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Geoelectric Investigation of Ground-water for Potential of Drilling a Borehole at Owoyemi Quarters Odigbo, Ondo State of Nigeria

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ABSTRACT

Groundwater potential analysis was carried out at a proposed site across a location at Owoyemi Quarters, Odigbo, Ondo State, Southwestern Nigeria, to investigate the depth to bedrock, possible geologic structures of table water conditions. One Vertical Electrical Soundings (VES) was carried out along the site and this was done using a Schlumberger configuration. Evaluation of the geophysical properties of the soil was carried out across the site. The geophysical results showed three geo-electric layers; top sandy layer, weathered basement, fairly hard basement and weathered/fresh basement. The overburden thickness is about 6-8m, the fractures are presumed at 40-45m, 80-90m. The drilling should be done to the depth of about 100-120m to allow large reservoir within the aquifer. Hence, if upon drilling, the water yield is appreciable, the driller is advised to terminate the drilling process. The aim of this work is to drill a borehole for the Owoyemi Quarter's that will serve the quarters its environs.

Keywords: *Groundwater, Potential, Geoelectric Method, Grain Size Analysis, and Drilling.*

INTRODUCTION

This investigation of geotechnical potential analysis that is commonly applied to Geotechnical geophysics is the application of geophysics to geotechnical engineering problems, such investigations normally extend to total depths of less than 30m. Geotechnical geophysical surveys are performed on the ground surface, subsurface within boreholes, in water, and from the air. A geotechnical site investigation is the process of collecting information and evaluating the conditions of the site to design and construct the foundation for a structure and identifying the location of potential water table conditions (Adepelumi et al, 2009).

There is no gain saying that without water there would be no life of any kind on earth. Apart from air, it is the most important. Water is one of the most essential natural resources for the survival of human, animal, and plants. It covers approximately 7 of 1%

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of the Earth's surface and plays a vital role in sustaining life, supporting agriculture, industrial production, environmental balance, and socioeconomic development (UNESCO, 2023). Despite its abundance on the planet, only about 2.5% of the Earth's water is freshwater, and less than 1% is readily the sustainable management of water resources a global concern (Shiklomanov &Rodda, 2003).

Water is indispensable for domestic activities such as drinking, cooking, washing, sanitation, and, recreation. It is equally important in agricultural production, where it supports irrigation and livestock farming, and in industrial operation, where it is used for processing, cooling, and manufacturing activities (Freeze &Cherry, (1979). The available of adequate and safe water resources is therefore directly linked to public health, food security, economic growth, and the environmental sustainability.

In the last decade, the involvement of geophysical and geotechnical methods in civil engineering has become a promising approach (Adepelumi et al, 2009; Adepelumi and Olorunfemi, 2000). Geophysical methods in cooperation with geotechnical investigations are able to provide answers to those problems, and will even disclose several types of structures that typical use of geotechnical methods, like drills, or field investigation, might fail to detect (Soupios et al., 2007). To make water available for the Site, we there-for commissioned this work for immediate development of groundwater. This will be done through the drilling of one borehole, it is our hope that this borehole will serve the site for its present and future needs of the water necessary for domestic use.

The purpose of this geotechnical investigation research is to provide series of information on the research site for the engineers with a basic understanding of how geotechnical geophysical tools are used to image or characterize the shallow subsurface of the Earth, typically to depths of less than several 10m. Groundwater also constitutes a significant portion of the world's freshwater resources and serves as a dependable source of portable water for billions of people worldwide. According to the United Nations, groundwater accounts for nearly 99% of all liquid freshwater available on Earth's and supplies drinking water t approximately half of the global population (UNESCO, 2022). In developing countries such as Nigeria, groundwater is often preferred over surface water because it is generally less susceptible to contamination and seasonal fluctuation (Todd & Mays, 2005).

