

RESEARCH ARTICLE

GROUNDWATER EXPLORATION FOR WATER WELL SITES IN ABATA ASUNKERE COMMUNITY, ILORIN, NIGERIA

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ARTICLE DETAILS

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ABSTRACT

In this study, Electrical resistivity investigation was carried out at different sections of Abata Asunkere Community, Ilorin, Nigeria with the aim of evaluating groundwater potential and properties of the aquifers. Geophysical technique adopted in this work were the Vertical Electrical Sounding (VES) and 2-D Electrical Resistivity Tomography (ERT) using Schlumberger array configuration. ERT was established on two profiles at the study area with total distance of 80 m apart with 5 m electrode spacing. Eight (8) VES points were sounded along the established profiles. The results revealed four geo-electric layers which correspond to the topsoil, clayey layer, sandy clay and the last layer to the bedrock in all the VES points sounded. The topsoil has apparent resistivity values ranging from 5 to 437 Ω -m and 0.5 m to 1.7 m while the last layer which is the fractured/fresh basement rock has resistivity ranges of 27 Ω -m to 9800 Ω -m and is characterized by infinite thickness. The curve types obtained are H, QH and HK curve type signatures with the H curve type covering about 60 % of the study area. High potential for groundwater was observed at the northeastern and southern part of the study area. Aquifers in most part of the study areas are relatively shielded from contamination because of high protective capacity of the overburden material. It was hence concluded that, the study area has a promising groundwater potential. Based on these results, groundwater exploration at optimum yield was recommended. Depending on the volume of water available during drilling, the maximum depth of drilling may reach up to 60 m.

KEYWORDS

Groundwater, Survey, drilling, profile, Psuedo-section, Geosections.

1. INTRODUCTION

Water is commonly referred to as an essential food and basic component upon which life depends (Asry et al., 2014). Water has many diversified functions which include, those of drinking and developmental purpose (Akinola et al., 2014; Al-Garni, 2009). In recent time, the use and by extension, the sustainability of water is becoming complex as a result of population growth, urbanization and industrialization (Mishra et al., 2021; Schwarzenbach et al., 2010). There is a either a direct or indirect correlation between development and water utilization (Chinyem, 2013; Eke et al., 2010; Hazell et al., 1988). For most developmental activities, the quality and availability of both surface and groundwater are the major components. For areas with poor feasibility of surface water for desired activities, groundwater is the most reliable alternative, in as much as the anticipated yield and quality are good enough. As a result, site investigation/exploration, which is also referred to as pre-construction evaluation, is usually performed for to ensure effective and sustainable utilization of groundwater resources (Arefayne and Abdi, 2015; Tzanakakis et al., 2020; Paranychianakis et al., 2015).

Groundwater has countless advantages over surface water. These include, but not limited to its portability, all year availability, as well as its presence in almost all spots beneath the earth, ready to be exploited. As a result of these, groundwater is the most sort out for. Determining the depth at which groundwater exists is usually not a straightforward task, several

scientific techniques are usually employed to extract information regarding its depth of occurrence in the earth's subsurface. Hydro-geophysical methods are the most usually employed method since they provide us with necessary information regarding the subsurface geology of the area while acting as tools for groundwater resource mapping and help in water quality evaluations (Hazell et al., 1988; Onimisi et al., 2014). Other commonly used methods employed in the exploration of groundwater include electrical resistivity tomography, magnetometry, gravity, ground penetrating radar, seismic, and remote sensing. These techniques have been employed in groundwater exploration with varying degree of success. More importantly, gravity and magnetics methods have been used successfully to map regional aquifers and large scale basin features reported the use of seismic methods in the delineation of subsurface aquifers and fractured rock systems (Aizebeokhai et al., 2018; Oyeyemi et al., 2020; Reynolds, 1997).

