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Application of Resistivity Sounding In Groundwater Investigation: A Case Study of Rimin Gado and Tofa Local Government Areas of Kano State, Nigeria.

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Abstract: *Over thirty Vertical Electrical Sounding survey were carried out in Tofa and Rimin Gado local government areas of Kano state. Dynamic water level from open wells was also collected and was used as a guide for the selection of the electrode spread. The schlumberger array with a maximum electrode spread of 100 m was employed in all the points. Results from the sounding data indicates that the area is generally underlain by five geoelectric or geologic section which include Lateritic top soil or Lateritic sand, Silty sand or Sandy clay, Weathered basement or Clayey sand, Fractured basement and Fresh basement. Based on the result obtained the weathered as well as the fractured basements forms the aquiferous zone within the study area, with the weathered being more promising. The resistivity of these zones varies from 9 to 1640 Ωm with an average value 255 Ωm, while the thickness varies from a value of 1.66 to 28 m with an average value of 10.67 m. Depth to this zone varies from 5 to 31 m with an average value of 8.1 m. The study also shows that the Rimin Gado area appears to have more potential for groundwater development as compared with the Tofa area.*

Key words*: Geoelectric, Kano State, Resistivity sounding, Rimin Gado, Tofa, Vertical Electrical Sounding.*

I. Introduction

There is a steady rise in the demand for groundwater in most hard rock areas most of which cannot boast of any constant surface source of water supply (Adanu, 1994)? This is as a result of growing Population in both rural and urban areas which raises the demand for potable water and other amenities in many parts of the world. Groundwater is considered to be the best form of water and as the only reliable alternative means of water supply to the city. But for boreholes to serve as viable alternative, the search must first of all assess the potential and viability or otherwise of the area in question. This is because for the current and future scale of groundwater development in Basement aquifers and for sustainable water supply, observed failure rates, variability of yields and maintenance problems are overwhelming evidences of the need to have a good understanding of the hydro-geological settings before borehole construction. The two area of study Rimin Gado and Tofa local government areas (fig.1) are located on the western part of Kano state. Kano area (Fig.2) is underlain by rocks of the Nigerian Basement Complex comprising migmatite-gneiss complex, Younger Metasediments, Older and Younger Granites. The aquifers of the Basement Complex rocks are the regolith and the fractures in the fresh bedrock which are known to be interconnected at depth (Mohammed, 1984; Alagbe, 1987; Adanu, 1989; Uma and Kehinde, 1994). Bala (2008) has shown that regolith aquifer derived from schists and gneisses of sedimentary origin (orthogneisses) proved to be a difficult groundwater terrain contrary to the observations in the earlier works that not only indicated similarity in aquifer performance across the different bedrock types, but also that these aquifers compare with those in other parts of the African Shield. The failure rate in most groundwater project recorded in Basement Complex aquifers has informed the general acceptance of a geophysical survey as a compulsory prerequisite to any successful water well drilling project (Dan Hassan, 1999). The electrical resistivity method involving the vertical electrical sounding (VES) technique is extensively gaining application

