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AQUIFER CHARACTERIZATION USING THE NEW ADMT (AUDIO MAGNETOTELLURIC) METHOD: A CASE STUDY OF KWARA STATE COLLEGE OF EDUCATION, ILORIN, SOUTHWESTERN NIGERIA

BY

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Abstract

The New ADMT equipment of Electromagnetic Method (Audio Magnetotelluric Method) was used in characterizing the aquifer zones within the Kwara State College of Education, Ilorin. The ADMT data measured along seven profiles of 200m at inter profile distance of 25m and interstation separation of 10m were done using the 16 electrodes instrument. The ADMT data revealed features significant to groundwater potential as conductive zones in the images obtained. Three distinct zones were delineated based on the current density distribution. The fresh basement terrain corresponds to the highly resistive zone indicated by red colour. The intermediate zone has current density value range of -20 to 25 typical of rocks and soil component which are slightly resistive to slightly conductive and corresponds to the partially saturated units, having color rage from blue to yellow. The third zone is highly conductive with current density value greater than 30 which includes the saturated weathered or fractured basement, fault zones, clay units and saturated sandy units within the study area, this zone is indicated with purple to blue colour. This survey has helped in detecting sites that are suitable for groundwater exploration by identifying water bearing fractures and weathered zones in the study area. The areas with high conductivity correspond with conductive overburden material such as clayey soil, saturated soil, water filled fractures and faults or weathered zone within the basement.

Keywords: Basement; Fracture; Groundwater potential; ADMT; Terrain; Conductivity; characterization

Introduction

Water is life, as it is one of the most important substances on Earth, essential for continuity in the life of humans, plants and animals. Any community or city that lacks sufficient amount of safe and healthy water, life becomes frustrating and difficult for every living thing. Water has various uses which when available, it impacts our community positively. Insufficient supply of safe and healthy water or use of contaminated water in any region can cause hardship to the public that depend on it for livelihood. Groundwater is the main source of quality and adequate water supply for domestic, agricultural and industrial use in most parts of the world. The study area is within the basement complex terrain of Nigeria which are hard rock region. Groundwater is trapped within fractured zones, faults or highly weathered basement found within the rocks due to tectonic activities. Water saturation and yield in any locality depends on a number of factors theseincludes the topography, degree of weathering of the basement rocks, thickness of weathered overburden, degree or size of the fractures and their interconnectivity in the basement rocks.

Study location and General geology

The study area located in Sawmill area of Ilorin metropoli, lies between latitudes 4º41' to 5º04' North and Longitudes 8º50' to 8º06' East. Sawmill area is a suburb of Ilorin situated along Ilorin- Lagos road. The area is characterized by savannah vegetation with grassland, woodland and shrub land. The great development experienced

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within the last decade have negatively impacted the vegetal cover. In the area. The study area is underlain by metamorphic and igneous rocks of the Precambrian rocks of the Nigerian basement complex. The study area is situated in the basement complex region of Ilorin Town and groundwater is found in the weathered transition zone, fractures, joints and cracks of the basement with little amount of water in the freshly unweathered bedrock underneath the weathered layers . The major lithologic units found in the study area are different textures of granites, gneiss, migmatites, diorites and pegmatites. The highest temperatures of about 35 º is usually experienced during the dry season (November to March) and in the rainy season (April to October) the temperature drops to around 27ºC. Its climate is tropical with an average humidity of 68.6 %. Geophysics is of great importance and serves as a great tool in groundwater investigation and exploration of basement geometry . It plays a major part in exploration of healthy and productive groundwater reserves. Boreholes and wells drilled without geophysical investigation often fail to produce sufficient and healthy water. Over the years, different geophysical methods have been employed in search of groundwater either singly or combined. The choice of geophysical methods used during a field survey depends on the scope or stretch of the area involved, the cost of the survey, geology of the area and availability of software for interpretation of the acquired data. The ground conductivity of an area is a reflection of its physical and chemical conditions such as lithology, porosity, degree of water saturation and the presence or absence of fractures within the bedrock. ADMT Electromagnetic method is very sensitive to water bearing fitures/fractures or weathered basement and this makes it a great tool in groundwater exploration. It was employed in this study as a tool to map areas showing high conductivity which is a good indicator of fractured zones, faults or weathered horizon with good groundwater availability. It is an inexpensive, fast and effective method in detecting best sites for groundwater location. Its usefulness in groundwater exploration, investigating fracture zones and in assessing the impact of solid waste disposal on the quality of groundwater, detecting the protective capacity of aquifers cannot be overemphasized. The aim of this study is to use the ADMT equipment method to characterized the subsurface aquiferous zones of the college and to present information for the best sites to drill boreholes or well.