Electrical resistivity tomography is the most commonly used method in groundwater exploration owing to its effectiveness in the correlation of many geological formation properties such as porosity and permeability which are critical to hydrogeology with electrical conductivity signatures (Eke et al., 2011; Osinowo et al., 2020; Hung et al., 2019). This method is also widely appreciated because of its portability in equipment, ease of operation, usefulness and efficiency in drilling operations (Chinyem, 2013). Decline in borehole yield and groundwater quality is a common problem within Ilorin metropolis. Most borehole failures have been attributed to poor pre-drill survey, data misinterpretation due to handlers'

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inexperience and poor communication between geophysicists and the drillers. As a result, this study used the electrical resistivity method in search of potential well locations for groundwater supply zones in Ansaru-

Islam Secondary School along Alore Okekere Ilorin, Kwara State, with a view to improving yields of future boreholes.

2. MATERIALS AND METHODS

2.1 Site Description and Geological Setting

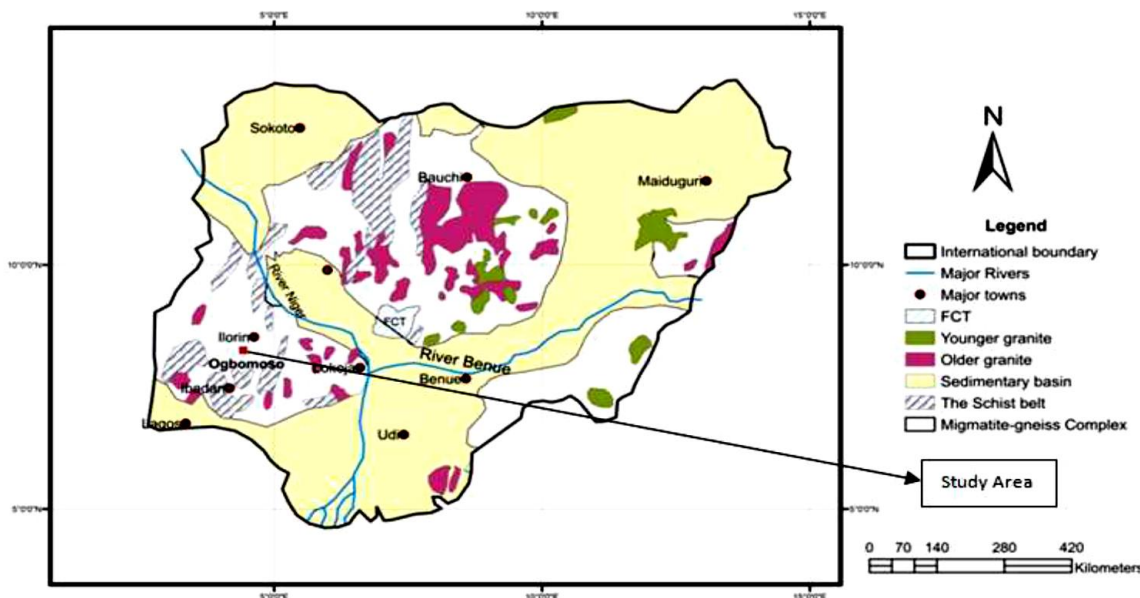


Figure 1: Geological map of Nigeria showing the study area (Akinola et al., 2014).

The study was conducted in Southeastern Nigeria sedimentary basin within Ansarul Islam Secondary School, along Abata Asunkere, Alore area of Ilorin, Kwara State. The area is situated on the latitude N 8° 30'16.76 N and longitude 4°31'55.72" East, with elevation of 303.91 m area cover by 400 m by 200 m. Figure 1 is the geological map of Nigeria showing the study location.

2.2 Field Survey

A 3-day assessment was carried out in October 2021 employing the electrical resistivity method. The assessment was conducted with Herojat resistivity meter. A levelled terrain in the study area was located. Eight (8) VES points along two profiles were marked and sounded as shown in Figure 2. The Terrameter was used to measure and record the resistance of the subsurface with a set maximum (AB/2) of 80 m. The required apparent resistivity obtained is the product of the values of the resistance obtained in the field with their respective Geometric factor (k). The obtained data was plotted on a bi-log graph and the resultant curve was quantitatively and qualitatively read.

