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Estimation of Hydraulic Characteristics from Electrical Resistivity Data in Coastal Aquifers of Southern India

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Abstract: The applicability of geophysical techniques has been examined for evaluating aquifer properties like transmissivity and hydraulic conductivity of coastal aquifers, Tuticorin, Tamil Nadu. The pumping test data of 10 wells are interpreted by using forward modelling to obtain the aquifer characteristics in the study area. The available vertical electrical soundings (VES) data in the vicinity of the sites of pumping test have been interpreted; and true resistivity and thickness are determined at each site in the study area. Empirical relationships are established for estimating the hydraulic parameters from the electrical data.

The area under study is divided into three major geological formations viz. Archaean (hard rock), Tertiary and coastal sediments. The empirical relationships have been shown (1) between formation factor and hydraulic conductivity; (2) between transmissivity and transverse resistance and (3) between aquifer resistivity and hydraulic conductivity, in three different geological formations. The result shows a linear relationship between hydraulic conductivity and transverse unit resistance and between hydraulic conductivity and formation factor. These relations are further used to estimate the hydrogeological parameters viz transmissivity and hydraulic conductivity at remaining 18 vertical electrical sounding points, where pumping test data is not available. The hydraulic properties of aquifer at different points are then used to generate the corresponding contour maps. The thematic maps are finally utilized for the selection of suitable well sites in the study area using the electrical and aquifer parameters. The results indicate that the hard rock formation near the coast ofTuticorin is the most potential zone of groundwater for future exploitation.

Keywords: Groundwater, hydraulic conductivity, transverse resistance, aquifer resistivity, formation factor, Coastal aquifer, Tamil Nadu.

INTRODUCTION

In recent years there has been a growing awareness in the field of groundwater management and thus need to accurately assess groundwater resources. To accomplish this, it is essential to have knowledge of aquifer parameters such as hydraulic conductivity. The hydraulic conductivity is commonly estimated through pumping tests carried out on wells. Several industrial activities are in operation near the coast at a distance of about 8 km west of Tuticorin town, in the coastal belt of the state of Tamil Nadu. The deterioration of groundwater quality in future is the concern of people around these industries and further saline water incursion may add to the problem. Detailed investigations were carried out around these areas. Shallow and moderate depth groundwater resources up to 50m depth in coastal belt of Tamil Nadu,are being utilized for drinking and irrigation needs. There are exploitation pressure on this limited groundwater resources and growing concern of deterioration of groundwater quality due to anthropogenic activities such as unplanned disposal of industrial effluents, sewerage, etc.

The objective of this study is to find the relationship between aquifer properties and surface resistivity parameters in the study area Tuticorin, Tamil Nadu, India and to estimate hydraulic conductivity and transmissivity from the interpreted surface electrical resistivity parameters. The result can be used for further study of groundwater regime in the area and improving the quality of groundwater models.

Surface geophysical methods have been used to delineate aquifer zones in the area. The geophysical character of the aquifer zone has been estimated at various points. Since there are only a few bore wells available in the study area, these are utilized to carry out pumping tests and thus to

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estimate aquifer hydraulic parameters at these sites. Correlation coefficients were then established between geophysical parameters and aquifer hydraulic parameters. These correlations were then utilized to estimate aquifer parameters at other places in the study area, where bore wells were not available. This method has rapidly characterized the aquifer system in the study area and proven to be cost effective.

STUDY AREA

The study area (lat. 8.77–8.85°N and long. 78.04–78.17°E) falls in the eastern coastal belt of Tamil Nadu. The study area lies west of Tuticorin. It forms a watershed called as a Sterlite Industries India Ltd (SIIL) watershed, covering an area of about 112 km^2 (Fig. 1). The topographic elevation varies from 26.22m above mean sea level (amsl) in the east near Tuticorin town to 0 m amsl near sea and slopes from west to east. The slope is gentle in the western and the central part and nearly flat in the eastern part of the watershed. The topography of the study area shows that the groundwater trough is developed towards the north-eastern part of the SIIL. The area receives rainfall during the northeast monsoon season, which is active during the months of October to December. The long-term average annual rainfall of Tuticorin town is 568mm (Singh et al., 2006). The daily rainfall, for the year 2006, recorded at SIIL rain gauge station, indicates that it was above normal with significant high-intensity daily rainfall events compared to previous years since 2000. The area experiences semi-arid tropical climatic condition and falls in the east coast plains and hill regions of agro-climatic zone, as classified by the Indian Council of Agricultural Research (ICAR) (Mondal et al., 2010). The land is utilized for cultivation of cotton, maize etc. Parts of the land are fallow and some barren with vegetation such as thorny shrubs with a thin cover of dry grass and palms.

