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Delineation and evaluation of groundwater potential zones using electrical resistivity survey and aquifer performance test in Uppodai of Chittar – Uppodai water shed, Tambaraparani River Basin, Tirunelveli-Thoothukudi Districts, Tamilnadu

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ABSTRACT

Geophysical Resistivity survey and aquifer performance test were conducted to delineate groundwater potential zones of Uppodai, Chittar – Uppodai water shed, Tambaraparani River Basin, Tirunelveli and Thoothukudi Districts. It is located between the North latitude of 8º 52′ to 9 º 10′ and the east Longitude of 77 º 35′ to 77 º 55′. The area is constrained with crystalline rocks of Achaean age consisting of gneisses, charnockites, granites, basic and acidic intrusives. In order to understand the subsurface lithology, 12 Vertical Electrical Soundings (VES) were carried out. The field resistivity data have been interpreted using RESIST 87 software. The resistivity value and subsurface layer thickness for the first layer varied from 18 Ωm to 122 Ωm and 8.3m to 41.4m.The depth to basement is observed at a shallow depth of 10.m in the northwestern part and more than 50m in southern part of the study area.

For understanding the aquifer characteristics 5 aquifer performance tests were conducted in the study area. The transmissivity and storage coefficient values computed from Jacob's straight line method varied from 43.6525 msq /d to 167.4367 msq/d and 0.00001 to 0.00163 respectively. The optimum yield and Recovery rate have been obtained as 3.0 m3/d to 100 m3/d and 34.0 hours to 379.3 hours respectively. The interpreted result of VES synchronizes with aquifer characteristics. The present study has proved the use of resistivity method and aquifer test as excellent tools to delineate groundwater potential zones and subsurface lithology.

INTRODUCTION

The conventional Schlumberger resistivity sounding is extensively used for routine groundwater investigations both in alluvial and hard rock terrain. The aquifer characteristics study helps to evaluate groundwater potential by aquifer performance test. The aquifer characteristics of the water bearing formations are transmissivity, storage coefficient, specific capacity etc. In the present study Uppodai of Chittar – Uppodai sub basin, Tambaraparani River, Tirunelveli District, Tamilnadu has been taken for understanding the subsurface lithology and aquifer characteristics for delineating groundwater potential zones by conducting geoelectrical soundings and aquifer performance test.

STUDY AREA

The study area Uppodai is a dry sub- basin. It is part of another sub basin of Chittar, which forms the Tambaraparani river basin (Fig.1). Since agriculture is the major activity, seasonal runoff in the Odai during rainy days is not sufficient to fulfil the water requirement for both domestic and irrigational purposes. The ground water is the only ultimate source for all needs. In this scenario of more dependence on groundwater, existing open wells are deepened and new deep bore wells are constructed for irrigational practice. This situation has severely affected the shallow open wells, due to decline of water level.

