Geo-electric Investigation of the Groundwater Potential of the Federal Housing Estate, Eastern Part of Ado-Ekiti, Southwestern Nigeria

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Abstract- This study aimed at evaluating the potential for groundwater development in the eastern part of Ado-Ekiti, Southwestern Nigeria using Vertical Electrical Sounding (VES). Data were acquired with ABEM SAS 300 and processed through partial curve matching techniques and assisted with 1-D forward modelling. Geoelectric parameters were determined from the VES interpreted result. Seven (7) different VES type curves (H, A, HA, KH, HK, GH and HKH) indicating inhomogeneity of the subsurface layer beneath the study area were observed. Weathered layer resistivity map having values ranging from 3.2 – 272 Ωm, overburden thickness value varies between 0 and 28 m and bedrock relief values range from 360 – 480 m were delineated. It was estimated from the result that the northwestern and southeastern part which constituted about 15% of the study area possess high groundwater potential while the remaining 85% of the study area exhibit low/moderate potentials for yielding substantial water. Hence, the groundwater potential rating of the area was considered generally low.

Keywords- Geoelectric, Groundwater potential, Overburden thickness, Vertical Electrical Sounding.

1 INTRODUCTION

The incessant upsurge in population along with enormous industrial and agricultural complexes has globally led to a great demand for water (Omosuyi et al., 2008). Water is one of the most precious of all natural resources. However, its availability remains a source of concern for human race. Water is used for agricultural, recreational, domestic and industrial purposes. Groundwater is defined as water that exists below the earth surface within saturated layers of sand, gravel and pore spaces in crystalline as well as sedimentary rocks (Akinlalu et al., 2017). Indiscriminate sinking of boreholes without employing systematic pre-drilling geophysical investigation has led to unsuccessful boreholes with poor or low yield (Bayode et al., 2007). Groundwater is believed to serve as a principal source of highly potable water for domestic, industrial and agricultural purposes. Olorunfemi and Oloruniwo (1987) using electrical resistivity in basement terrain, SW Nigeria established that both the weathered and the fractured basement layers make up aquifer zones. This was furthered collaborated by the work of Ariyo and Adeyemi (2004), that characterized the lithologic units of Iware and discovered two main aquifer systems while using Vertical Electrical Sounding (VES) technique.

Olorunfemi and Fasuyi (1993) delineated five kinds of aquifer in the basement complex of southwestern Nigeria via geophysical techniques. Anomohanran (2011) in Olowe, Nigeria and Al-Amoush (2012) in Wadi Al-Butum Area, Jordan discovered a disparity in lithologic units identified from borehole logs and that of electrical resistivity method they had employed. Afterward, several others utilizing electrical resistivity method of geophysical investigations were carried out in various locations. Abiola et al. (2009) carried out groundwater potential and aquifer protective capacity of overburden units in Ado-Ekiti and discovered that clay content of the overburden was high, which informed low groundwater potential rating of the area.

Ademilua and Eluwole (2013) classified Afe Babalola University Ado-Ekiti into good, moderate and poor groundwater potential zones using the electrical resistivity method of geophysical prospecting. Hydrogeological importance can be deduced from some VES curve types, such that the KH and HKH curve types that often indicate probable zones of fracturing and groundwater accumulation (Oladope, 2004). An inadequate supply of water is observed at the study area (area around federal housing corporation, Ado-Ekiti) due to failed boreholes. Hence, there is need for appropriate geophysical investigation of the area to enhance delineation of its groundwater prospects.

2 METHODOLOGY

2.1 DESCRIPTION OF INVESTIGATED SITE ENVIRONMENT

The area of research is located between Latitudes 7°37’ and 7°39’N and Longitudes 5°13’E and 5°22’E (Fig. 1) within Ado-Ekiti, Southwestern Nigeria with an elevation of approximately 500 m. The study area is well accessible through a good road network system. The study area lies within the Precambrian Basement Complex rock of Southwestern Nigeria (Rahaman, 1988); and is underlain principally by Migmatite-Gneiss (Fig. 2).

2.2 METHODS

Three (3) traverses were established across the study area and forty-two (42) Vertical Electrical Soundings (VES) were carried out using the Schlumberger configuration. The electrode spacing (AB/2) varied from 1- 180m. The apparent resistivity values were plotted against electrode spacing (AB/2) on a bi-logarithmic graph sheet to generate depth sounding curves. Partial curve matching was carried out on the field curves and assisted by 1-D forward modelling computer using WINRESIST version1.0 software as described by Varder-Velper (1988) in Akintoninwa and Adelusi (2009) in order to generate the geoelectric parameters (layer resistivity and thickness).

