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Delineation of Subsurface Geological Formations using Electrical Resistivity Methods in Ongur River Sub Basin, Tamil Nadu, India

V.S.T. Gopinath [#1], B. Gowtham [*2], V. Arulprakasam [*3] A. Subburaj [*4]

[1] *Central Ground Water Board, South Eastern Coastal Region, Chennai*
[2] *Department of Geology, Presidency College, Chennai*
[3] *Central Ground Water Board, South Eastern Coastal Region, Chennai*
[4] *Central Ground Water Board, South Eastern Coastal Region, Chennai*

Abstract— The application of Geophysical Electrical Resistivity methods by means of Vertical Electrical Soundings for deciphering the subsurface characteristics of Hard rock terrains has been attempted in the Ongur River Sub Basin, Tamil Nadu. 77 Vertical Electrical Sounding (VES) were conducted at regular station intervals. The VES data were interpreted by Curve Matching Technique using Standard Master Curves as well as 'IPI2Win' software. The interpreted VES results coupled with Hydro geological data have been used to delineate subsurface geological formations and ground water potential zone, which will help in identifying areas suitable for groundwater management in Hard rock terrains.

Keywords— Electrical Resistivity, VES, IPI2WIN Software

1. Introduction

There is an ever-increasing demand for fresh water resources to meet the requirements for Industrial, Agricultural and domestic sectors. The over– exploitation of groundwater resources and its contamination have put a several stress on the available ground water resources in the country. In many parts of the country, ground water development has already reached a critical stage, resulting in acute scarcity of the resource. Over- development of the ground water resources results in declining ground water levels, shortage in water supply, intrusion of saline water in coastal areas and increased pumping lifts necessitating deepening of ground water abstraction structures (CGWB, 2007). Geophysical surveys have found enormous applications in hydro geological studies. The resistivity methods are employed successfully to estimate the thickness of the rock formation and also the electrical nature of the formation which provides useful information regarding the ground water potential (Griffth & King, 1965; Parasins 1966, and Balakrishna, 1980). In the present study an attempt is made to identify the subsurface geological formations and ground water potential zones for better ground water management planning in Ongur River sub basin, Tamil Nadu, India.

2. Study Area

Ongur river sub basin is one of the sub basin of Varahanadi river basin in Tamil Nadu. Ongur River sub basin consists of Ongur and Periar rivers, which are ephemeral in nature. The sub basin includes major part of Kancheepuram district and remaining part from Tiruvannamalai and Villupuram districts. The sub basin is observed with sedimentary formation along the coast and hard rock terrain in the western part. Electrical resistivity method of geophysical technique happens to be the most preferred methods in groundwater contamination studies and hydro geologic investigations (Mazak et al., 1987, Carpenter et al., 1990). However, Electrical resistivity surveys have been found very useful for mapping the resistivity structure of the complex subsurface geology (Singh et al., 1985; Griffiths et al., 1993). The sub basin lies between 79°30' and 80°00' east longitudes & 12°15' and 12°30 north latitudes. The total areal extent of the Ongur sub basin spreads to an area of 1480.08 Sq.km. The study area is covered by Survey of India topographic sheets 57P/11, 57P/15, 57P/16 and 57P/12 (Fig 1). In the present study an attempt has been made to identify the ground water potential zones, for better ground water management planning by using surface electrical methods in Ongur River Sub basin, Tamil Nadu.

3. Methodology

In all 77 Vertical Electrical Soundings (VES) were conducted in a nearly grid pattern, by deploying the CRM 500 and using the Schlumberger electrode configuration with maximum current electrode separation of 200 m depending on the available spread length covering 1480.08 Sq.km. Initially, the VES curves were interpreted during field survey by curve matching techniques using two and three layer master curves (Orellana, et al., 1966 and Bhattacharya, et al., 1968) and subsequently IPI 2 Win

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program is used on interpretation thereafter equivalent resistivities of different layers were estimated and results keeping in view the local geology and hydrogeology.

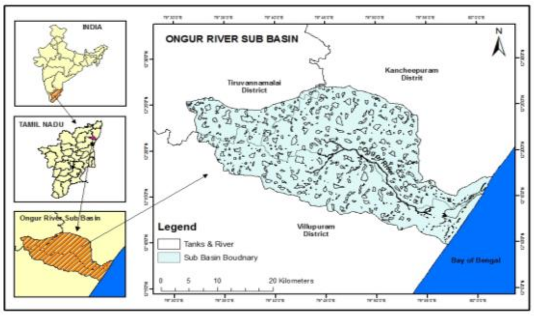

Fig. 1: Location Map of the study area

4. Results and Discussion

Based on the interpreted results of Vertical Electrical Sounding conducted in the area, three to four subsurface Geo electrical layers could be deciphered (CGWB, al 2001, 2006). With a view to depict the survey results in a realistic and effective way, contour maps for different geo-electric layer parameters were generated to infer the nature of the topsoil and to demarcate the ground water potential zones in order to achieve the objectives. From the Longitudinal Conductance (S) and Transverse Resistance (T) values ground water potential zones are demarcated. Different resistivity ranges were assigned to have associated with different geological formations/litho units.