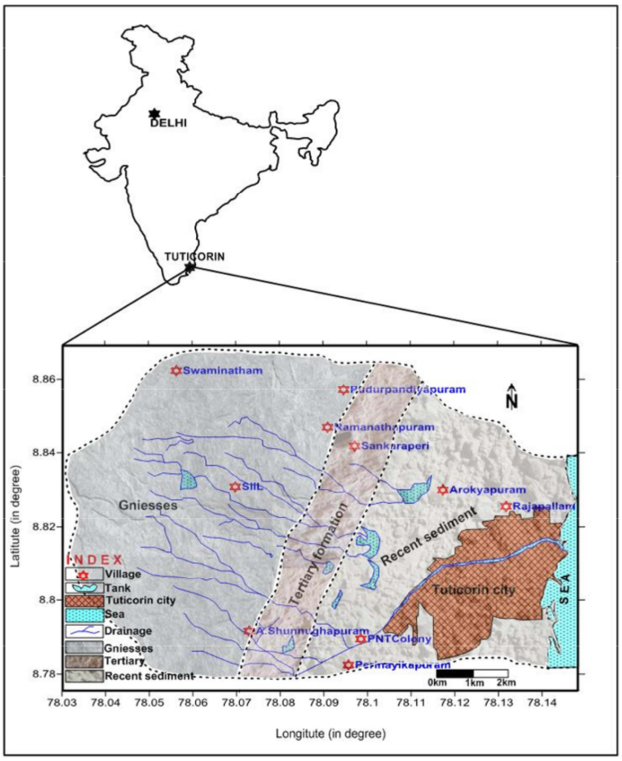

Fig. 1. Location and geological map of the study area

GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERISTICS

Gneisses, charnockites and quartzites of Archaean age, calcareous sandstone and shale limestone of Tertiary age, and alluvium of recent age underlie the watershed area (Fig.1). The Archaean groups of formation are crystalline and metamorphic, and finely foliated with the general NW–SE trend (Balasubramanian et al., 1993). The formations that include quartzite as ridges in the western part, are weathered, jointed and fractured. Recent to sub-recent sand occupies the coastal areas. It consists of coarse and calcareous grit, sandstone and shale limestone. The watershed area is covered with black soil in the western part (in and around the SIIL plant), red soil (sandy loam to sandy soil) in the central part and alluvial sandy soil in the eastern part. The maximum soil thickness is about 3m. The sandy soils have originated from sandstone and have low soil-moisture. The alluvium soils are wind-blown sands and shale constituting beach sand and coastal dunes, have low soil moisture. The watershed area has a large number of open and bore wells tapping shallow phreatic aquifers and fractured aquifer systems. The wells are being used for domestic and irrigation purposes. The depth of open wells ranges from 7 to 12m and bore wells from a few metres to a maximum depth of 70m below ground level (Singh et al., 2006). Most of the wells are less than 20m in depth (Table 1). In Tertiary and alluvial areas, the sandy zone is the main aquifer system. The static water level during the pre-monsoon (2006) period varies from 1.8 to 14.4m below ground level (bgl) and in post-monsoon period it varies from 0.9 to 12.86m bgl. Shallow groundwater has been recorded in the SIIL premises and in the coastal area.