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3 RESULTS AND DISCUSSIONS

3.1 GEOELECTRIC CHARACTERISTICS

The types of VES curves encountered in the study area range from H, A, HA, HK, QH, to HKH (Figs. 3a and 3b), however the dominant is the H type. The KH and HKH curves thus suggest subsurface geoelectric configurations apparently favourable for groundwater occurrence (Oladapo, 2004). The A-type curves, which are characterized by an increase in the resistivity from topsoil to the bedrock, therefore indicate non-permeable zones. The summaries of the geoelectric interpretation results (layer resistivity and thickness) were presented in Table 1. These results were further used to generate weathered layer, overburden thickness and bedrock relief maps.

![Fig 1: Location map of the study area](image1)

![Fig 2: Geological map of study area (Ademilua and Eluwole, 2013)](image2)

![Fig 3 (a): Typical VES curve (H-type) from the study area.](image3a)

![Fig 3 (b): Typical VES curve (KH-type) from the study area.](image3b)

![Table 1. Curve Interpretation](table1)

| VES Curve | Lithology          | Resistivity | Thickness | Depth |
|-----------|--------------------|-------------|-----------|-------|
| HA        | Top soil           | 360         | 0.8       | 0.8   |
|           | Weathered layer    | 223         | 1.1       | 1.9   |
|           | Partly weathered   | 3293        | 9.4       | 11.3  |
|           | Fresh basement     | 8488        | -         | -     |
| KH        | Top soil           | 160         | 1.2       | 1.2   |
|           | Weathered layer    | 514         | 0.6       | 1.8   |
|           | Fractured basement | 55          | 1.5       | 3.3   |
|           | Fresh basement     | 6660        | -         | -     |
| H         | Top soil           | 250         | 0.9       | 10.9  |
|           | Weathered layer    | 272         | 0.8       | 1.7   |
|           | Fresh basement     | 1657        | -         | -     |
| HK        | Top soil           | 100         | 0.7       | 0.7   |
|           | Clayey layer       | 71          | 1.3       | 2.0   |
|           | Fresh basement     | 262         | 1.6       | 3.6   |
|           | Fractured basement | 66          | -         | -     |
| HA        | Top soil           | 23          | 0.5       | 0.5   |
|           | Weathered layer    | 4           | 0.4       | 0.9   |
|           | Partly weathered   | 10          | 8.7       | 9.6   |
|           | Fresh basement     | 615         | -         | -     |
| H         | Top soil           | 179         | 0.7       | 0.7   |
|           | Weathered layer    | 49          | 18        | 18.7  |
|           | Fresh basement     | 804         | -         | -     |
| HA        | Top soil           | 226         | 1.5       | 1.5   |
|           | Weathered layer    | 27          | 5.8       | 7.3   |
| No. | Location | Partly Weathered Layer | Weathered Layer | Fractured Layer | Fresh Basement |
|-----|----------|------------------------|----------------|---------------|---------------|
| 8   | QH       | 61                     | 7.3            | 14.5          |
|     |          | Fresh Basement         | Infinity       | -             |
| 9   | HA       | 69                     | 3.3            | 3.3           |
|     |          | Weathered Layer        | 56             | 0.8           |
|     |          | Fractured Layer        | 28             | 12.3          |
|     |          | Fresh Basement         | 366            | -             |
| 10  | HKH      | 145                    | 0.8            | 0.8           |
|     |          | Top Soil               | 89             | 0.7           |
|     |          | Weathered Layer        | 386            | 2.0           |
|     |          | Fractured Layer        | 30             | 7.3           |
|     |          | Fresh Basement         | 1206           | -             |
| 11  | H        | 72                     | 1.0            | 1.0           |
|     |          | Top Soil               | 57             | 5.3           |
|     |          | Weathered Layer        | 405            | -             |
| 12  | H        | 98                     | 0.1            | 0.1           |
|     |          | Top Soil               | 35             | 15.1          |
|     |          | Weathered Layer        | 373            | -             |
| 13  | KH       | 118                    | 0.7            | 0.7           |
|     |          | Top Soil               | 591            | 1.5           |
|     |          | Lateralitic Layer      | 15             | 7.3           |
|     |          | Fractured Layer        | 152            | -             |
| 14  | H        | 295                    | 0.0            | 0.6           |
|     |          | Top Soil               | 16             | 5.4           |
|     |          | Weathered Layer        | 142            | -             |
| 15  | H        | 67                     | 1.5            | 1.5           |
|     |          | Top Soil               | 15             | 3.4           |
|     |          | Weathered Layer        | 619            | -             |
| 16  | H        | 288                    | 1.3            | 1.3           |
|     |          | Top Soil               | 26             | 5.8           |
|     |          | Weathered Layer        | 724            | -             |
| 17  | A        | 133                    | 1.0            | 1.0           |
|     |          | Top Soil               |                |               |