Materials and Method

The ADMT Electromagnetic (Audio Magnetoteluric) method was used for the survey. The ADMT method uses electromagnetic fields to detect the subsurface materials positioned underneath the earth. The ADMT geo-equipment was used for field data collection; this equipment uses the principle of electromagnetic (EM) induction. These methods make use of the responses of the ground to the propagation of electromagnetic field; which are composed of an alternating electric intensity and magnetizing force. This survey method does not require contact with the ground, therefore the speed with which EM can be operated is much greater and faster than other electrical methods. We therefore present a technique that enhances the visualization of the subsurface using 3-D electrical resistivity imaging. The observed resistivity values are commonly presented in pictorial form to give a picture of the subsurface resistivity distribution. However, geological structures and spatial distribution of subsurface petro-physical properties are inherently three-dimensional in nature. Fractured zones are detected as good conductors with high current density values while resistive correspond to low density zone. Some advantages of the ADMT method is its effectiveness for locating zones of high electrical conductivity even in a hard rock environment with surface or near surface outcrops. Data collection is fast, inexpensive and does not require many field crews as it is possible for a single person to carry out the investigation.

Results and Discussion

Profile 1 has a total length of 9 meters running in a N-S direction, and a depth of 200 meter deep. The conductive zones are indicated by the colour code as seen on the legend. These zones are well displayed as green, blue and yellow in the image produced. The conductivity of the conductive zone range between 0.13 ohm meter to 0.16 ohm meter, while the basement unfracture zone indicated with 0.67 ohm meter to 0,76 ohm meter. The images indicate that the moderately conductive body at depth of 40m to about 100m is vertically dipping. The other areas on the

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image shows a highly resistive body at depth from near surface to about 60m depth from station 1 to 5 resulting from the dry sandy material of compacted dry sand and is sitting on a highly resistive basement.

Profile 2 is parallel to the first profile and is 50m away. These zones are well displayed as the green, blue and yellow in the image produced are well mixed with the hard basement in the area. The conductivity of the conductive zone range between 0.50 ohm meter to 1.06 ohm meter, while the basement un-fracture zone indicated with 1.13 ohm meter to 1.22 ohm meter. The images indicate that the moderately conductive body at depth of 50m to about 100m is vertically dipping. The other areas on the image shows a highly resistive body at depth from near surface to about 80m depth across the profile resulting from the dry sandy material of compacted dry sand and is sitting on a highly resistive basement. The conductivity variation across this profile is well defined.

Profile 3 has a total length of 80 m. Fig. 3 shows a highly conductive zone across the station distance 80 to 150 which is likely to be a fractured zone within the basement with water accumulation occurring at depth between 50 and 100 . There are few areas with high resistivity at this profile as seen. The zones are well displayed as green, blue and yellow in the image produced. The conductivity of the conductive zone range between 0.3 ohm meter to 1.9 ohm meter, while the basement un-fracture zone indicated with 2.1 ohm meter to 2.4 ohm meter. The images indicate that the moderately conductive body at depth of 40m to about 120m is vertically dipping, as seen at point 6 in the image. The other areas on the image shows a highly resistive body at depth greater than 120m depth across the station resulting from the dry sandy material of compacted dry sand and is sitting on a highly resistive basement. The highly resistant zones are also seen at station depth of 160 ,175 and at 190m respectively. The highly conductive zones are interpreted as clayey soil materials, while the highly resistive zones are interpreted as dry sandy soil component within the profile.