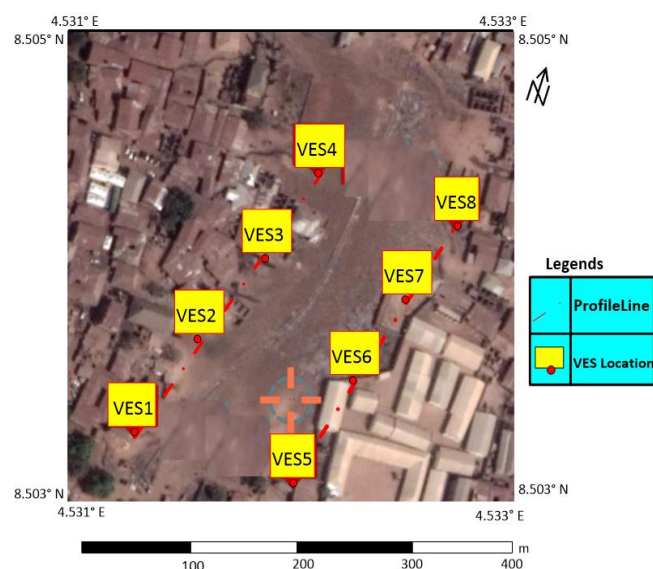


Figure 2: Base map of the study area

3. RESULTS AND DISCUSSION

3.1 Curve Matching And Interpretations

The apparent resistivity and thickness obtained were modelled using the IPI2WIN software. The outcomes of these models are displayed as series of curves in Figures 3 (a-h). It was revealed that most of the modelled curves show four (4) subsurface geo-electrical layers in VES 2, 3, 4, 5, and 7 while VES 1, 6 and 8 revealed three (3) subsurface geo-electrical layers. This is suggestive of stratified sedimentary structure, which comprises of a minimum of three Geo-electrical strata, which consists majorly of diverse clay and sandy soil. A maximum of four Geo-electrical strata beneath the earth surface was mapped out showing geo-electric signature involving KH, QH and H curve types. The first layer which is the topsoil consists of Clayey sand to sandy clay material with resistivity and thickness range of 5 - 437 Ω -m and 0.5 - 1.7 m, respectively. This layer also occurs in multi-layer in some parts of the study area serving as the second layer. Beneath this, is a weathered basement rock with resistivity and thickness range of 1 - 16 Ω -m and 5 - 15 m, respectively. This layer overlaid an infinitely continuous layer suspected to be fractured/fresh basement rock which has resistivity range of 27 - 9800 Ω -m, characterized by infinite thickness. The bedrock layer (weathered/fractured basement layer) has revealed lower resistivity value which is an indicator of good water zone.