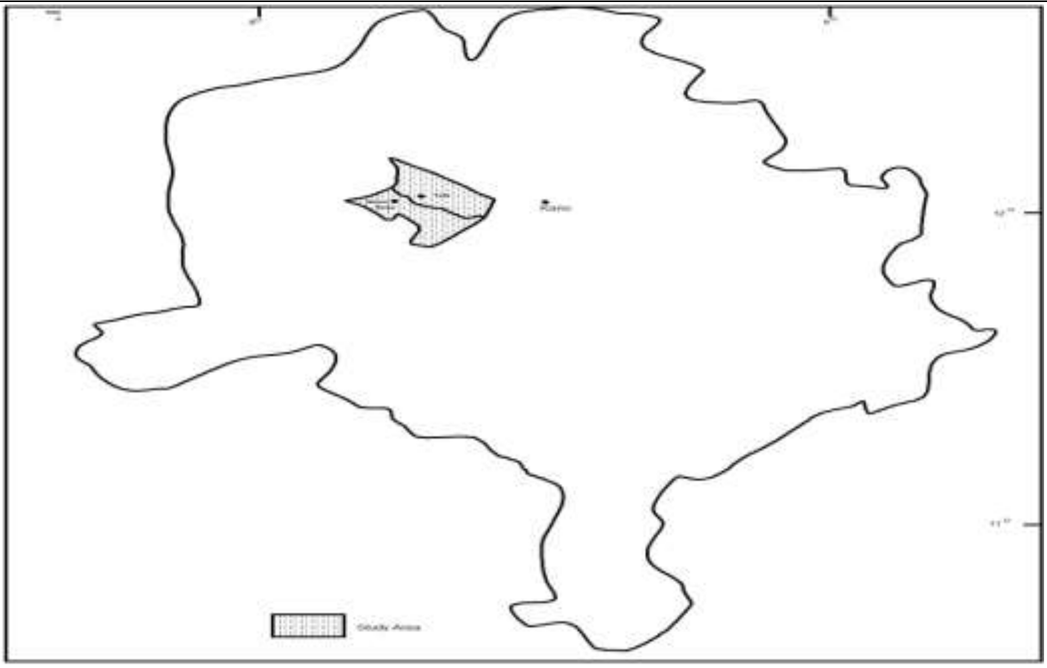

Fig.1: Location map of the study areas.

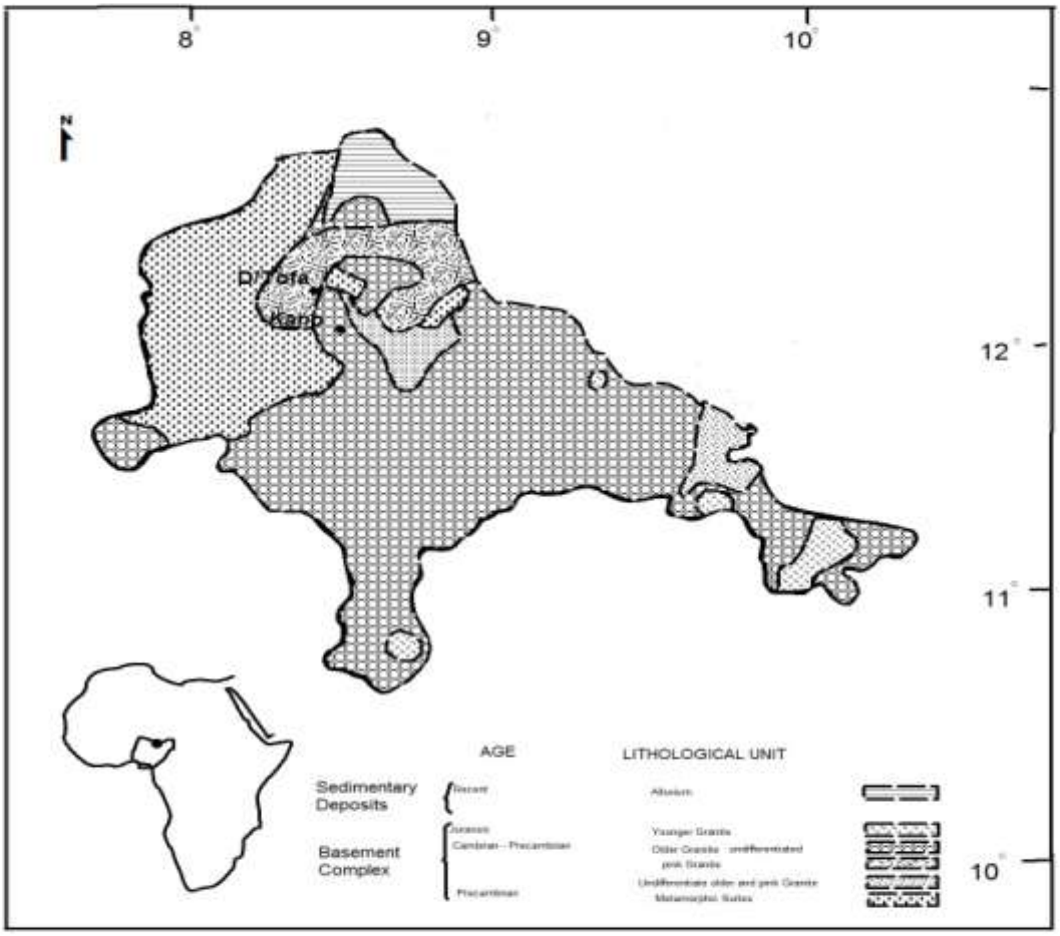

Fig.2: Geologic Map of Kano and parts of Jigawa state (KNARDA,1989).

in environmental, groundwater and engineering geophysical investigations (Zohdy *et al.*, 1980; Aina *et al.*, 1996; Olorufemi et al., 1993 and 2004; Afolabi and Olorufemi 2004 and Abubakar and Danbatta 2012, Abubakar and Yola, 2012). The present work is aimed at applying this technique in study areas so as to compare and established their groundwater potential and to serve as a guide for future groundwater development.