Profile 4 shows many interesting signature and point of hydrogeological importance with the only exception in station 3 that depicts a highly resistive zone between 40 to 120m This resulting anomaly is as a result of noise from the iron fencing and the building along this profile. The zones are well displayed as the green, blue and yellow in the image produced in the area. The conductivity of the conductive zone range between 0.19 ohm meter to 0.68 ohm meter, while the basement un-fracture zone indicated with 0.75 ohm meter to 0.87 ohm meter. The images indicate that the moderately conductive body at depth of 40m to about 110m is vertically dipping. The other areas on the image shows a highly resistive signature at depth from near surface to about 80m across the profile due largely to dry sandy material of compacted dry sand and is sitting on a highly resistive basement. The conductivity variation across this profile is well defined.

Profile 5 present another good prospect for ground water exploitation and the anomaly seen must have resulted from the clayey soil material down to the fracture zone within the basement rock with good potential for ground water accumulation. These zones are well displayed as the green, blue and yellow in the image produced are well mixed with the hard basement in the area. The conductivity of the conductive zone range between 0.20 ohm meter to 0.76 ohm meter, while the basement un-fracture zone indicated with 0.84 ohm meter to 0.96 ohm meter. The images indicate that the moderately conductive body at depth of 50m to about 130m is vertically dipping at point 5 could be a promising site for borehole in the area. The other areas on the image shows a highly resistive body at depth from near surface to about 150m depth at point 2m in the profile resulting from the dry sandy material of compacted dry sand and is sitting on a highly resistive basement.

Profile 6: The conductivity variation across this profile is well defined. These zones are well displayed as green, blue and yellow in the image produced. The conductivity of the conductive zone range between 0.15 ohm meter to 0.50 ohm meter, while the basement un-fracture zone indicated with 0.55 ohm meter to 0.61 ohm meter. The images indicate that the moderately conductive zone across the profile to the depth of 60m to about 180m is vertically

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dipping, especially at point 7 and 8. The other areas on the image shows a highly resistive body at depth from near surface to about 150m depth from station 1 to 2 resulting from the dry sandy material of compacted dry sand and is sitting on a highly resistive basement.

Profile 7 present a very good prospective zones for ground water exploitation and the anomaly seen must have resulted from the highly clayey soil material down to the fracture zone within the basement rock with good potential for ground water accumulation. These zones are well displayed as the green, blue and yellow in the image produced are well mixed with the hard basement in the area. The conductivity of the conductive zone range between 0.19 ohm meter to 0.61 ohm meter, while the basement un-fracture zone indicated with 0.67 ohm meter to 0.75 ohm meter. The images indicate that the moderately conductive body across the entire area is vertically dipping at point 1 to 7, could be a promising site for borehole in the area.