INVESTIGATIONS

Hydrogeological and geophysical investigations

Table 1 Water quality and static water levels in observation wells in the watershed area

Sl. No.	Well code	Village name of well	Type of well	Depth (m)	July 2006		January 2007	
					WL (m)	EC (µS/cm)	WL (m)	EC (µS/cm)
1	T-1	Terku Virapadiyapuram	TW	70	14.24	3850	11.7	3960
2	T-3	Kumargiri	TW	70	16.4	3370	13.49	1545
3	T-5	Swaminatham (S)	DW	12	5.81	6000	4.01	5900
4	T-7	Nayinapuram	TW	54.86	11.31	500	7.6	510
5	T-9	Pudur Pandiyapuram	DW	8.4	6.33	400	4.76	300
6	T-10	Pandarampatti	BW	70	8.6	7900	7.7	8000
7	T-11	Pandarampatti (W)	TW	33.52	8.99	2230	7.07	1965
8	T-14	Sankararapperi (E)	DW	10	7.35	6300	6.4	6500
9	T-16	Ramanathampuram	DW	11.5	9.1	1846	7.65	1739
10	T-17	Silverpuram	DW	9	7.87	10380	7.2	6620
11	T-18	Milavittam	DW	12.4	9.72	4600	8.23	6880
12	T-19	Madathur (N)	DW	9	6.58	2200	5.81	2100
13	T-22	SIIL-II (N, PZ-11)	BW	18.28	5.88	12290	5.3	11040
14	T-27	SIIL-VII (W, PZ-2)	BW	18.28	2.55	5300	1.3	4560
15	T-31	SIIL-XI (N)	BW	18.28	5.02	7300	3.86	7350
16	T-32	SIIL-XII (W, PZ-6)	BW	18.28	4.56	9300	3.2	9350
17	T-35	Ayynaduppu	DW	10.66	6.48	5230	4.72	5180
18	T-36 A	Shunmughapura	DW	8.6	6.98	3100	5.7	3000
19	T-37	Kailashpuram	DW	6.3	5.38	200	4.78	150
20	T-40	Vadakku -Silukkanpatti(E)	TW	60	14.45	3300	8.5	3200
21	T-41	Madattupatti	DW	12.32	11.63	3300	8.52	3000
22	T-44	Periyanayakapuram	DW	4.58	3.81	4800	2.15	5000
23	T-47	Levinjpuram	DW	6.25	5.36	4500	4.38	4850
24	T-50	Seetapuram Nagar	DW	2.96	1.81	1700	0.86	2090
25	T-52	PNT Colony (S)	DW	3.2	2.81	900	1.5	690
26	T-54	Mappali Urani	DW	5.5	5.18	12600	4.37	12800
27	T-56	Davishpuram	DW	6.88	6.55	9100	5.81	9600
28	T-57	Arokayipuram	DW	5.96	5.26	7200	4.63	9100
29	T-58	Rajapallam	DW	5.83	4.69	2100	3.72	1970
30	T-60	SBI Colony (St. Ann's School)	DW	4.09	3.44	2800	2.58	3050
31	T-62	Holy Cross Girls School	DW	3.77	3.46	900	2.54	1100
32	T-64	Chinakannupur (Milivattam road)	DW	6.75	3.34	17597	2.85	17200

(resistivity survey) were carried out for deciphering sub-surface litho zones, prevailing hydrogeological conditions, and aquifer parameters such as specific yield/ storage coefficient, hydraulic conductivity, etc. The water levels in the study area were monitored using water level indicator at 32 observation wells and are shown in Table 1. To estimate the aquifer properties, pumping test was carried out at 10 locations in the area and the data were analyzed by numerical method (Singh, 2000). A total of 28 vertical electrical soundings (VES) were conducted using Schlumberger electrode configuration with current electrodes spreading from 50 to100m..

Well Inventory

Groundwater occurs in the weathered and fractured zones of gneisses and sandy aquifers in sedimentary and alluvial formations. In order to assess the groundwater regime, well inventory has been carried out in the area. Various parameters such as location, diameter, depth of well, depth of water level, well use, quality have been recorded from selected open and bore wells. The static water level in wells during the pre-monsoon period varies from 1.81m bgl to 16.4m bgl and in post-monsoon period it is from 0.86m bgl to 13.49m bgl (Table 1). Shallow groundwater has been recorded in bore wells located inside the industrial complex and in open wells near the coast. Deep water table conditions (>14m) is observed in wells at localized pockets and are mainly due to the exploitation of groundwater for domestic/irrigation purposes. The well inventory data indicates that seasonal rainfall causes 0.4 m to 5.95m water level rise in the area. Electrical conductivity (EC) varies from 200 to 17,597 µS/cm in pre-monsoon and in post-monsoon from 150 to 17, 200 ìS/cm.

