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Azimuthal Square Array Resistivity Method and Goundwater Exploration in Sanganoor, Coimbatore District, Tamilnadu, India

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Abstract

The groundwater prospecting were conducted using Azimuthal square array direct current electrical resistivity method in Sanganoor,Coimbatore district, Tamilnadu. In the present investigation also it is shown that from the surface Azimutal square array electrical resistivity sounding data it is possible to estimate the groundwater water yield in the sanganoor site of granitic rocks. In this application data were collected from the field using CRM-500 Resistivity meter, Azimuthal square array technique, electrodes, wirespoll, used for the sounding. The resistivity data were processed using the formulae and plotted in the graphical form of Anisotropy graph, Radar diagram and Master curve plotting were used to identify the fracture/fault zone in the granitic rocks and it aquifer characteristics of the study area. From the resistivity profiling data is used to recognize geology of the top layer covered with clay with fine sand and calchie deposits mixed with gneissic rocks. The square array electrical resistivity method used to predict the water bearing zone is occurs at three layers of different depth that range of resistvity from 100 ohm.m to 120 Ohm.m in the study area.

Key words: Azimuthal square array, resistvity sounding, electrical method, Coimbatore, fault zone.

Introduction

In the present study, the main aim of the investigation through electrical resistivity, Square Array method is used to measure the apparent resistivity of the study area. Coimbatore district is one of the important industrial cities of Tamil Nadu State. Sanganoor site is a study area and a part of the Coimbatore city. It houses the Coimbatore Airport. Major textile and wetgrinder industries, and a considerable number of foundries and motor / pump industries of the district are also located here. The city lies between 10.8° and 11.13° of the northern latitude and 76.87° and 77.11° of eastern longitude in the extreme west of Tamil Nadu near Kerala state at an elevation of 432 metres from sea level. Mean valued to 11.00° N 77.00° E. The study area location in between 11°02' 17.9" of the latitude and 76° 57'18.7" of longitude in the extreme west of Tamil Nadu (figure1). In present area underlain by hard rocks, the picture is much more complex and difficult[1]. Ground water being a hidden resource is often developed without proper understanding of its occurrence in the study area. Most of the wells are drilled indiscriminately based on requirement[2-5]. As a result, many of the times, the wells drilled have gone either unproductive or became failures causing financial loss to the users.

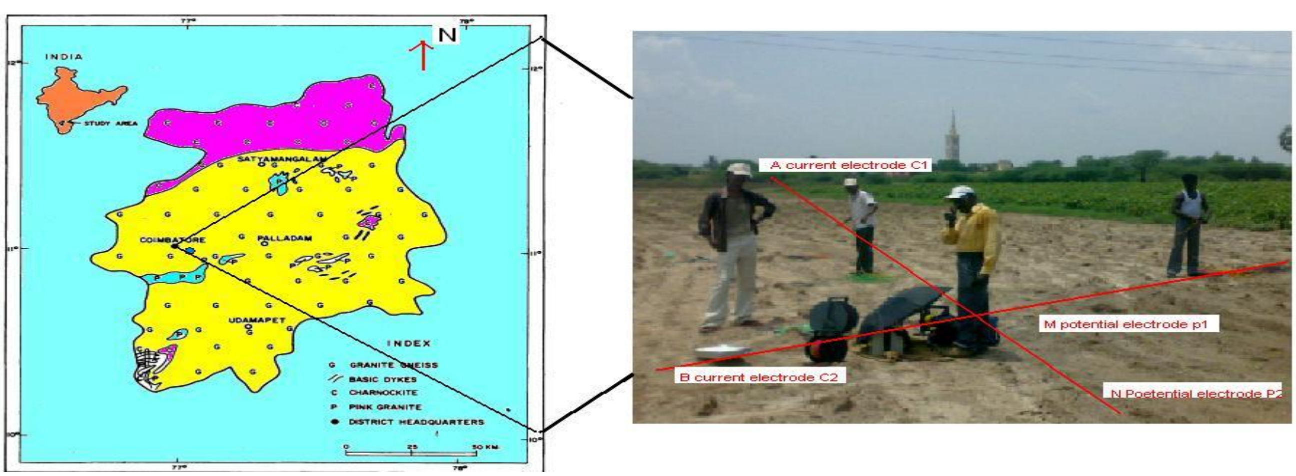

Figure -1
Shows the Geological map of study area Sangnoore site, Coimbatore District

Material and Methods

Azimuthal square array (dc) resistivity is a modified resistivity method, where in the magnitude and directions of the electrical anisotropy are determined. An electrode array is rotated about its center so that the apparent resistivity is observed for several directions. The side length of the square is defined as spacing and is equal to the depth of penetration. The array is expanded symmetrically about the centre point with an increment in 'a' spacing of $(2)^{1/2}$ in square array method[6-9].