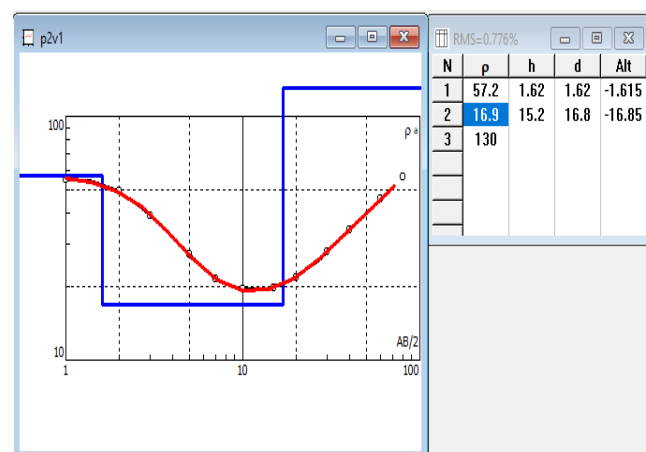


Figure 2a: Sounding curve for VES 1

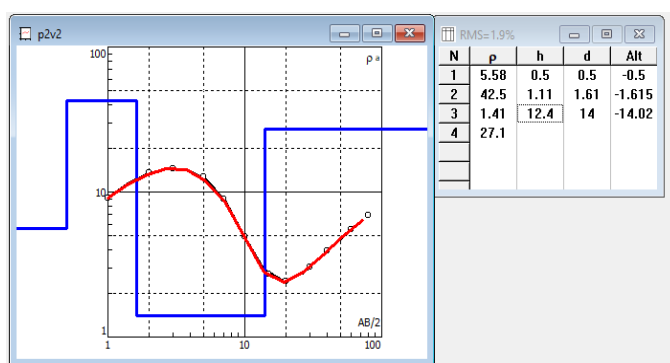


Figure 2b: Sounding curve for VES 2

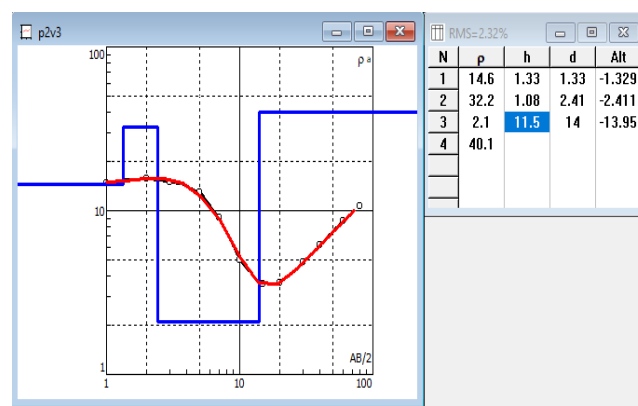


Figure 2g: Sounding curve for VES 7

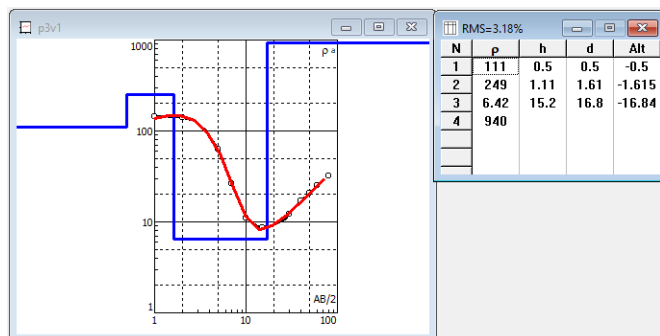


Figure 2c: Sounding curve for VES 3

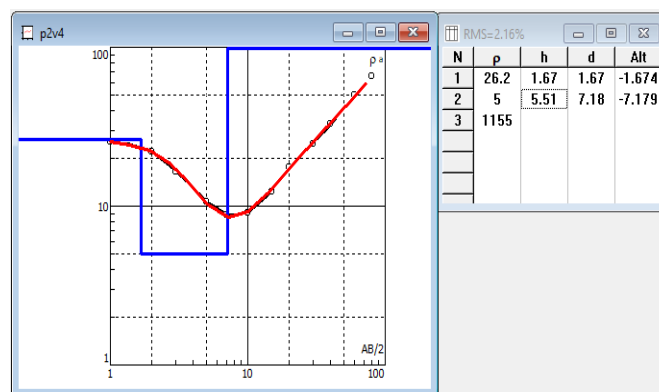


Figure 2h: Sounding curve for VES 8

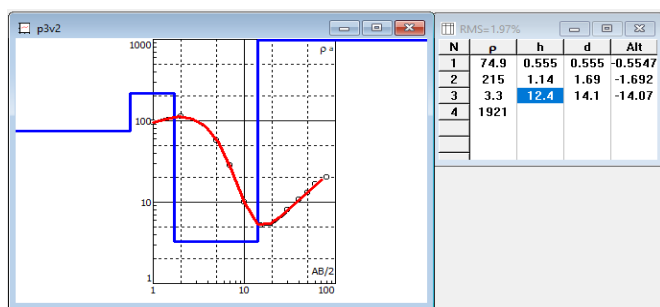


Figure 2d: Sounding curve for VES 4