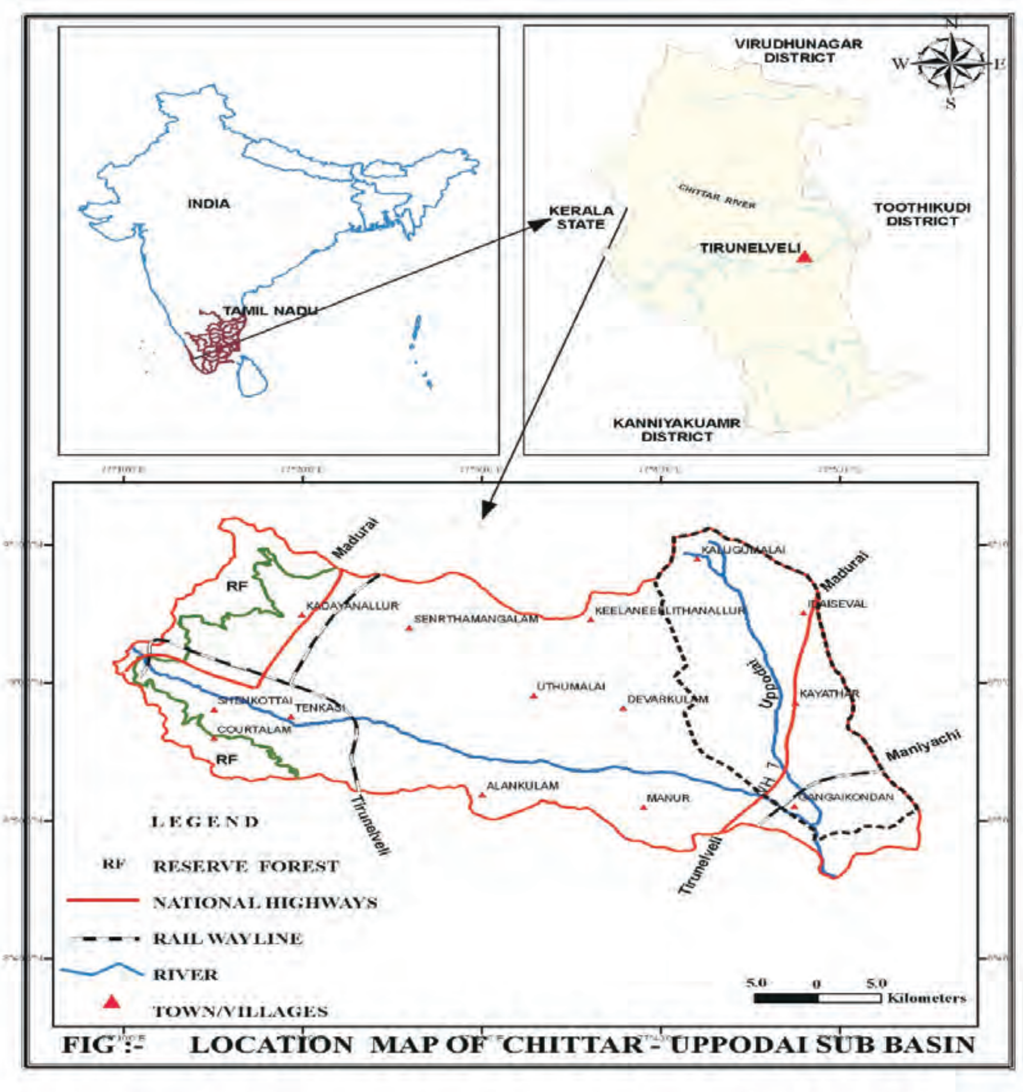

Figure1. Location map of the study area.

GEOLOGY OF CHITTAR-UPPODAI RIVER BASIN

Geologically the area consist of crystalline rocks of Achaean age namely gneisses, charnockites, granites and intrusives. The gneiss is covered most of the study area whereas charnockite occurs as small patches. The geological map of the area is shown in the Fig 2. The general geological succession of the region is presented below (after Varadaraj 1989).

There major soils types black cotton, red and alluvial soils are present. The plain region is mostly covered by the black cotton soil which is locally known as "Karisal".

HYDROGEOLOGY AND HYDROMETEOROLOGY

Evaluation of aquifer hydraulic properties is an important aspect for all kinds of groundwater resource assessment. In the study area, groundwater occurs mainly under water table conditions in the weathered crystalline complex terrains due to lack of sufficient secondary porosity. Precipitation is the main source for groundwater replenishment. The pattern of precipitation is essentially of a tropical monsoon type where the effect of winter monsoon is dominant. Plain lands of the basin fall under the semi-arid climatic type (Rammohan 1984). The average precipitation of 722.5mm is recorded in Kayathar station during the year 1901 to 2003. The actual annual evapotranspiration is found to be 636mm.

Period	Lithogroup	Lithology
Quaternary	Recent	soils, alluvium, kankar, laterite
Western ghat super group	Acid intrusives	Pegmatites, Quartz vein, Pink granites, Grey granites, Leucogranites
ARCHAEAN	Basic intrusives	Basic dykes, Basalt, Dolerites
	Migmatic complex	Garnetiferous quartzofeldspathic granulite gneisses
	Charnockite group	Charnockites, Pyroxene granulites
	Khondalite group	Crystalline limestone, Calc granulites, Garnetiferous biotite-sillimanite quartzites