The Iso resistivity contour map has been drawn on the basis of VES results is shown in Fig 2. The first layer generally represents the topsoil or the weathered part of the uppermost charnockite. The resistivity of this layer is varying from 3 to 1006 Ohm m. Its thickness is varying from 0.2 to 9.0 m. The low resistivities less than 10 Ohm m and occasionally raising to 100 Ohm m are caused by the Black Soil or highly weathered granite gneiss. Resistivity more than 10 ohm.m represents highly weathered charnockite in most of the area where as some patches less than 10 ohm.m represents looms soil.

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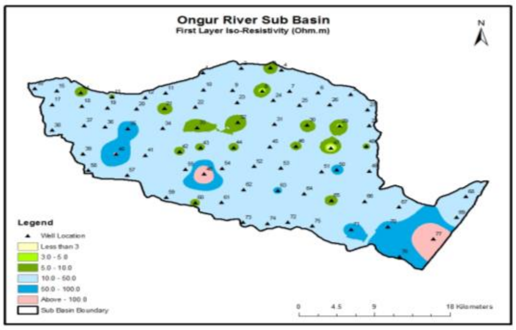

Fig. 2: Distribution of first layer resistivity

The resistivity of the 2nd layer is varying between 3 and 3500 Ohm m with thickness ranging from 0.8 to 60 m (Fig 3). The resistivities less than 5 Ohm m in the some patches of the study area represent alluvium with 3 to 5 Ohm m as clay, 5 -10 Ohm m as silty sand or sandy clay and 10 to 50 Ohm m as sand and / or clayey sand and weathered charnockite in the eastern part of the area. Resistivities between 50 - 100 Ohm m represents Coastal sand in the eastern, where as other places weathered charnockite of the study area, 100 – 500 ohmm indicates fractured charnockite and more than 500 ohmm represents massive charnockite.

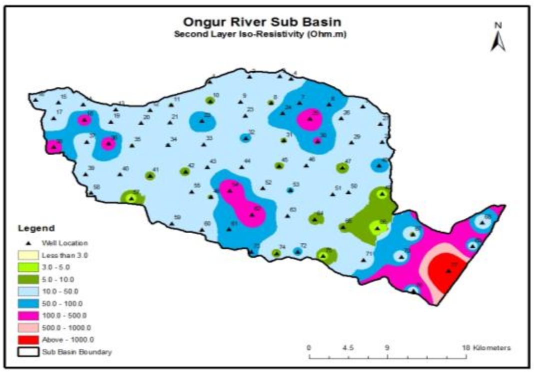

Fig. 3: Distribution of Second layer resistivity

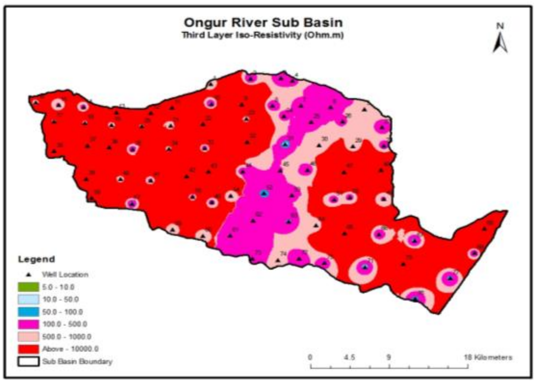

Fig.4: Distribution of Third Layer resistivity

The resistivity of the 3rd layer is varying between 2.5 and 9999 Ohm m with thickness ranging from 3.5 to 49.0 m (Fig 4). The resistivity values between 100 - 500 Ohm m elongating in NE-SW direction, infer jointed/fractured charnockite which may be due to the presence of group of lineaments. The high resistivity more than 500 Ohm m represents massive charnockite in major part of the study area.

The Transverse Resistance (T) and Longitudinal Conductance (S) known as Dar Zarrouk parameters which have been shown to be a powerful interpretation aid in groundwater surveys (Zohdy et al, 1974) are effectively useful for demarcating ground water potential zones

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(Narendra, 2007). Ayolabi, (2005) stated that from the geo electric parameters such as longitudinal conductance and transverse resistance the coefficient of anisotropy of the overburden material can be determined. Singh, (2003) stated that the transverse resistance (T) and longitudinal conductance (S) are used for better resolution of thin layers of both resistive and conductive properties of the geological formations.