1.2 Geology of the Area

The Northern Nigerian Basement Complex comprises three groups of rocks namely, migmatites and (high grade) gneisses derived from Birrimain sedimentary rocks through high grade metamorphism and granitization; the Younger Metasediments of Upper Proterozoic age which are low grade metamorphic rocks that were folded along with the migmatite and gneisses during the Pan-African orogeny; and the Older Granite series which were intruded during the Pan-African orogeny (McCurry, 1989). In the study area, Hazell *et al.*, (1988) also reports the occurrence of rocks of the Younger Granites series (Falconer, 1911), so termed because they are Jurassic in age (Figure 2), as well as volcanics, and occasional younger dykes and flows. Kano Agricultural and Rural Development Authority, KNARDA (1989) identifies the individual members of the Older Granite suite, but rocks of the Younger Metasediments and those of the migmatite-gneiss complex were simply grouped as the migmatite-gneiss complex in some places (Figure 2).

1.3 Materials and methods

About twenty four (24) dynamic groundwater levels were measured from open wells from the study area which serves as a guide to the electrode spread used in the present study. The data also serves as guide in understanding the local variation in groundwater level of the study area. Over thirty (30) Vertical Electrical Sounding (VES) data points were acquired using an ABEM Terrameter SAS 300 within the study areas, fourteen of which are from Tofa and Eighteen from Rimin Gado local government areas. The schlumberger electrode array was employed in all the sounding points with a maximum electrode spread of 100 meters as recommended (Abubakar and Auwalu, 2012). Most of the spread were oriented in an N-S direction depending on the trends of structures which were observed locally, a few however were oriented E-W. The survey was carried out between the months of December, 2011 to January, 2012. The data were later reduced and subjected to both qualitative and quantitative interpretation.

1.4 Results and Discussion

Geoelectric models for the the study area in the form of Vertical Iso-ohms Section (VIS) and Iso-ohms Map (Resistivity contours) at different depths were plotted. These were used to delineate the aquiferous zone within the area of study. The acquired VES field curves were initially interpreted using the conventional partial curve matching technique and the Petrowski's method (Telford *et al.,* 1976). Initial estimates of the resistivities and thickness of the various geoelectric layers were deduced from this preliminary interpretation. The deduced parameters were later used as starting models in an "Interpex" computer program. This computer assisted resistivity interpretation is based on the calculation of theoretical VES curves, and gave the 'best fit' for the data obtained.

The dynamic water level measured from open wells varies from 6 to 27 meters with an average value of 19.7 meters. There is a strong local variation in the water levels and this has been observed to be controlled by topography, thickness of overburden as well as the geology. Not all the wells however are high yielding even though the survey was carried out not at the peak of dry season, this could be attributed to the fact that some of the wells are taping water not from the static water level but rather from a dynamic water level of the aquifer. Results from the sounding data indicates that the study area is underlain generally by five (5) geoelectric or geologic layers although in some areas the fifth layer was not encountered as a result of variation in the over burden thickness. The layers include; Lateritic top soil or Lateritic sand, Silty sand or Sandy clay, Weathered basement or Clayey sand, Fractured basement and Fresh basement. Based on the result obtained the weathered basement makes the possible aquiferous zone within the study areas. The resistivities of these zones varies from 9 to 1642 Ωm with an average value 272.4 Ωm, while the thickness varies from a value of 1.19 to 28 m with an average value of 10.67 m. Depth to this zone varies from 3 to 21.83 m with an average value of 8.1 m. The general geoelectric or geologic section of the study is presented in figure 5. The dynamic water level contour map (fig.3) indicates that most of the wells from the Tofa area are deeper than those in Rimin Gado area. These deeper zones are usually recharge areas and hence the groundwater moves from these areas to shallow ones. Based on this the groundwater could be moving from most of the Tofa area to the Rimin Gado area. The possible aquifer thickness also appears to be less in Tofa area as compared with those in the Rimin Gado area (fig.4). There is no much variation in the resistivity of the auriferous (average value 289 Ωm) as compared in the Rimin Gado area as compared with the Tofa area (average value 255.98 Ωm).