The Basement Complex terrain of south western Nigeria is characterized by crystalline rocks with negligible primary porosity. Consequently, groundwater occurrence is restricted to weathered overburden and fractured bedrock zones (Olorunfemi and Olorunniwo, 1985). Studies conducted within Ondo State have shown that the occurrence, storage and movement of groundwater are strongly controlled by lithology, weathering thickness, fracture density and lineament distribution. Productive groundwater zones are generally associated with weathered and fractured basement aquifers. Geophysical investigations can also be used as the basis for making better

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selection of voids location in design and construction of a building foundation as well as a location of potential water table. Geotechnical and geophysical investigations, in many instances, enhance the reliability and speed of geotechnical investigations, and reduce the cost of the investigation.

In Nigeria, rapid population growth, urbanization, industrialization, and climate variability have increased the demand for water resources, particularly groundwater. Many rural and semi- urban communities depend largely on boreholes and hand-dug wells for their daily water supply due to inadequate public water infrastructure (Adelana & MacDonald, 2008). However, the success of borehole drilling depends largely on understanding the subsurface geological conditions and identifying aquifer zones capable of yielding sustainable quantities of groundwater.

Groundwater occurs within pores fractures, and weathered zones of subsurface geological formations known as aquifer. The occurrence, distribution and movement of groundwater are controlled by factors such as lithology, porosity, permeability, fracture density, and the degree of weathering of rocks (Fetter, 2018). Consequently, detailed hydrogeological and geophysical investigations are necessary before borehole drilling to minimize the risk of drilling dry or low-yield wells. Geophysical methos, particularly electrical resistivity techniques, have become valuable tools for groundwater exploration due to their effectiveness, non- destructive nature, and cost efficiency.

The Vertical Electrical Sounding (VES) method is widely employed for delineating subsurface layers, determining aquifer characteristics, estimating overburden thickness, and identifying groundwater- bearing formation (Telford et al, 1990). By measuring variations in subsurface electrical resistivity, geoelectric surveys provide crucial information for locating suitable borehole sites and evaluating groundwater potential.

The present study focuses on the geoelectric investigation of groundwater potential for borehole drilling and borehole analysis at Owoyemi Quarters, Alagbede, Odigbo and its environs in Ondo State, Nigeria. This study aims to characterize the subsurface geology, identify potential aquifer zones, determine their geoelectric properties, and assess their suitability for sustainable groundwater development. The findings are expected to contribute to effective groundwater resource management and improve access to portable water within the study area

The method aid the process of the geotechnical site investigation and preparation of a report. Some common methods of soil investigation and sampling are noted, comments and typical values for relevant properties are provided, and classification systems used in a geotechnical site investigation report are summarized.

The aim of this geophysical investigation for groundwater exploitation is the assessment of potential through drilling of one borehole at Owoyemi Quarters, Odigbo using Geophysical Method.

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Location

The location of the site where the borehole is to be drilled is at Akinfolarin Road, Orita Odigbo, Ondo State. The access roads are motor able all the year round, so there is no problem of accessibility for the drilling rig and the supporting vehicles during the rainy season.

Geology and Hydrogeology

Ore where the survey was done is underlain by rocks of the crystalline Nigeria Basement Complex, Principal among which are granites (charnokitic/Bauchitic) and gneiss. These rocks were emplaced in Precambrian times and have over time been subjected to tectonic activities characterized by large changes in temperature and pressure resulting in features like joints, faults and fractures within the Basement Complex rocks. Such fractures are those that influence the groundwater in crystalline rocks especially if they exist at depth and are over laid by a thick superficial cover (overburden).

Although there are visible outcrops in the area worked upon, outcrops also exist in the adjoining areas. This is a clear index to the fact that on a regional projection, such rocks exist at depth beneath the superficial cover that is predominant in the area. This is of immense hydrogeological interest in this investigation.

METHOD

Geophysical Investigation

The geophysical investigation was carried out using surface electrical resistivity method with Geosensor DDR2 and accessories. The techniques employed in order to meet the objectives of the investigation were

(1) Horizontal Profiling (HP) using Wenner electrode configuration and

(2) The Vertical Electrical Sounding (VES) using the Half Schlumberger {Hummel} electrode configuration. For the VES, the Schlumberger electrode configuration was adopted. A Geosensors DDR2 was used to carry-out field measurement of resistance (R) from which apparent resistivity (pa) was calculated by the relation.