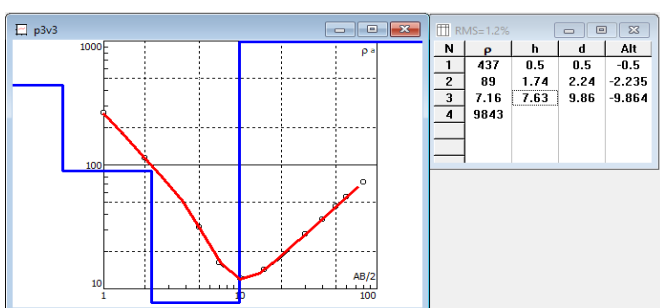


Figure 2e: Sounding curve for VES 5

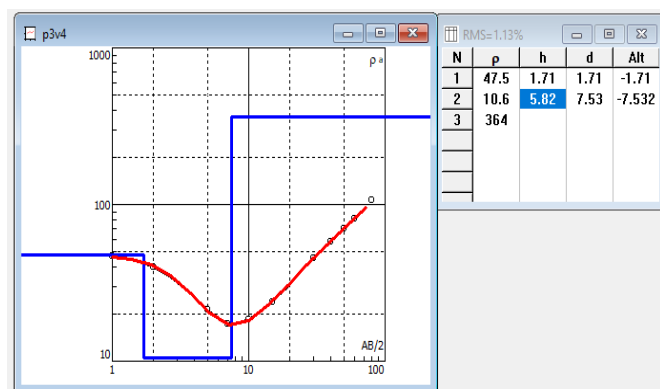


Figure 2f: Sounding curve for VES 6

3.2 Geoelectric Sectioning

In Figure three (3) and four (4) which represent the geo-electric sections across profiles one and two, shows different lithology, ranging from sandy clay topsoil, weathered rock and the fractured to fresh rock with respect to their depths and thickness with resistivity values of each layer been displayed respectively.