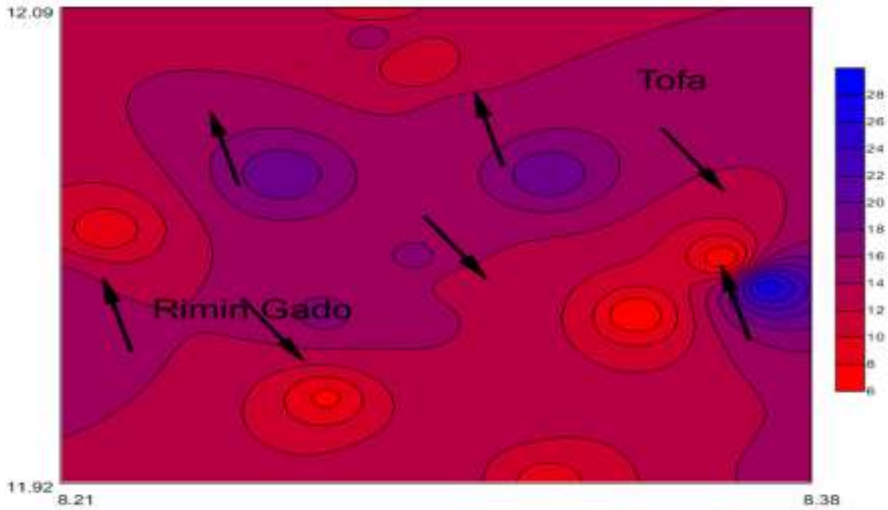

Fig.3: Dynamic water level map of the study area showing groundwater flow direction.

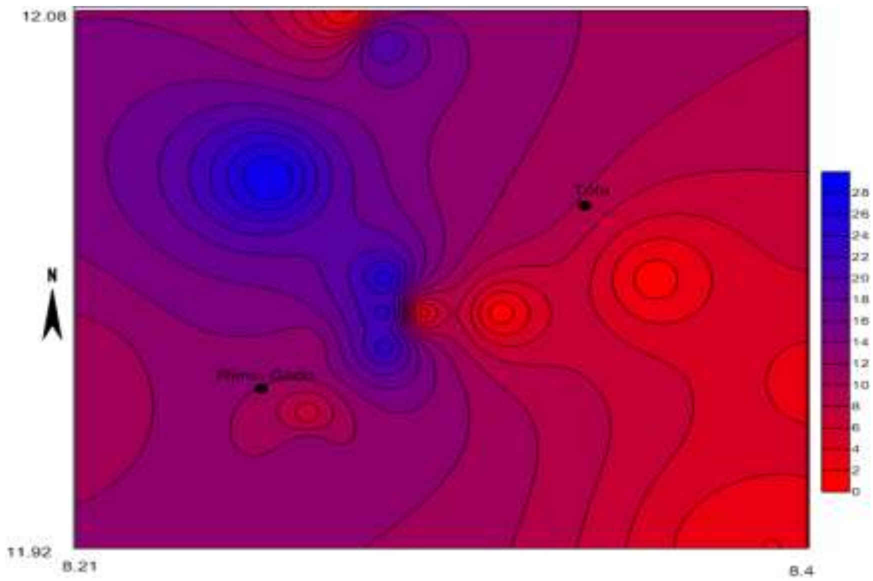

Fig.4: Aquifer thickness contour map of the study areas.

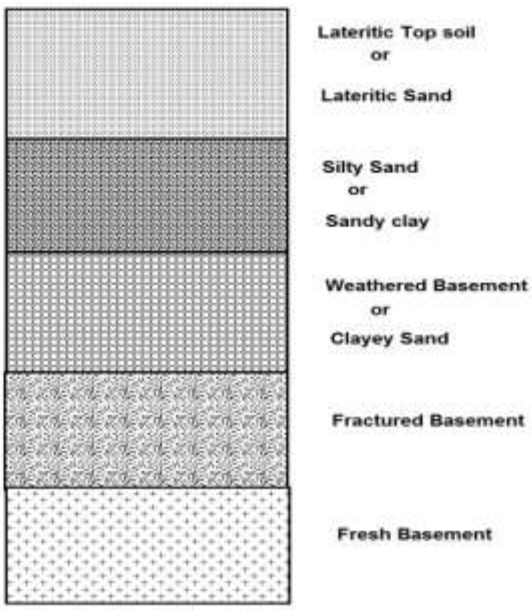

Fig.5: General geologic / geoelectric section of the study areas.

1.5 Conclusion

In conclusion it can be said that the study area is generally underlain by five (5) geoelectrical / geologic layer with an average low resistivity value of 272.4 Ωm, an average thickness value of 10.67 m and an average depth value of 8.1 m. The Rimin Gado area appears to have more potential for groundwater development in view of the low resistivity and better thickness of the aquiferous zone as compared with Tofa area. The study has also shown that in order to have a sustainable groundwater development project there is the need for adequate geophysical investigation to assess the groundwater potential of the area.

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