The T and S values are estimated (fig 5 & 6) from VES results by using the following relationships.

$$T = \sum_{i=1}^{n} (h_i \times \rho_i) \quad ohm.m^2 ; \quad S = \sum_{i=1}^{n} (h_i / \rho_i) \quad mhos$$

Where, h_i= i^{th} layer thickness and ρ_i = i^{th} layer resistivity.Generally increasing T values is indicative of an increase in thickness of the resistive material (Zohdy, 1974). Variation in the total thickness of low resistivity material can be successfully identified by using the difference in S from one depth probing station to the other

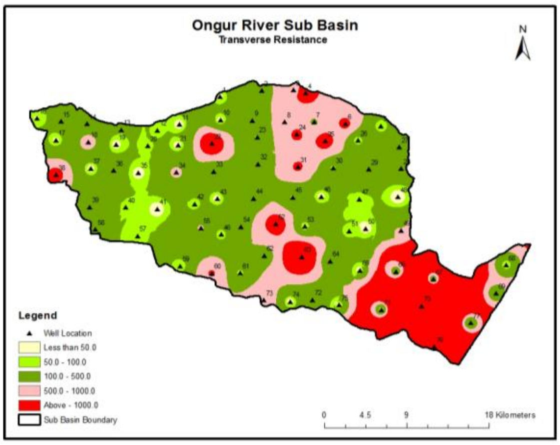

Fig. 5: Transverse Resistance (T) Layer Map

range from 0.11 to 1.95 mhos. The averages of T and S values are 479 Ohm m^2 and 0.43 respectively.

More than average Transverse Resistance (T) values of 479 Ohm m^2 observed in the eastern part and some patches in middle and western part of the area where as remaining area occur less than average values. General the T values range from 17.78 to 2680 Ohm m^2. However at few places exceed 6000 Ohm m^2. The S values

Based on the Transverse Resistance (T) and Longitudinal Conductance (S), the areas where Transverse Resistance (T) is above average values and Longitudinal Conductance (S) is below average values (T - High Value; S - Low Value) were considered as ground water potential zones and demarcated in the area and shown in fig 7.

(Zohdy, 1969; Henriet, 1975; Worthington, 1977 and Galin, 1979). Arulprakasam (2010) stated that the higher (T) and (S) values indicating a good potential but brackish to saline nature and deeper basement. In the present study area, in The VES 3,4,6,7,8, 24,25 and 31 northern part, VES 52,60, 63 and 73 southern part and VES 49, 66, 67, 70, 71, 76 and 77 eastern part, whose T and S values are falling in this range in the areas where Transverse Resistance is below average and Longitudinal Conductance is above average were considered as shallow basement.

The higher (T) and lower (S) values were seen in the centre part of the study area. It is indicating a good potential and deeper basement. Lower (T) and (S) values are observed in northwestern part of the area, which reflects the shallow basement and poor potential area (Hard rock area). Higher (T) and lower (S) values noted in southeastern area, indicates deeper basement with good groundwater potential.

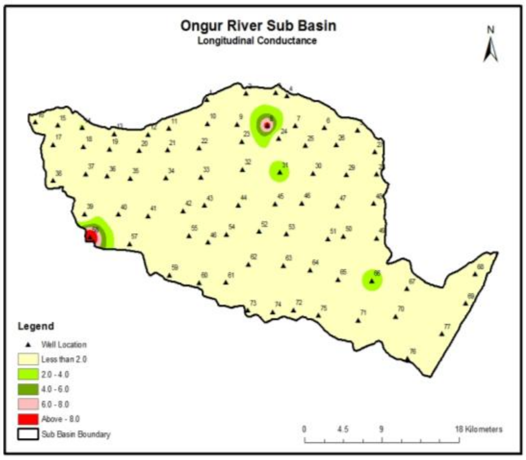

Fig. 6: Longitudinal Conductance (S) Layer Map

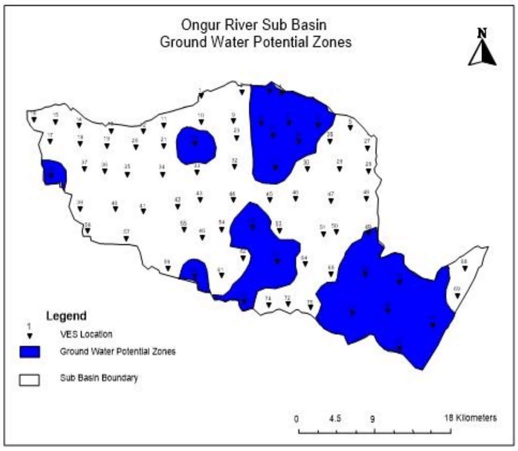

Fig. 7: Ground Water Potential Zone Map

5. Conclusions

The VES technique can be effectively used for deciphering the subsurface geological formations and ground water potential zones, which will help in identifying areas suitable for sustainable development of ground water resources in the area. The interpreted VES results revealed that ground water potential zones identified in the eastern and middle part of the area.

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