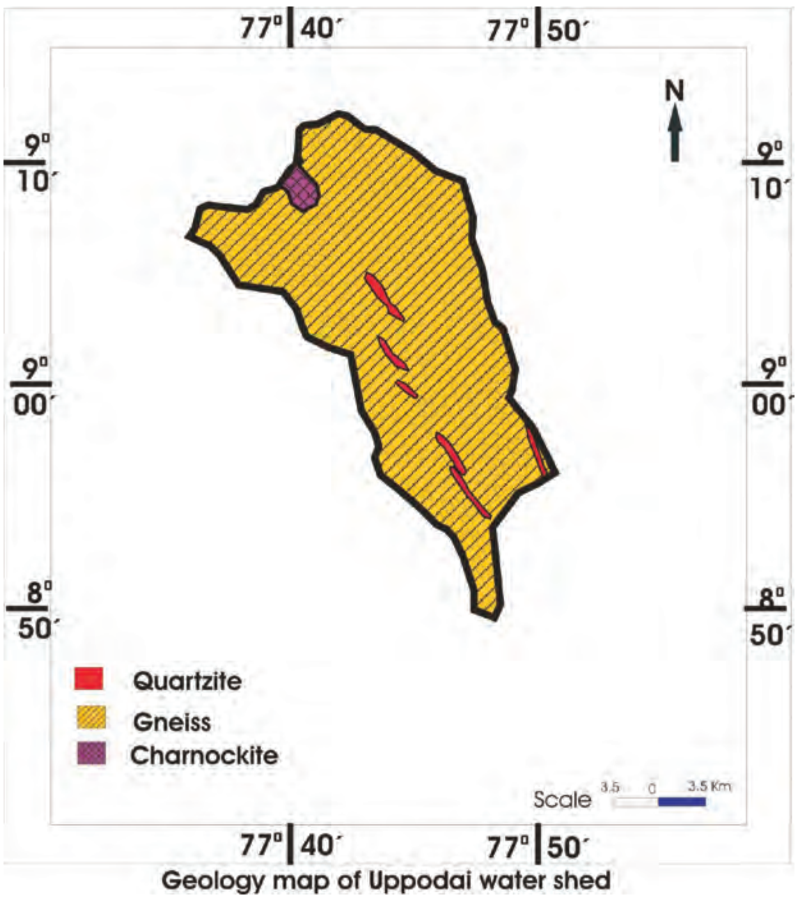

Figure 2. Geology map of the study area.

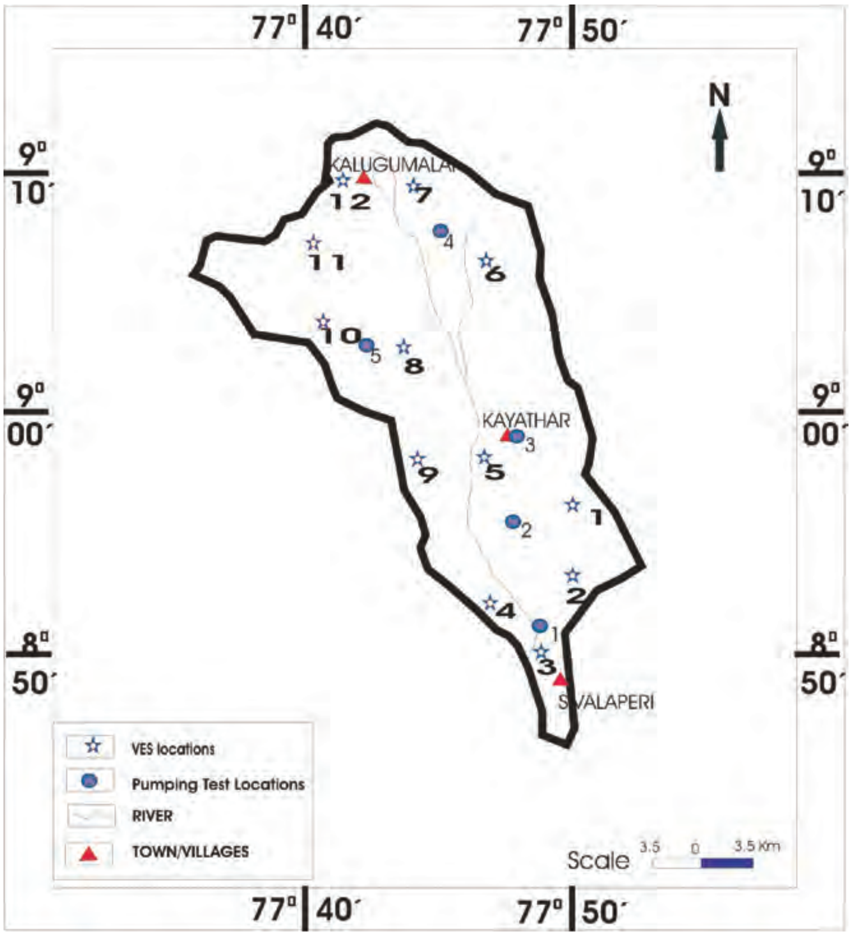

Figure 3. Map of VES and pumping test locations.

MATERIALS AND METHODS

In this study baseline information were prepared from the Survey of India topo sheets and geology map from Institute of Remote Sensing (IRS), Anna University generated map for understanding the geolithology and tectonic setting of the study area. Twelve vertical electrical soundings (VES) were conducted using the Schlumberger configuration with AB/2 spacing ranging from 2m to 100 m to comprehend subsurface lithology and groundwater potential zones of the study area. The field measurements were acquired using DDR – 3 model resistivity meter. Obtained data was interpreted with RESIST 87 software.