Field Measurements: For each square, three measurements are made, in which two perpendicular measurements namely Alpha (α) and Beta (β) Gamma (γ). The same will repeat after rotation of certain angle, such as 15^0, 45^0 and they are denoted by the letter α', β', The α and β measurements provide information on the directional variation of the sub surface apparent resistivity (ρa). The "γ" measurement serves as a check on the accuracy of the α and β measurements (figure 2).

Apparent resistivity

$$\rho_a = \frac{K\Delta V}{I} \quad (1)$$

Where ρa = apparent resistivity; K = geometric factor for the array; ΔV = potential difference, in volts; and I = current magnitude, in amperes.

The geometrical factor (K) for square array is calculated by using the formula

$$K = \frac{2\pi A}{2 - (2)^{1/2}} \quad (2)$$

Where A= square-array side length, in meter[10],

Where N = bedrock anisotropy.

$$N = \left[(T+S)/(T-S)\right]^{1/2} \quad (3)$$

Where T = A-2+B-2+C-2+D-2; S = 2 [(A-2-B-2)2 + (D-2-C-2)2]1/2

The data generated for bed rock anisotropy (N) and apparent anisotropy (λa) by using the equation number, are utilized to construct the diagram to characterize the anisotropism of bedrocks in the study areas. The square array is more sensitive to anisotropy than Schlumberger or Wenner array[11] Plots of bed rock anisotropy (N) versus apparent anisotropy (λa) show high upward trends. The higher apparent anisotropy measured by square array is an advantage because the anisotropy is less likely to be obscured by heterogeneities in bed rock or overburden, relief or electrode placement error[12] than the other electrodes arrays like Wenner or Schlumberger.

Interpretation: The apparent resistivity is calculated by multiplying apparent resistance measured in azimuthal square array survey with the configuration factor. Secondary porosity, apparent anisotropy, bedrock anisotropy are calculated using apparent resistivity. The calculated values were tabulated and three types of graph were plotted. The three types of graphs are: i. Anisotropy graphs. ii. Azimuthal polar plots. iii. Depth sounding graphs.

Anisotrophy graph: The anisotropy calculated from the collected data of bed rock anisotropy (N) and apparent anisotropy are utilized to plot the anisotropy graphs. It has used for the depth wise analysis of the groundwater availability and the fault / fracture trends in the study area (figure 3).

Azimuthal Polar Plots: The apparent resistivity values calculated for the three locations are plotted as Azimuthal graphs. From these azimuthal plots in the study area three fracture directions long with homogeneous rock mass are identified on the basis of the relative of increasing order of apparent resistivity values (figure 4).