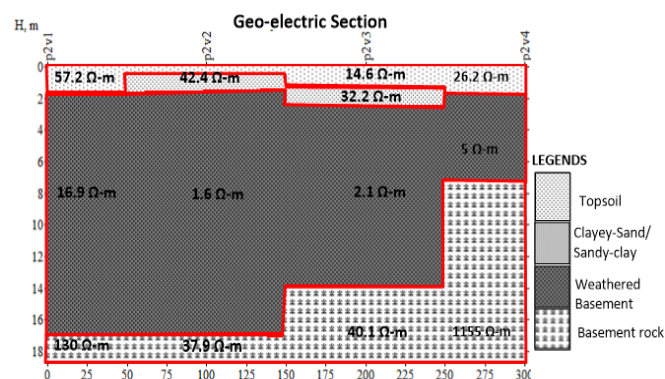


Figure 3: Profile One 2D Geo-electric Section

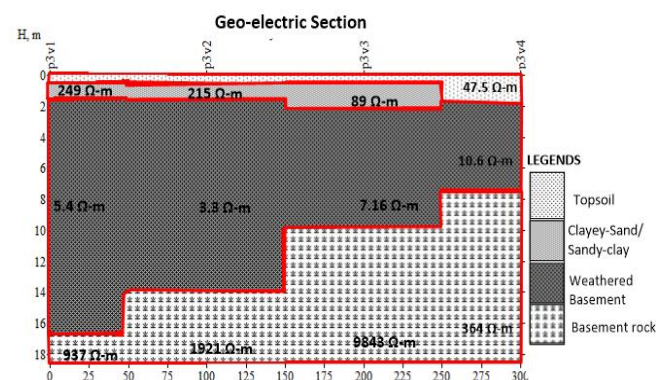


Figure 4: Profile Two 2D Geo-electric Section

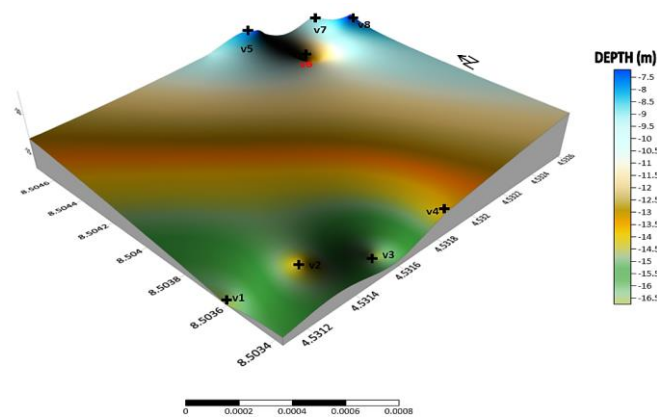


Figure 5: 3D Bedrock Topography Map

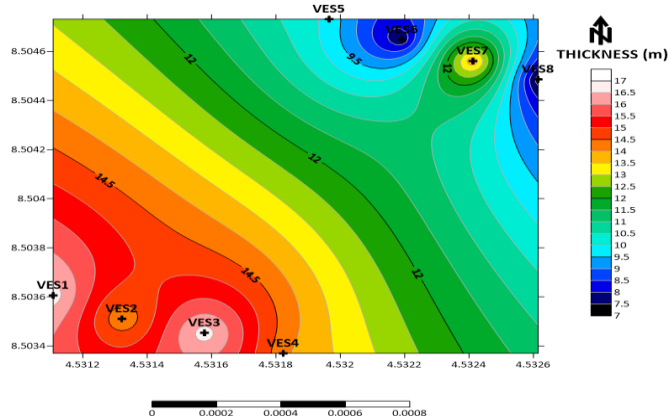


Figure 6: Overburden thickness Contour Map

From the data obtained from the models and curves, bedrock and overburden thickness maps, Figure 5 and Figure 6, were produced by picking all depths and thickness values corresponding to the respective resistivity for all VES points using Golden Surfer Geophysical software package.

In Figure 5, it was observed that the bedrock has an irregular topography. The areas with shallow bedrock depth correspond to VES 5, 7 and 8. The area with intermediate bedrock depth corresponds to VES 2 and 4. Also, the area which corresponded to VES 1, 3 and 6 has the deepest depth to the hard rock. It was inferred that, the bedrock slopes from the East to the West. That is, where we have the deepest, intermediate and the shallowest bedrock depth corresponded to thickest, intermediate and the thinnest overburden thickness respectively. Figure 6, which is the aquifer thickness map of the study area with thickness range of 5 to 15 m, shows high aquifer thickness (12 - 15 m) along profile one which covers VES 1 to 4 points, with intermediate aquifer thickness (8 - 10 m) showing up only at VES point 7. Also, the areas which is covered by the remaining VES points along profile 2 (VES 5, 6 and 8) indicated the presence of thin aquiferous formation (< 8 m). This means that the aquifer is thicker towards the south-west with intermediate and thinner thickness towards North-Eastern part.

4. CONCLUSION

Electrical resistivity investigations have been successfully carried out at different sections of Abata Asunkere community, Alore area of Ilorin metropolis. High potential for groundwater was observed at the northeastern and southern part of the study area. Considering the result obtained, it is an indication that the study area has a good potential for boreholes due to the features that enhance groundwater permeability and storage.

REFERENCES

Aizebeokhai, A.P., Ogungbade, O., and Oyeyemi, K.D., 2018. Geoelectrical Resistivity Data Set for Characterising Crystalline Basement

Aquifers in Basiri, Ado-Ekiti, southwestern Nigeria. Data in Brief, 19, Pp. 810 -816. doi: 10.1016/j.dib.2018.05.091.

Akinola, O.O., Bolarinwa, A.T., and Ademilua, O.L., 2014. Lithologic Features and Petrochemical Characteristics of Metasedimentary Rocks of Igbetti Area, Southwestern Nigeria, 2 (4), Pp. 82 - 89.

Al-Garni, M.A., 2009. Geophysical Investigations for Groundwater in a Complex Subsurface Terrain, Wadi Fatima, KSA: A Case History. Jordan Journal of Civil Engineering, 3 (2), Pp. 118 - 136.