Aquifer Parameter Estimation

Major part of the study area has large diameter open wells which have rarely reached the basement rock in the crystalline and completely/partially penetrating the

Table 2 Summary of pumping tests

S. No.	Well code	Pumping period (min.)	Maximum drawdown (m)	Recovery time (min)	Discharge (m^3/d)	Transmissivity (m^2/d)	Storativity
1	T-5	116	1.49	1360	686	35	0.009
2	T-9	146	0.71	295	426	7	0.0005
3	T-14	100	0.93	3804	469	38	0.00001
4	T-16	78	1.18	5610	327	0.8	0.003
5	T-31	75	1.4	90	269	34	0.00001
6	T-36	105	1.63	1812	451	60	0.001
7	T-44	120	0.68	1406	459	80	0.01
8	T-52	32	1.09	149	36	16	0.00003
9	T-57	45	0.96	485	51	19.5	0.00001
10	T-58	23	1.74	305	226	60	0.00001

sedimentary terrain. The change in water level with time is interpreted to arrive at aquifer parameters. The availability of an existing well makes the pumping test cost-effective. In the study area, ten wells were selected for pumping tests. The tests were performed using submersible pumps and observations were made in the same well. The pumping test data (both pumping and recovery) has been interpreted considering the field conditions to evaluate aquifer parameters. The location of these pumping wells is shown in Fig. 2 and a summary of the tests is shown in Table 2.

Geophysical Investigations

The most popular method used for groundwater exploration is vertical electrical sounding (VES). To determine the aquifer geometry and groundwater quality, 28 VES with a maximum half current electrode separation of 100 m, have been carried out. Some of the VES are carried out near the bore well or in very close proximity. Schlumberger configurations were used for the geoelectrical soundings. Initially VES data have been interpreted through curve matching technique (Orellana and Mooney, 1966) and then interpreted by using computer program, which involves the inverse modelling method (Alva Kurniawan, 2009). The interpreted data was used to establish empirical relationship between aquifer parameters and geoelectrical parameters for different geological formation. The data generated was utilized for the development of aquifer model. The location of these soundings and the inventoried wells used for correlation are shown in Fig.2, and the interpreted sounding curves for four VES are shown in Fig.3. In the study area, the VES results show four to five sub-surface layers

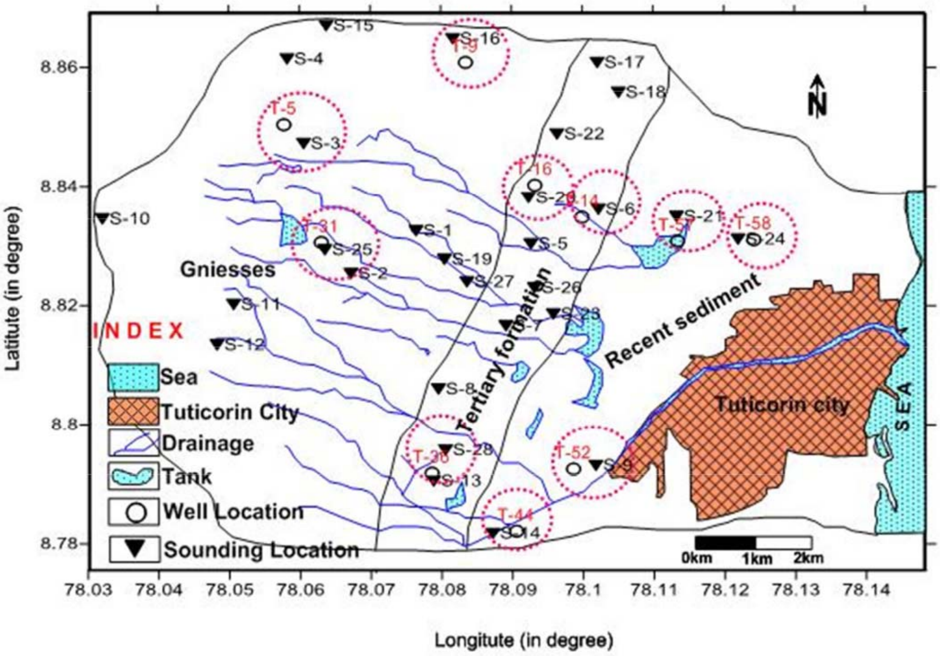

Fig.2. Experimental sites of the study area.