| No. | Location | Weathered Layer | Fractured Layer | Fresh Basement |
|-----|----------|----------------|----------------|---------------|
| 18  | H        | 143            | 2.9            | 3.9           |
|     |          | Top Soil       | 414            | 0.8           |
|     |          | Weathered Layer| 18             | 2.8           |
|     |          | Fresh Basement | 1151           | -             |
| 19  | H        | 62             | 1.8            | 2.7           |
|     |          | Top Soil       | 194            | 0.9           |
|     |          | Weathered Layer| 6205           | -             |
|     |          | Fresh Basement |                |               |
| 20  | HA       | 42             | 2.3            | 3.5           |
|     |          | Partly Weathered Layer | 281 | 2.1 |
|     |          | Fresh Basement | 588            | -             |
| 21  | H        | 390            | 0.6            | 0.6           |
|     |          | Top Soil       | 60             | 5.9           |
|     |          | Weathered Layer| 3785           | -             |
|     |          | Fresh Basement |                |               |
| 22  | HA       | 188            | 1.1            | 1.1           |
|     |          | Top Soil       | 118            | 1.8           |
|     |          | Weathered Layer| 1021           | -             |
|     |          | Fractured Layer| 46             | 3.1           |
|     |          | Fresh Basement |                |               |
| 23  | HA       | 1120           | 0.8            | 0.8           |
|     |          | Top Soil       | 24             | 2.4           |
|     |          | Weathered Layer| 5676           | 1.3           |
|     |          | Fresh Basement |                |               |
| 24  | KH       | 375            | 1.2            | 1.2           |
|     |          | Top Soil       | 562            | -             |
|     |          | Fractured Layer| 1081           | 0.5           |
|     |          | Fresh Basement |                |               |
| 25  | H        | 205            | 0.8            | 0.8           |
|     |          | Top Soil       | 80             | 6.8           |
|     |          | Weathered Layer| 821            | -             |
|     |          | Fresh Basement |                |               |
| 26  | H        | 63             | 1.2            | 1.2           |
|     |          | Top Soil       | 34             | 5.3           |
|     |          | Weathered Layer| 2702           | -             |
|     |          | Fresh Basement |                |               |
| 27  | H        | 124            | 2.5            | 2.5           |
|     |          | Top Soil       | 9              | 3.8           |
|     |          | Weathered Layer|                |               |

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The weathered layer isoresistivity map (Fig. 4) shows that weathered layer resistivity values vary between 3.2 – 272 Ωm. This depicts a relatively porous and permeable geologic formation with tendency for relatively high groundwater yielding capacity. Low resistivities zones (< 90 Ωm), characterized as zones composed of clayey formation, encountered at the western part of the study area. These layers of low resistivity material are known to be porous but less permeable and therefore exhibit low groundwater potential.

### 3.3 Overburden Thickness Map

The overburden thickness map of the study area (Fig. 5) shows that the thicknesses of overburden layers vary between 0 and 28 m; with the southwestern part associated with thicknesses greater than 25 m. Areas around VES 42, 6, 9, 12 and 24 have moderate overburden thickness. The remaining parts of the study area are underlain by thin (0.9 m) overburden. The relatively thin overburden thickness (< 9 m) characterizing most of the study area implies low groundwater storage capacity.

### 3.4 Bedrock Relief Map

The bedrock relief map (Fig. 6) shows the relief of the bedrock of the area, with the northeastern and the southeastern parts indicating low bedrock relief (360-400 m); while moderate to high bedrock relief ranging from (400 to 480 m) are observed in the northwestern and southwestern parts. The accumulation of groundwater would tend towards the northern and southeastern part of the study area because of the low relief.

### 3.5 Groundwater Potential Map

Figure 7 shows the groundwater potential map of the study area. The northwestern and southeastern part of the study area constitutes high groundwater potential zones (about 15%) while the remaining 85% of the study area are inferred to be low/moderate groundwater potential zones due to clayey weathered layer, thin overburden and high bedrock relief. Therefore, suggests a generally low potential for groundwater zone in this study area.
4 CONCLUSIONS

Groundwater potential evaluation of the eastern part of Ado-Ekiti, Southwestern Nigeria was carried out. The VES results identified seven (7) different VES type curves (H, A, HA, KH, HK, QH and HKH) indicating inhomogeneity of the subsurface layer beneath the study area. The weathered layer and the partly weathered/fractured basement constitute the aquifer units within the study area. The overburden thickness is relatively moderate (0 – 28 m). Based on the relatively thin overburden, the clayey nature of the weathered layer and high bedrock relief of the study area, it can be concluded that the groundwater potential of the study area is low.

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