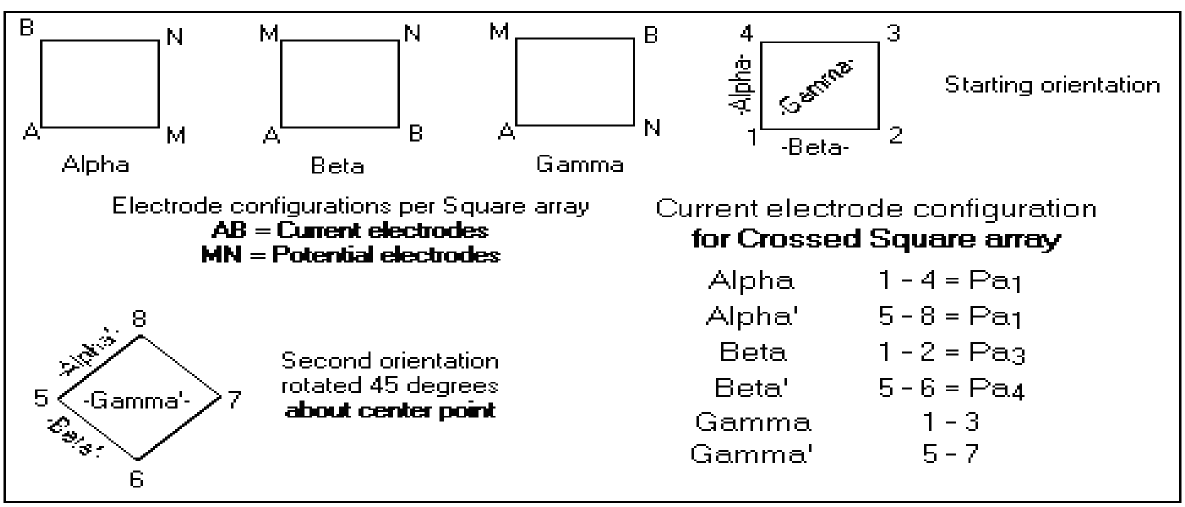

Figure- 2
Shows Square array electrode arrangements

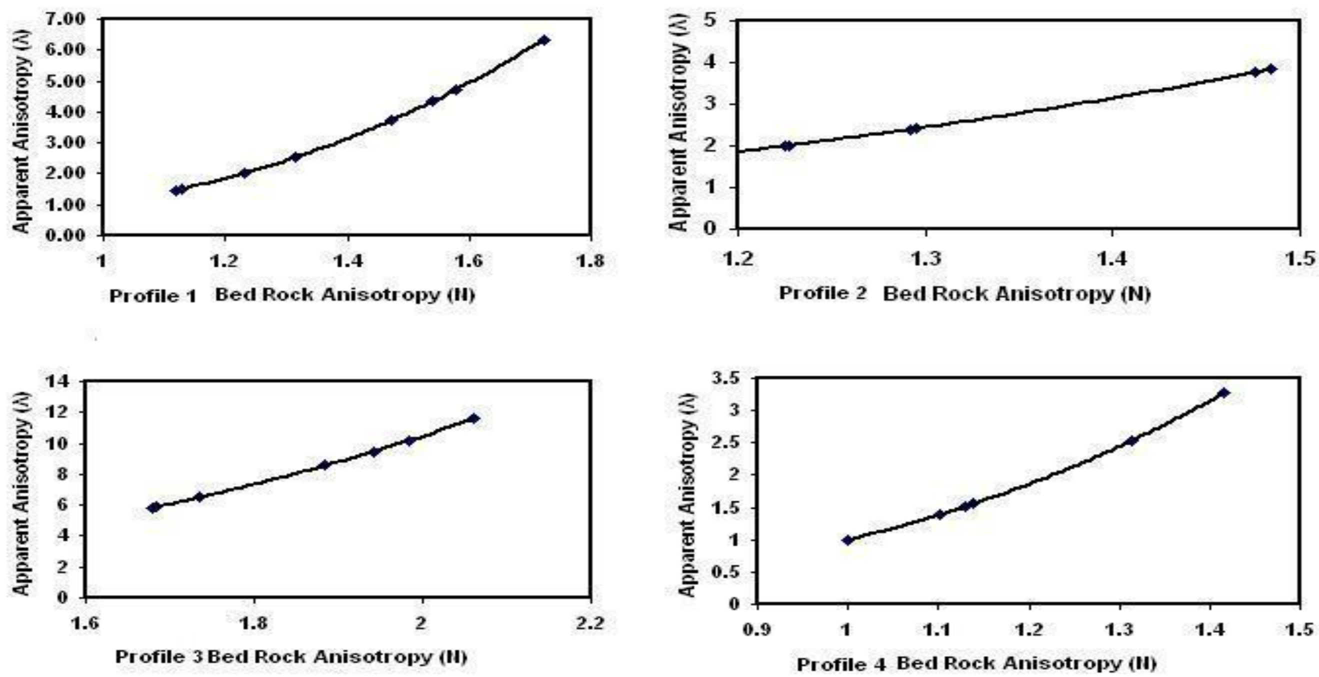

Figure- 3

Plots showing upward trends for bedrock anisotropy (N) and Apparent anisotropy (λ) measured for rocks at 4a. Profile 1, 4b. Profile 2, 4c. Profile 3. Profile 4