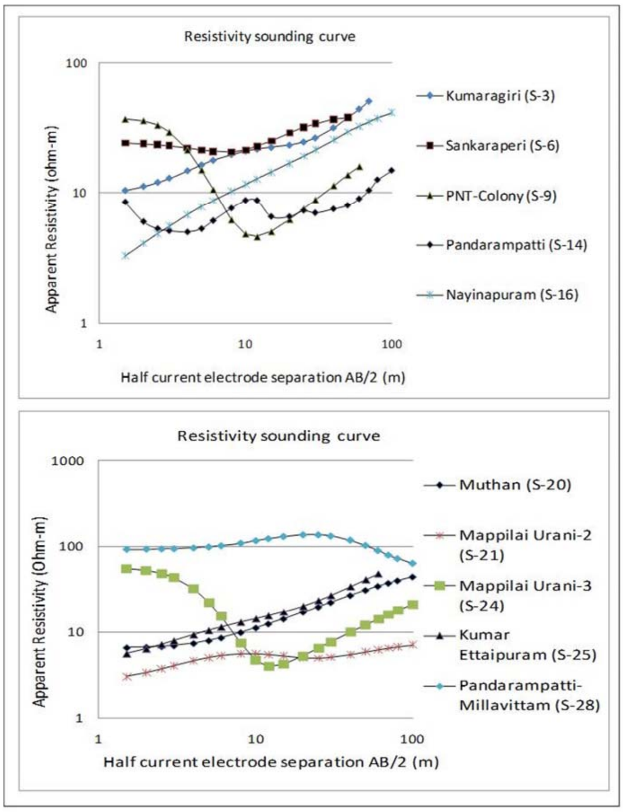

Fig.3 Resistivity sounding curves nearby observation well.

obtained after conventional curve matching and applying the inversion iteration method. The interpreted results of these sounding curves are shown in Table 3. The resistivities of different sub-surface layers in the study area encountered during investigation which are interpreted as shown below:

< 10 ohm-m	indicative of the presence of sand and clay saturated with sea water.
10 - 50 ohm-m	sand or clay horizon with brackish water/sandstone, shell limestone, with or without water.
50-150 ohm-m	semi weathered/fractured/jointed/ poorly connected fractured.
> 300 ohm-m	hard rock or bed rock.

CORRELATION BETWEEN GEOPHYSICAL AND AQUIFER PARAMETERS

Over the last few decades surface resistivity methods have been commonly used to obtain aquifer properties including hydraulic conductivity and transmissivity. Ungemach et al. (1969) correlated transmissivity with transverse resistance. Worthington (1975) showed an inverse relation between formation factor and intergranular permeability. Kelly (1977) and Kosonski and Kelly (1981) correlated aquifer resistivities and hydraulic conductivity obtained from pumping test results in Rhode Island, USA. Heigold et al. (1979) found an inverse relationship between aquifer resistivity and hydraulic conductivity in central Illinois, USA. Sri Niwas and Singhal (1981) concluded the relations between transverse resistance and transmissivity as more meaningful in alluvial aquifers than between longitudinal conductance and transmissivity. Sri Niwas and Singhal (1985) gave case studies for alluvial aquifers in varying geological environments of northern India by establishing relations to these parameters. Frohlich and Kelly (1985) and Huntley (1986) confirmed the applicability of relations between apparent formation factor and hydraulic conductivity for granular aquifers and transverse resistance and hydraulic conductivity in glacial aquifers in different parts of the USA. Shakeel et al. (1988) used the method of krigging to estimate the transmissivity from measurements of specific capacity and electrical transverse resistance. In recent years, Hubbard et al. (2000) stated that hydraulic conductivity over a wide range of scales is helpful for numerical modeling for understanding the hydraulic nature of the aquifer and to predict contaminant transport. de Lima and Sri Niwas (2000) have estimated these parameters for shaly sandstone aquifers by using IP-resistivity measurements and they conclude that the field and calculated values are in agreement.