In order to identify aquifer characteristics, aquifer performance test was conducted at 5 locations. Aquifer parameters like transmissivity (T), storage coefficient, specific capacity, optimum yield and time required for full recovery were calculated using BASIC Programme software (Balasubramanian 1986). The VES and pumping test locations are shown in the Fig. 3.

RESULTS AND DISCUSSION

After analyzing interpreted resistivity data, resistivity value range of the study area is found to be varied due to the sub surface strata dissimilarity. The resistivity value and layer thickness of the study area is given in the Table 1. It is observed that interpreted resistivity is represented by A and AK curves type (Figs 4a and 4b). Most of the VES locations (7Nos.) have three layer curves, whereas four and two layer curves are noticed in VES locations 2 and 3.

In first layer, the resistivity value is found to be 18 Ωm in VES location 9. Maximum resistivity of 122 Ωm is observed in VES location 4. The resistivity value varied from 163 Ωm to 2666.6 Ωm in second layer. The spatial variation of first layer resistivity suggests high resistivity value in the northeastern and southern side. In the middle portion and around Kayathar area low to moderate resistivity value is observed. Second layer spatial resistivity map indicates first layer trend, high resistivity value in northeastern and southern side. Resistivity variation of third layer

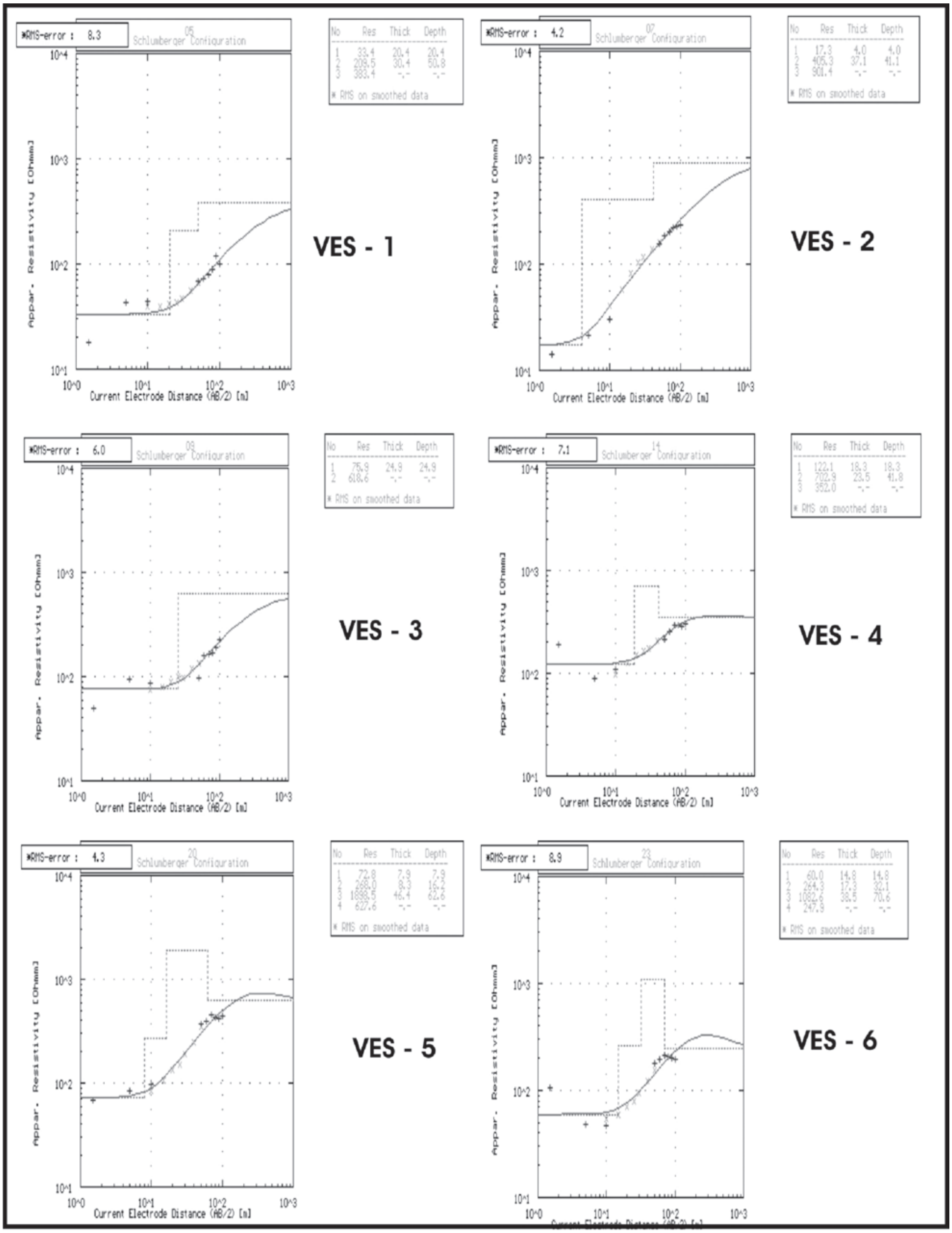

Figure 4a. VES curve of the study area.