Pa=KR Where R= Resistance in ohms

$$K= \frac{(AB/2)^2 - (MN/2)^2\pi}{2MN}$$

And AB = Current electrode spacing in meters.

MN = potential electrode spacing in meters

π =3.142

The theory and the field procedure of the VES are omitted in this write-up. The VES investigation was conducted at a point.

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Results and Interpretation of Vertical Electrical Sounding (VES)

All VES data plotted on a logarithmic graph with current electrode separation, AB/2 on the abscissa and the apparent resistivity, pa, on the ordinate. Interpretation of the VES curve was carried out using the methods stated below.

(i) Visual curve Inspection.
(ii) Partial survey marching using master curve for VES over layered structure by Orellana & Mooney (1966).
(iii) Comparison with previous works of one point that was isolated for VES through HP, one of those points appears most probable to meet the requirement for which the investigation was conducted at the site.

Interpretation of Results

VES 01

Table 1: Vertical Electrical Sounding of the Study area

Layer	True Resistivity (ohms)	Thickness (m)	Hydro –Geologic Remark
1	184	0-1	Top Soil
2	706	2-8	Weathered Basement
3	865	8-15	Fairly Hard Basement
4	1200	20-Above	Fresh Basement

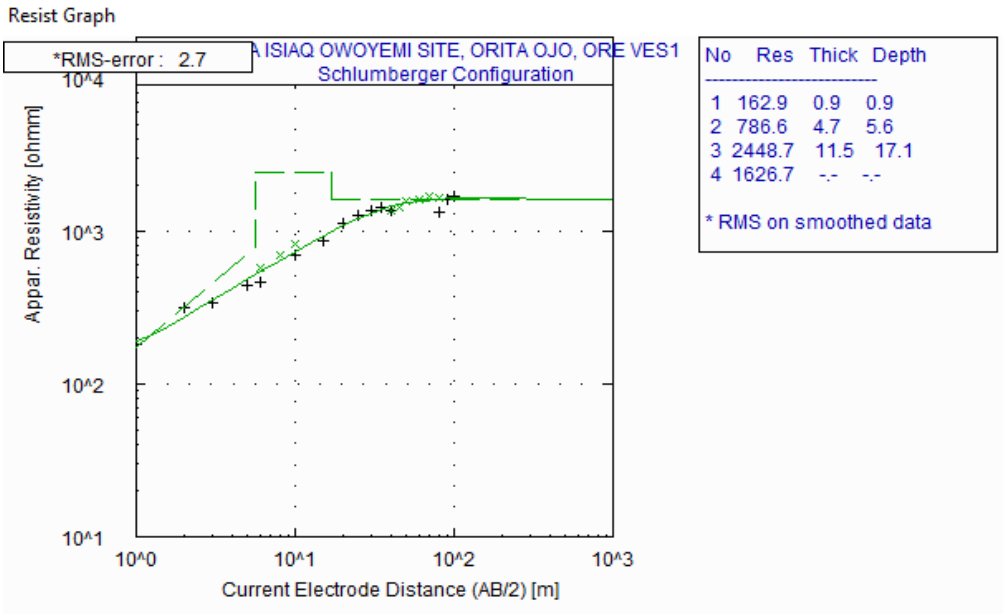

Figure 1: Vertical Electrical Sounding of the Study area

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CONCLUSION AND RECOMMENDATION

(a) Drilling should be done to a depth of about **100-120m** to allow a large reservoir within the aquifer.
(b) The hole should be cased down to the overburden and the aquifer zones should be screened by a Hydrogeologist/well driller.
(c) The Overburden thickness is about 6-8m. Fractures are presumed at 40-45m, 80-90m.
(d) The yield (quantity and quality) of the Borehole cannot be determined until after drilling and during a pumping test. Hence, if upon drilling, the water yield is appreciable, the driller is advised to terminate the drilling process.

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