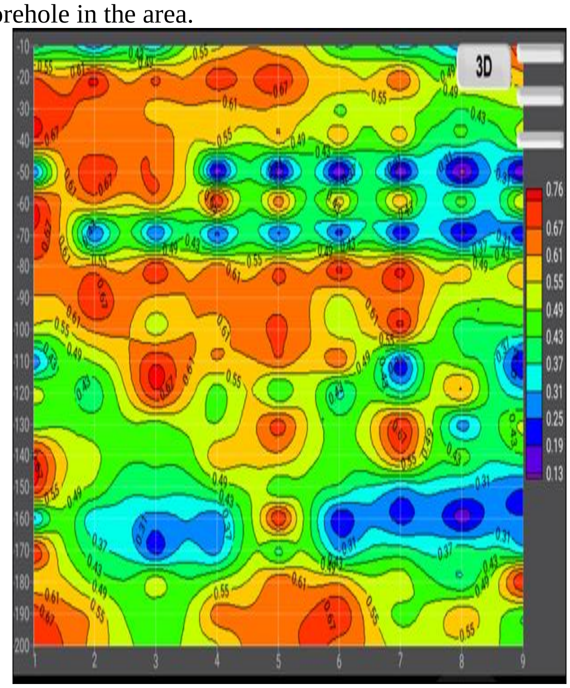

Fig. 1, Profile one

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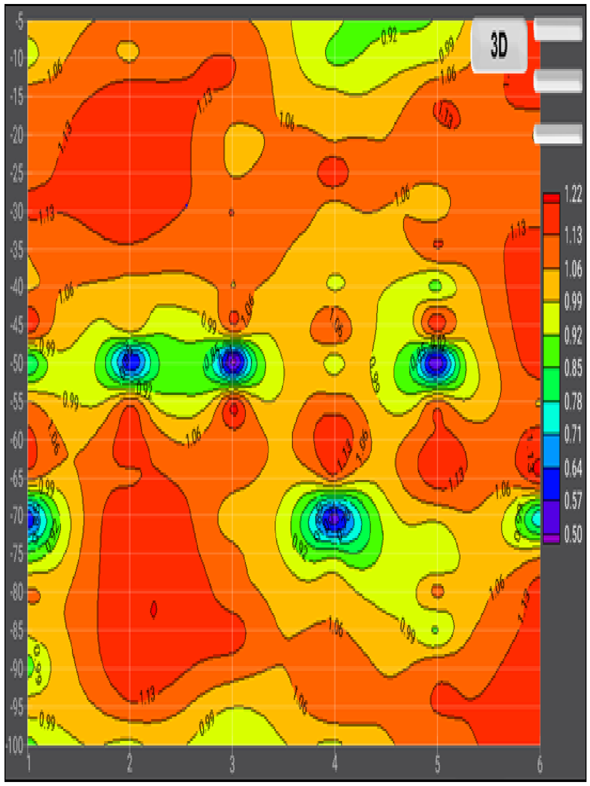

Fig. 2, Profile two

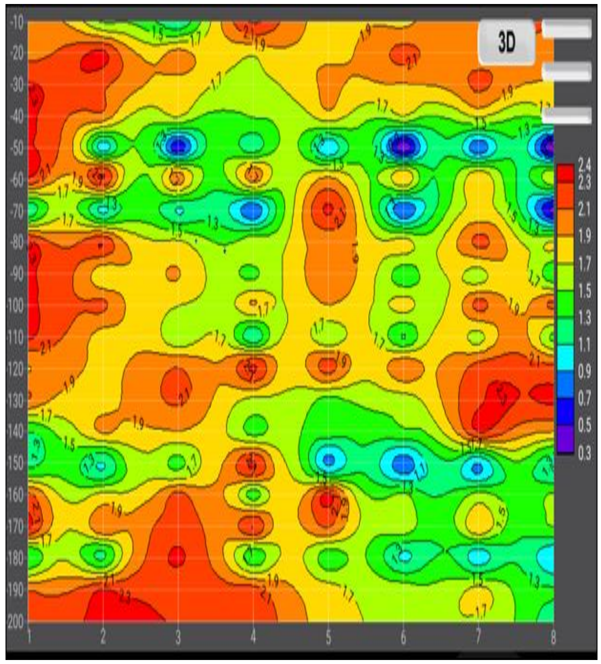

Fig. 3, Profile Three.

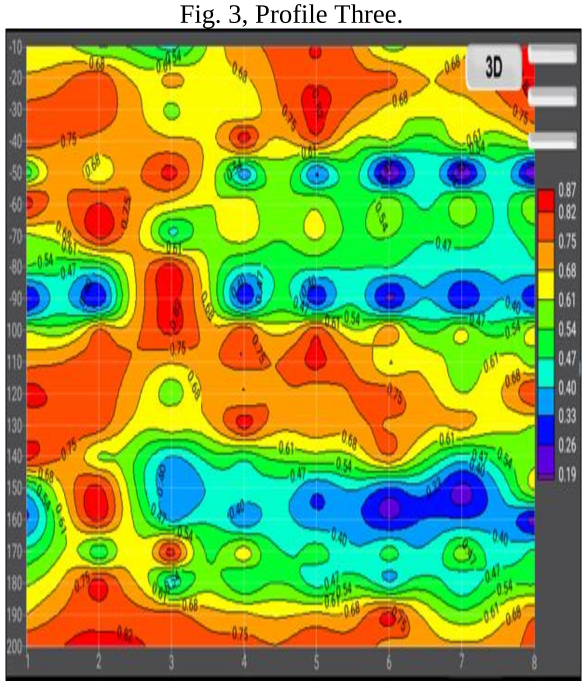

Fig. 4, Profile four.