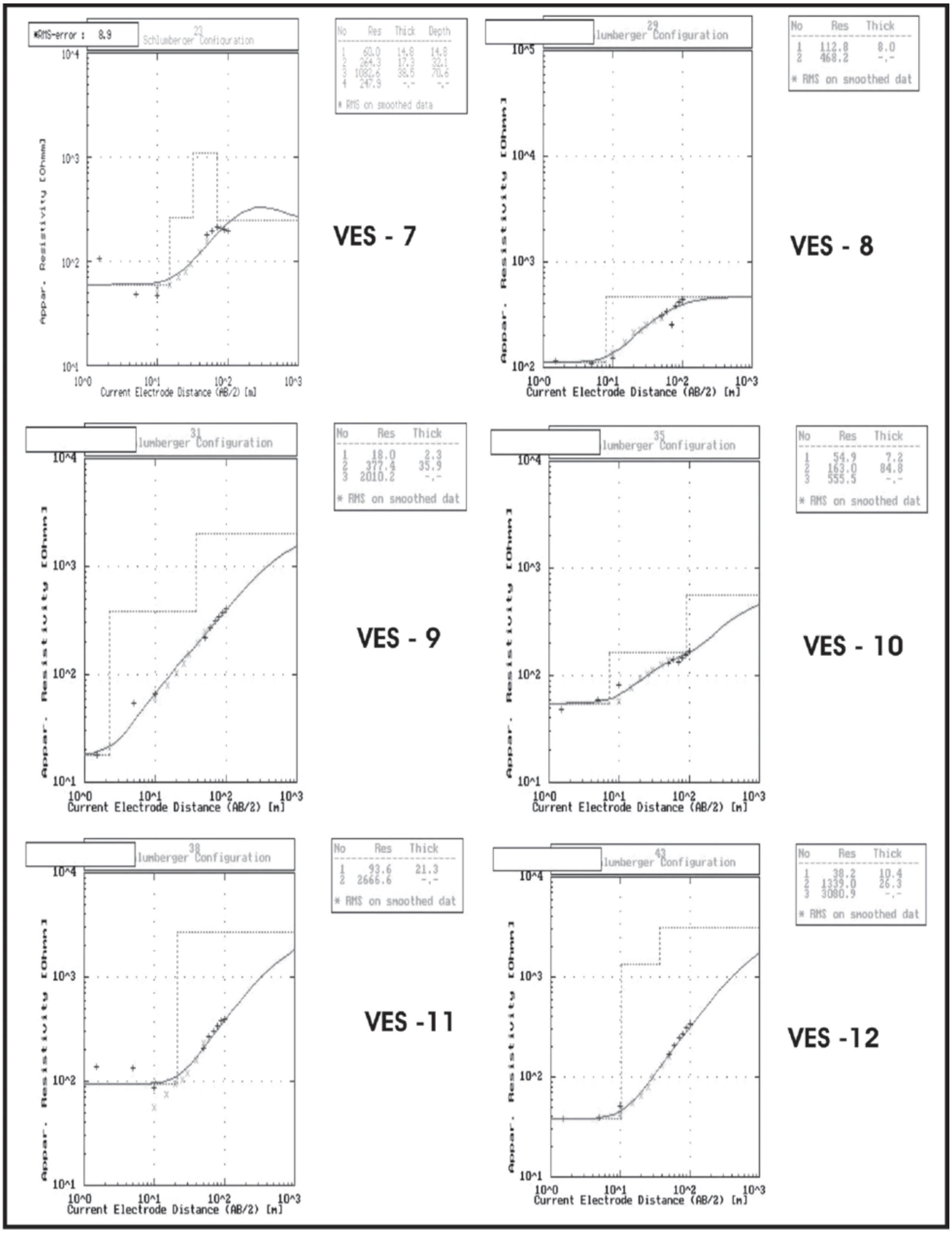

Figure 4b. VES curve of the study area.

Table 1. Interpreted resistivity and layer thickness.