Arefayne, S.H., and Abdi, S., 2015. Groundwater Exploration for Water Well Site Locations Using Geophysical Survey Methods. Hydrology Current Research, 7 (1), Pp. 1 - 7. doi: 10.4172/2157-7587.1000226.

Asry, Z., Samsudin, A.R., Yaacob, W.Z., and Yaakub, J., 2014. Groundwater Exploration Using 2-D Geoelectrical Resistivity Imaging Technique at Sungai. Udang, Melaka. Journal of Earth Science and Engineering, 2, Pp. 624-630.

Chinyem, F.I., 2013. Hydrogeophysical Investigation of Asaba Area, Delta State, Nigeria. Indian Journal of Science and Technology, 6 (5), Pp. 4453 - 4458.

Eke, K., Igboekwe, M., and O.M., 2011. Geoelectric Investigation of Groundwater in Some Villages in Ohafia Locality, Abia State, Nigeria. British Journal of Applied Science and Technology. 1 (4). doi: 10.9734/bjast/2011/600.

Hazell, J.R.T., Cratchley, C.R., and Preston, A.M., 1988. The Location of Aquifers in Crystalline Rocks and Alluvium in Northern Nigeria Using Combined Electromagnetic and Resistivity Techniques. Quarterly Journal of Engineering Geology and Hydrogeology, 21 (2), Pp. 159 - 175. https://doi.org/10.1144/GSL.QJEG.1988.021.02.05

Hung, Y.C., Lin, C.V., Lee, C.T., and Weng, K.W., 2019. 3D and Boundary Effects on 2D Electrical Resistivity Tomography. Applied Science, 9 (15), Pp. 1 - 19. doi:10.3390/app9152963.

Mishra, P., Kumar, B.K., Saraswat, S., Chakraborty, C., and Gautam, A., 2021. Water Security in a Changing Environment: Concept. Water, 13 (490), Pp. 1 - 21. https://doi.org/10.3390/w13040490.

Onimisi, M., Ayuba, R., and Daniel, A., 2014. Electromagnetic Geophysical Prospecting For Groundwater in Basement Complex Terrain: A Case Study of Ola-Oluwa Area of Osun State, Southwestern Nigeria. IOSR Journal of Applied Geological Geophysics, 2 (1), Pp. 26 - 30. doi: 10.9790/0990-02112630.

Osinowo, O.O., Agbaje, M.A., and Ariyo, S.O., 2020. Integrated Geophysical Investigation Techniques for Mapping Cassava Effluent Leachate Contamination Plume, at a Dumpsite in Ilero, Southwestern Nigeria. Scientific African, 8, Pp. 1 - 12. doi:10.1016/j.sciaf.2020.e00374.

Oyeyemi, K.D., Olofinnade, O.M., Aizebeokhai, A.P., Sanuade, O.A., Oladunjoye, M.A., Ede, A.N., Adagunodo, T.A., Ayara, W.A., 2020. Geoengineering Site Characterization for Foundation Integrity Assessment. Cogent Engineering, 7 (1), Pp. 1 - 15. doi:10.1080/23311916.2020.1711684.

Paranychianakis, N.V., Salgot, M., Snyder, S.A., and Angelakis, A.N., 2015. Water Reuse in EU States: Necessity for Uniform Criteria to Mitigate Human and Environmental Risks. Critical Reviews in Environmental Science and Technology, 45 (13), Pp. 1409 - 1468. doi: 10.1080/10643389.2014.955629.

Reynolds, J.M., 1997. An introduction to applied and environmental geophysics.

Schwarzenbach, R.P., Egli, T., Hofstetter, T.B., Von Gunten, U., and Wehrli, B., 2010. Global water pollution and human health. Annual Review of Environment and Resources. 35, Pp. 109 - 136. doi:10.1146/annurev-environ-100809-125342.

Tzanakakis, V.A., Paranychianakis, N.V., and Angelakis, A.N., 2020. Water supply and water scarcity. Water (Switzerland), 12 (9), Pp. 1 - 16. doi: 10.3390/w12092347.