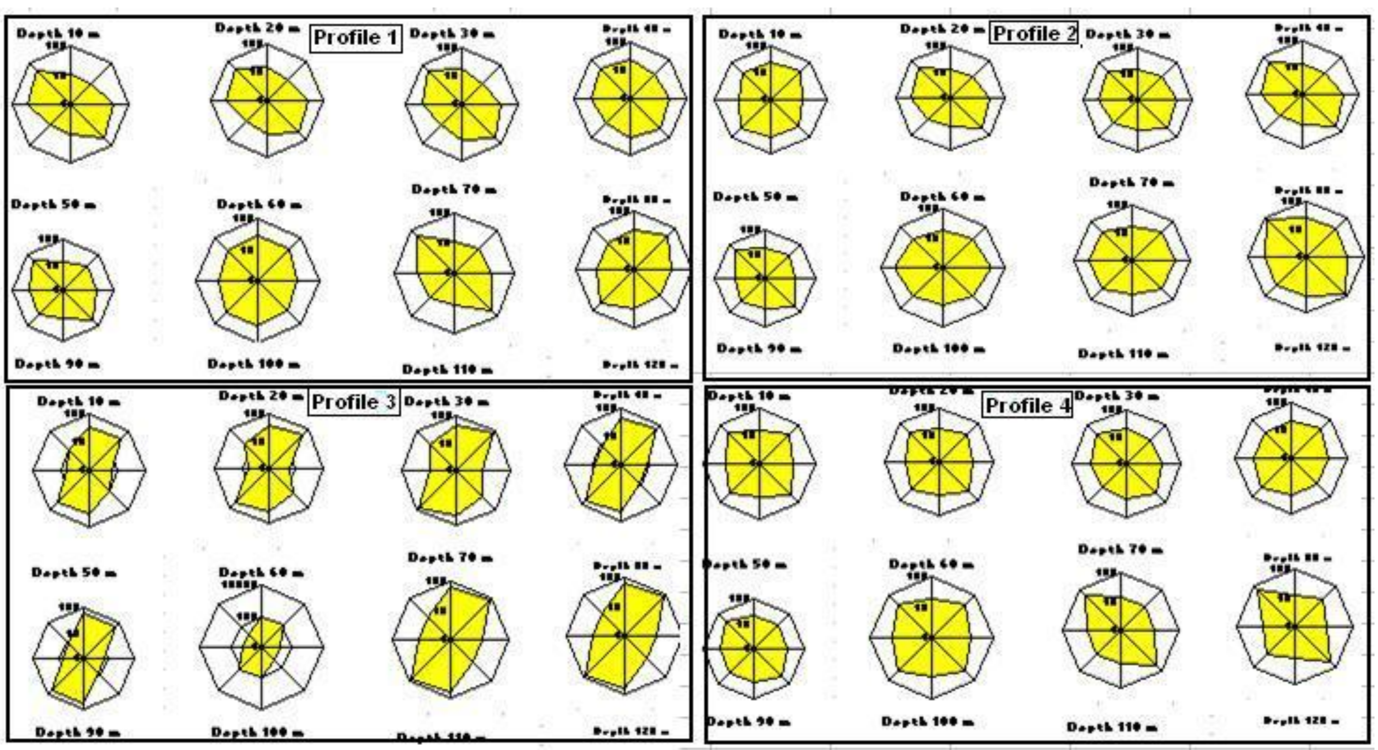

Figure - 4

Shows the pattern of apparent resistivity in Ohm-m plotted in different depths at four profiles

The longest axis of the ellipse in the polar plot indicates maximum resistivity of the rock mass. When the polar diagram conforms to an ellipse, it is taken to represent the anisotropy. The circular pattern of the plot exhibits rock mass without fault / fracture orientation. i.e the rock is isotrophic (table1).

Depth sounding and master curve plotting: The electrical resistivity depth sounding curve is plotted between apparent resistivity and 'A' spacing. Plotting of 'A' spacing versus apparent resistivity values obtained from alpha, alpha', beta', beta' orientation imply the horizontal resistivity zones. In the square array, 'A' spacing is equal to depth (figure 5).

The square array electrical resistivity method curve matching were used to identify the geological layers of clay with calchie, gneiss and Charnockite. The water bearing freshwater zone is identified fresh water zone (120 0hm.m) is identified below zone I - 20m and Zone II - 60m and Zone.