VES.No	ρ_1 (Ωm)	ρ_2 (Ωm)	ρ_3 (Ωm)	ρ_4 (Ωm)	h_1 (m)	h_2 (m)	h_3 (m)
1	33.4	209.4	383.4		20.4	30.4	
2	17.3	405.3	901.4		4.0	37.1	
3	75.9	618.6			24.9		
4	122.1	702.9	352		18.3	23.5	
5	72.8	268.0	1898.5	627.6	7.9	8.3	46.4
6	98.4	595.6	1074.9		11.8	25.4	
7	60.0	264.3	1082.6	247.9	14.8	17.3	38.5
8	112.8	468.2			8.0		
9	18.0	377.4	2010.2		2.3	35.9	
10	54.9	163.0	555.5		7.2	84.8	
11	93.6	2666.6			21.3		
12	38.2	1339.0	3080.9		10.4	26.3	

is found to be high in west and northwest region, where as low value is observed around Kayathar area and eastern side. The spatial variation of the resistivity value for the three sub surface layers is shown in the Fig.5.

The layer thickness of first layer is noted to be more than 10m in northwest and southern side. The second layer thickness also followed the first layer thickness. In addition, encouraging layer thickness of more than 20m was identified southern side of Kayathar. The spatial variation of the sub surface layer thickness is shown in Fig.6. In the depth to basement study, resistivity value of >500 Ωm has been taken to demarcate fresh rock. The basement is observed at a shallow depth of 10.4m in VES location12, where as basement is observed at 50m b.g.l in VES location 1.

AQUIFER CHARACTERISTICS

Aquifer parameters in the study area are given in Table 2. The interpretation of pumping test data provides important aquifer characteristics like transmissivity (T), storage coefficient, optimum yield, recovery rate etc,. In this study, transmissivity is calculated using Jacob's straight line method for drawdown measurement. The minimum and maximum value of trasmissivity obtained from Jacob's method is 43.652 msq/d and 168.7711 msq/d respectively. The drawdown transmissivity is found to be low towards north and northwestern side. It is increasing towards southern side (Fig.7). Similarly, the storage coefficient obtained using Jacob's method varied from 0.00001 to 0.00163. The optimum yield is found maximum in location number 1 and minimum in 2, with a range of 100.0 m3/d and 3.0 m3/d. It is found low in middle and northern side whereas moderate at southern side. Further, the recovery rate for the study area varied from 26.6 to 379.6 m3/d. The recovery is observed to be slow in major part of the region. However, high rate of recovery is noticed in middle portion of the area particularly near Kayathar location. The spatial map of optimum yield and recovery rate is shown in Fig.8. The minimum and maximum specific capacity value obtained using Slichter's (1906) and Narasimhan's (1965) method varied from 47.59 lpm/mdd/m in the location number 2 to 3758.8 lpm / mdd / m in the location number 1 and 1.59(2) to 97.63 lpm / mdd / m2 (1) respectively. The recovery transmissivity calculated by Theis recovery method varied from 29.5955 to 121.4954 msq/d.

It is observed that the drawdown transmissivity is following with the recovery transmissivity trend in the study area except in Gangaikondan location. It clearly shows that the study area is having low permeability and transmissivity in the sub surface strata. The Gangaikondan location is near the Chittar river bank; hence it has shown high recovery transmissivity.