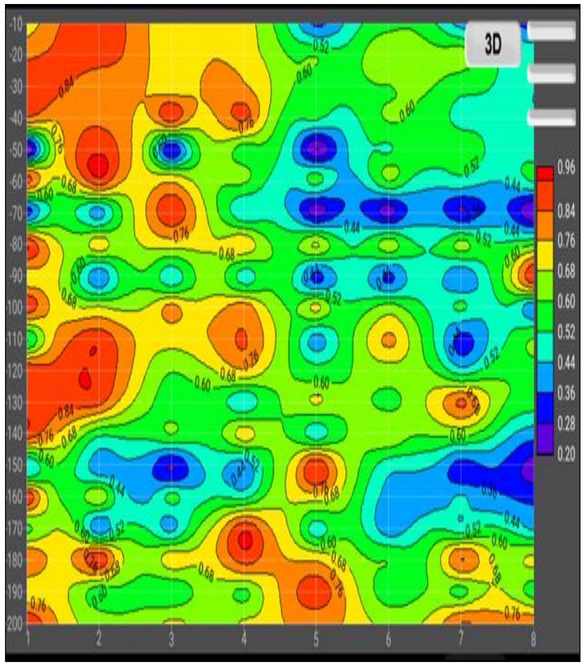

Fig. 5, Profile Five

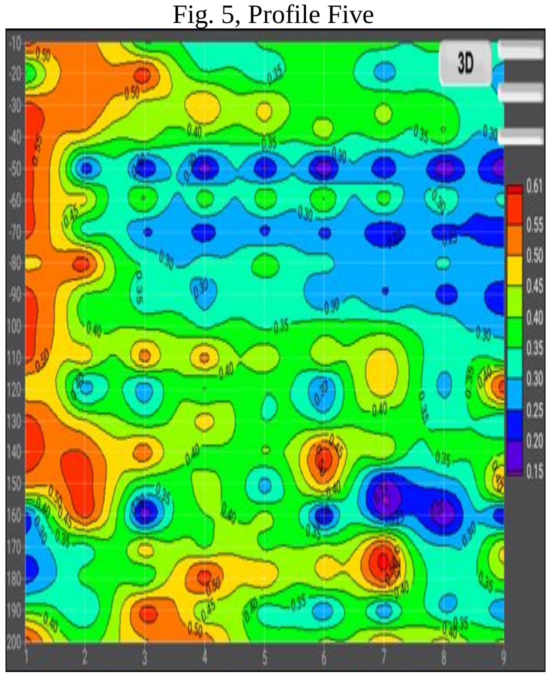

Fig. 6, Profile Six

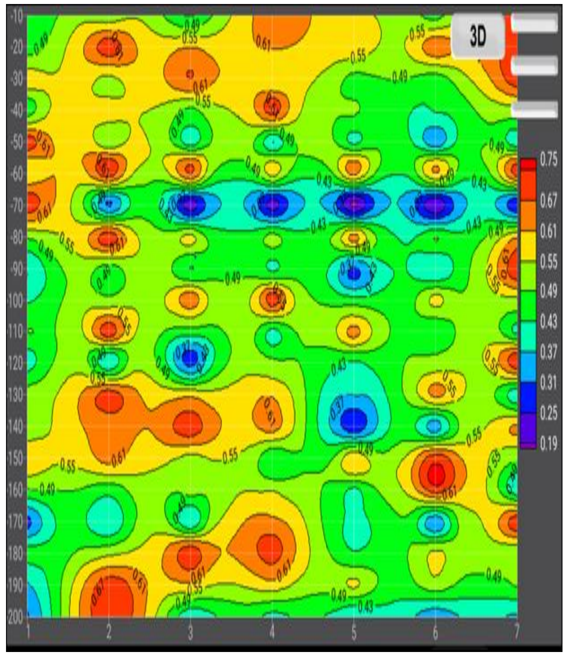

Fig. 7, Profile Seven

Conclusion

This study has revealed that the college of education campus, Ilorin generally has good groundwater potential based on the conductivity and the aquifer characteristics. The groundwater prospect of the study area is can be said to high (high conductive zones with 0.13 to 0.9 ohm meter), moderate (with conductivity values between 0.30 and 1.9 ohm meter) and low (low conductive zones with values greater than 2.4ohm meter). The eastern, western (profiles 1, 2 and 4) and some parts of the northern region (profiles 5, 6 and 7) of the study area show high groundwater potential while the central areas reveal (profile 3) a moderate groundwater potential zone. Due to the fact that one of the major factors controlling conductivity is moisture content makes it easy to use the ADMT method for groundwater investigation in the basement complex of Nigeria.

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