Results and Discussion

Azimuthal Square Array (DC) Resistivity method is used to study the fracture zone of the subsurface and to investigate the groundwater level of the Sanganoore village. The profile 1 is a high anisotropy region. High anisotropy implies the presence of rocks with different physical properties in different orientations in the subsurface of the study area at four profiles. In the square array, the depth is equal to 'A' spacing. Plotting of depth versus apparent resistivity values obtained from alpha, alpha', beta, beta' orientations imply the horizontal conductivity zones. Since, the study area is situated in igneous rocks; the maximum recorded apparent resistivity in this terrain is 200 Ohm-m and the resistivity range for the conductivity zone is arbitrary fixed as less than 6 Ohm-m. The water bearing weathered gneissic rock zone in the study area is occurred at zone 1 at a depth of 20 and zone II at depth of 60-70m.

Table-1
Depth and Orientation of fractures in the study area

Pattern	Depth (m) and Orientation of features in location Profile 1	Depth (m) and Orientation of features in location Profile 2	Depth (m) and Orientation of features in Profile 3	Depth (m) and Orientation of features in Profile 4
Ellipse	30m - NE -SW	60m NE-SW	-	40m,80m
Circular	40m,60m	10m,70m	-	10,20,80m
Single Fault	10,20,30,40,50 – NE- SW	20,30,40 NE-SW	40,50,60 and 70m	30m,50m,70m
Double fault	_	-	10,20,30	-

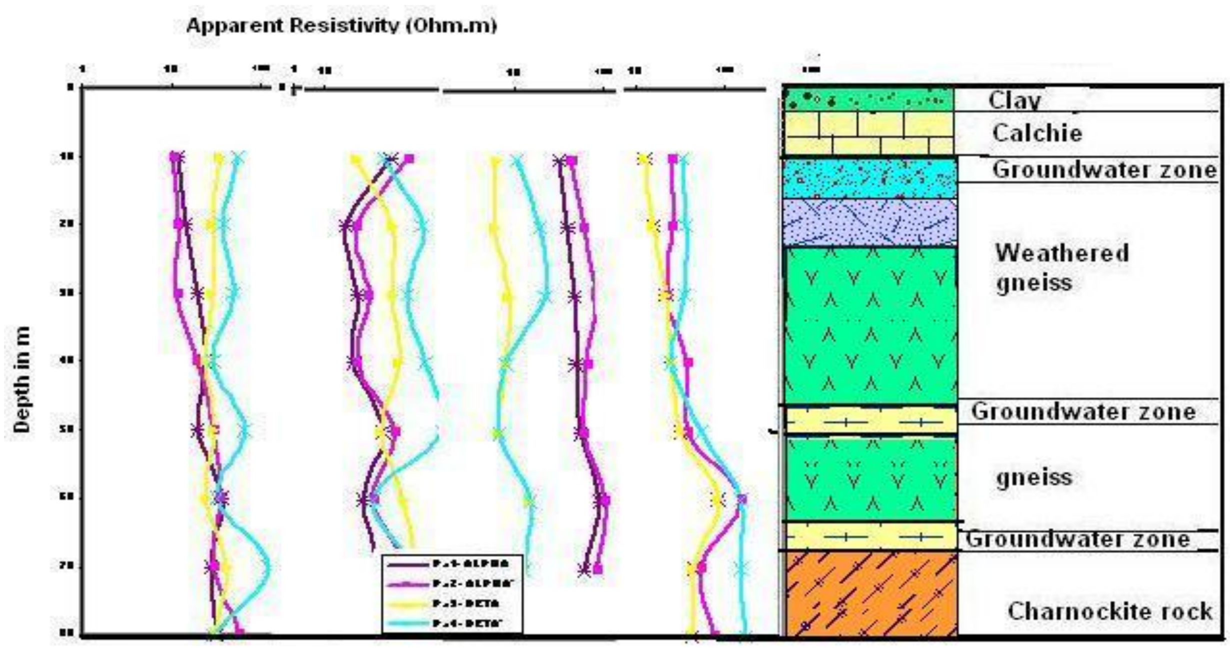

Figure - 5
Depth wise variation azimuthal apparent resistivity values at Profile 1,2,3 and 4

Conclusion

The Azimuthal square electrical resistivity method is used to locate the bore hole site. The well site yield (Fracuterd zone) and resistivity obtained form the square array showed that these are interrelated parameters (Azimuthal, Polar, Master Curve). The uppermost 20-30m depth variable resistivity layer (zone I) represents the top aquifer in the study area from profile 1 to 4. The second layer zone II from 60-70 m depth, representing freshwater bearing gneissic rock. From this study groundwater occurs at unconfined conditions in the weathered and fractured zones in other parts of the study area.

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