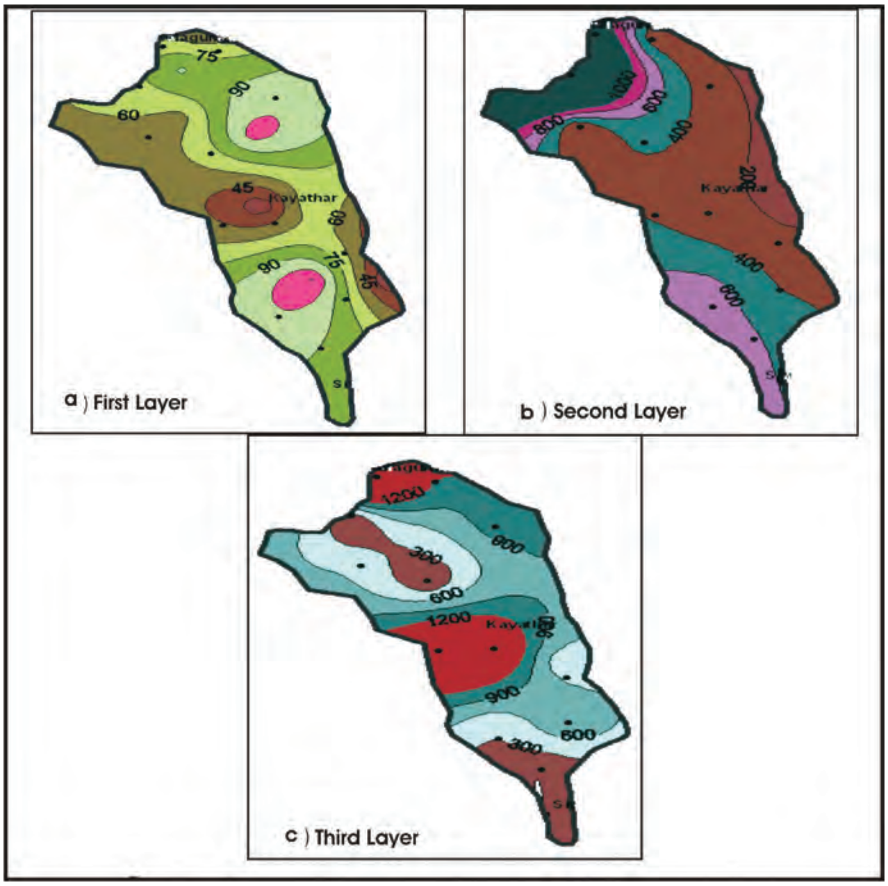

Figure 5 (a,b,c). Resistivity variation map of first, second and third layers.

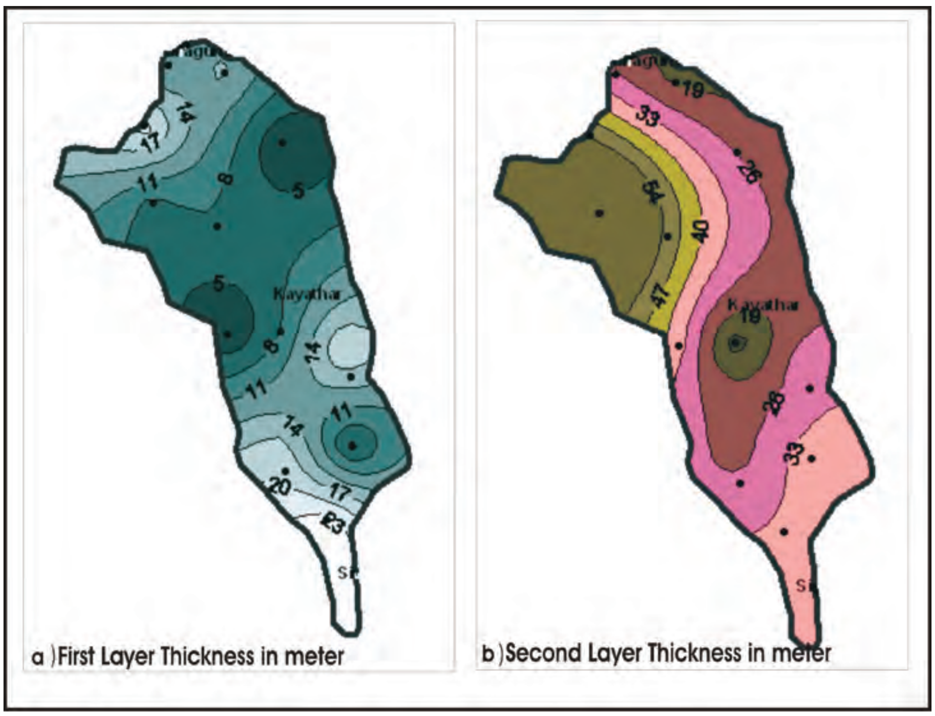

Figure 6 (a,b). Layer thickness variation of first and second layer.

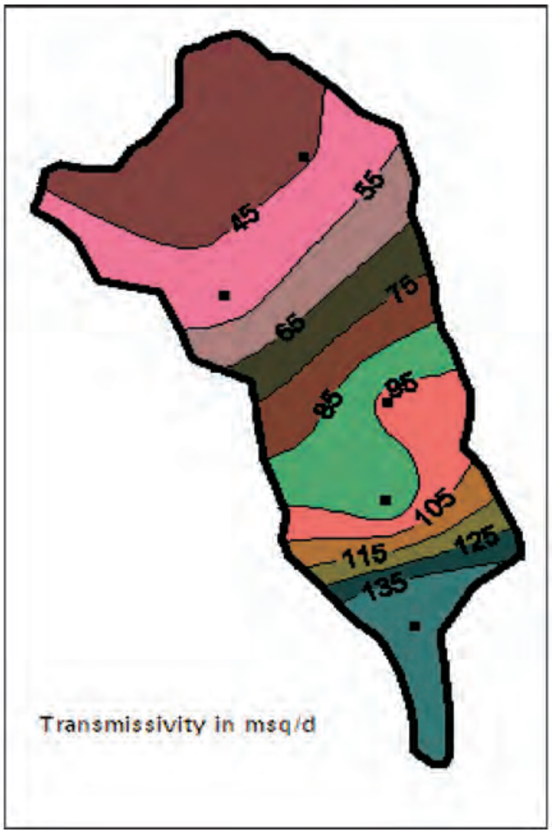

Figure 7. Spatial variation of drawdown transmissivity.

