the consistency of the results with existing hydrogeological data. In conclusion, this project has provided a comprehensive assessment of the groundwater potential in obasanjo quarters, offering valuable insights for water resources management and planning in the region. The outcomes of this investigations will play a vital role in enhancing the water security of that area and its soundings.

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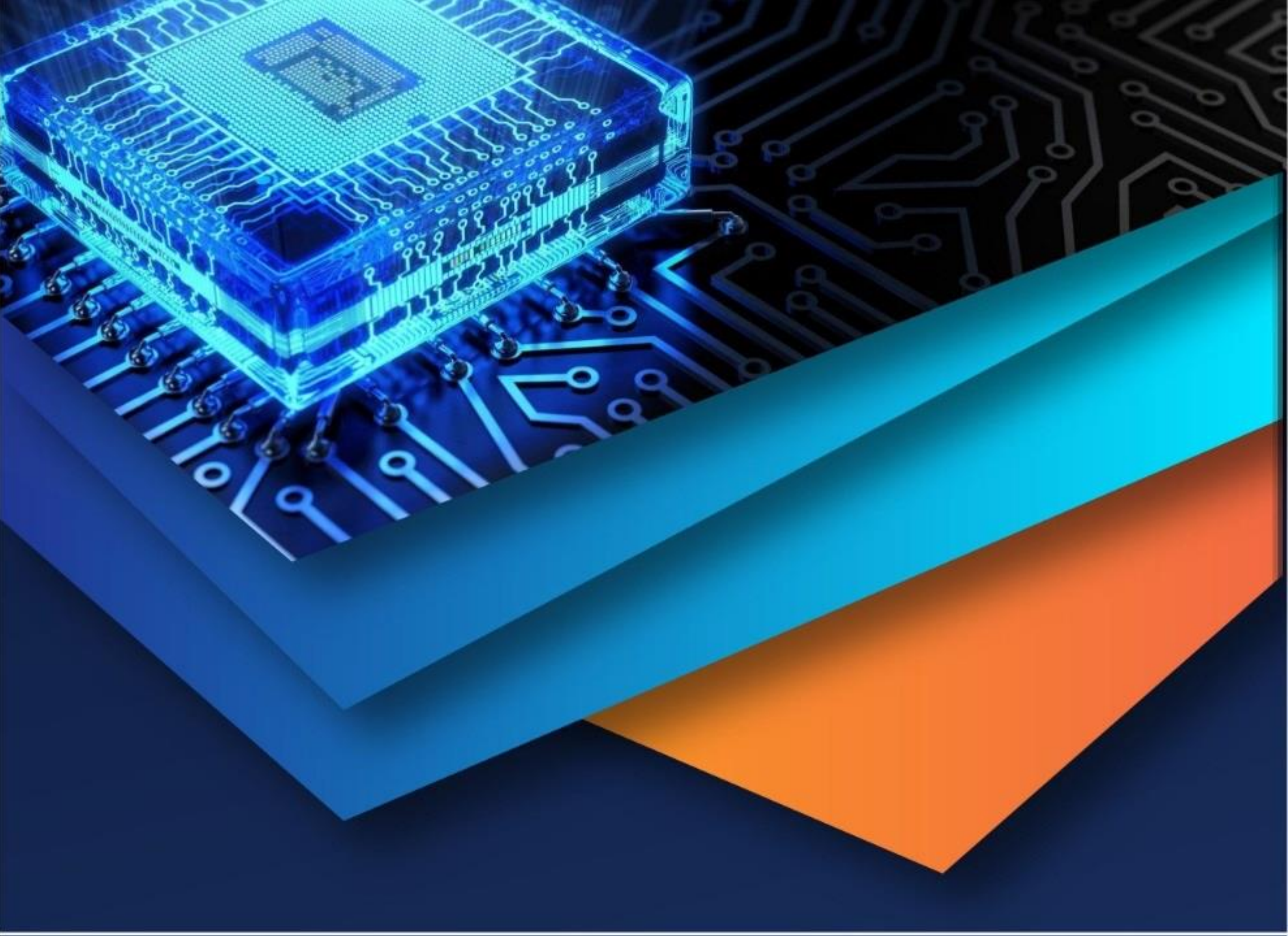

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