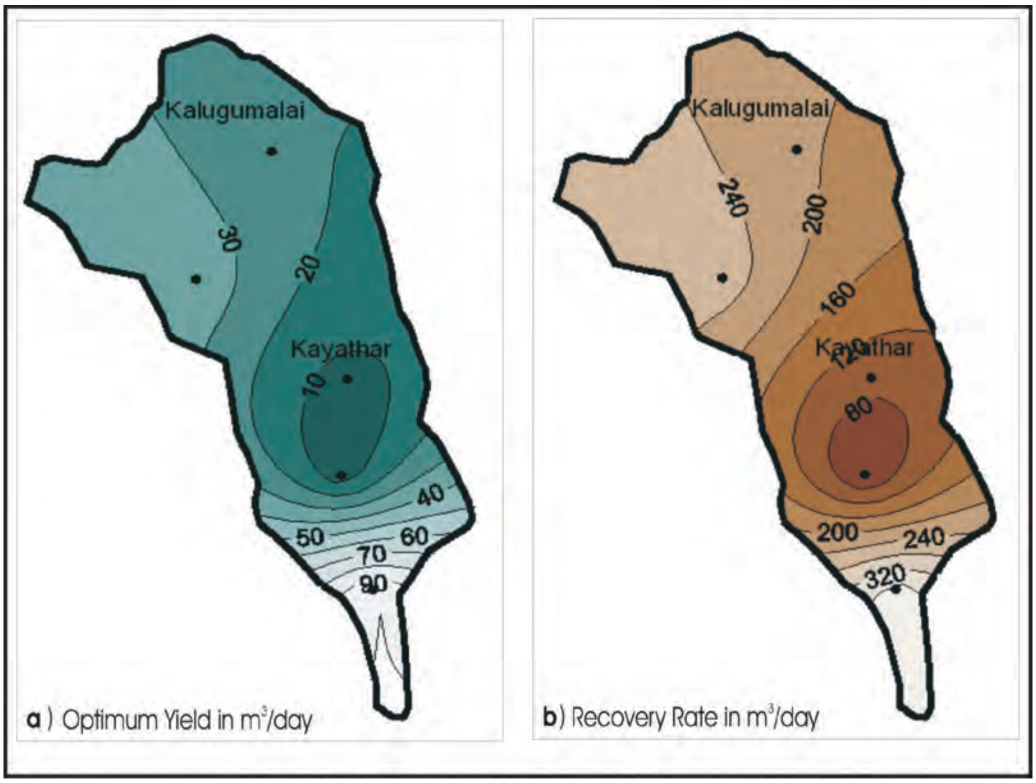

Figure 8. Spatial map of optimum yield (a) and recovery rate (b).

Table 2. Aquifer characteristics of the stud area.

Location No.	Jacob's Transmissivity (msq/d)	Senstivity Transmissivity (msq/d)	Slitcher's Specific capacity (lpm/mdd /m)	Optimum Yield (m^3/d)	Recovery Rate (m^3/d)	Narasimhan's Unit area capacity (lpm / mdd / m^2)	Theis Recovery method (msq/d)
1	167.4367	162.7513	3758.8	100.0	379.6	97.63	121.4954
2	85.50594	80.30435	47.59	3.0	34	1.59	35.41079
3	99.30902	90.77951	113.43	6.7	90.5	3.17	55.79242
4	43.6525	32.95784	84.41	22.3	207.5	1.86	83.46983
5	48.08246	40.06921	80.7	37.8	266.7	1.92	99.40349

CONCLUSIONS

In general the groundwater prospects are less in hard rock areas, especially in granitic terrains. The deeper aquifers in hard rock terrains have potential only when they are fed by fractures and thick weathered layer. The analysis and interpretation of resistivity data of the study area has shown low resistivity and satisfactory subsurface layer thickness around Kayathar area and some pockets of southern and northwest side.

Similarly, the aquifer characteristics also follow the resistivity characteristics, high recovery transmissivity and low recovery time around Kayathar area and southern side. It is noted that high Transmissivity is observed where the area has more weathered horizon. The optimum yield and Slitcher's specific capacity is also matching with the resistivity data interpretation. Thus, the present attempt helped to identify groundwater potential zones using surface resistivity technique and aquifer performance test.

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