Correlation between Hydraulic Conductivity and Formation Factor

The value of formation factor (F) at ten sites are calculated from the resistivity of completely water saturated aquifer (ρ_o) estimated from VES data and the resistivity of formation water (ρ_w) measured for samples from the pumping well, using well known Archie (1942) relation,

$$F = \frac{\rho_0}{\rho_w}$$

The hydraulic conductivity (K) values computed using the formula K=T/h (T=Transmissivity, h=aquifer thickness) are presented in Table 4. The plot of formation factor vs hydraulic conductivity along ordinate is presented in Fig.4. This figure shows a linear relationship between K and F in different geological formations such as Archaean complex, Tertiary sediments and recent sediments and can be expressed as

$K = 0.5386F + 0.5597$,

$K = 0.9216F + 0.6454$ and

$K = 2.6249F + 4.1099$ respectively.

Table 3 Details of VES in and around Tuticorin, Tamilnadu, India

S. No.	VES No.	ρ_1•	ρ_2	ρ_3	ρ_4	ρ_5	h_1	h_2	h_3	h_4	H	Types of curve
1	S-1	45.9	20.2	80	64.7		1.15	4.78	3.35		9.28	HK
2	S-2	13.35	8.468	27.85	12.12	94.06	2.1	2.1	2.8	5.5	12.5	HKH
3	S-3	32.5	67.5	15	317.7		3.2	5.5	6.95		15.6	KA
4	S-4	31.8	132	74.9	961		1.7	7.8	5.4		14.9	KA
5	S-5	74.83	36.72	68.63	28.71	140.8	0.67	1.34	6.33	8.13	16.52	HKH
6	S-6	14	100	20	36.7		0.5	8	7.5		16	KH
7	S-7	28.3	729	46	90		1.03	6.8	7.41		14.24	KH
8	S-8	56.48	10.62	72.94	36.25		1.49	5.3	9.95		16.75	H
9	S-9	4	2.3	74.4			5.75	2.5			8.25	H
10	S-10	16	56.1	20.3	133		2.21	11.5	9.3		23	KH
11	S-11	12.3	115	20.6	283		3.5	9.5	8.6		21.6	KH
12	S-12	21.92	45.24	20.3	78.76		3.3	9.8	12.33		25.43	KH
13	S-13	37.8	198	35.8	310		1.41	5.25	6.27		12.9	KH
14	S-14	10	2.6	49			5.5	16			21.5	H
15	S-15	20	80	20.5	161.4		2.8	7	9.28		19.08	KH
16	S-16	10	16	66.1			8.5	1.15			9.65	A
17	S-17	11.7	22.5	11.93	175.9		1.2	5.3	9.5		16	KH
18	S-18	24.8	11	2.54	56.7		1.42	5.45	7.36		14.2	H
19	S-19	32.1	12.5	20	141		6.8	6	9		21.8	HA
20	S-20	20	12.5				7.7	0.23	172		7.93	AA
21	S-21	5	10	2.14	8.29		2.5	6	11.5		20	KH
22	S-22	7.5	21.5	67.1	108		1.5	5.5	13.3		20	KH
23	S-23	61.1	20.5	60	10.5	500	1.2	6.3	22	5	34.5	HKH
24	S-24	1.25	8	2.5	80.5		7	0.5	2.5		10	H
25	S-25	12	55	19	268		1.89	6.17	5.21		14.21	KH
26	S-26	6.19	33.2	55	619		1.2	7.9	4.79		13.9	KH
27	S-27	49.5	15	35.3	67.1	137	1.2	6.3	4.5	27.7	39.7	HAA
28	S-28	98	35	200	52		6.65	5.65	7		19.1	KH

Table 4. Hydraulic conductivity from ten sites

S. No.	Well No./ VES No.	Location	Resistivity of the aquifer ρ_0 (Ωm)	Pore water resistivity ρ_w (Ωm)	Formation Factor $F=\rho_0/\rho_w$	Conductivity K(m/d) from pumping test	Predicted Conductivity (m/d)
1	T-5/S-3	Kumaragiri	15	2	7.5	5.03	5.08895
2	T-9/S-16	Nayinapuram	16	1.5	10.4	6.08	5.91284
3	T-31/S-25	Kumar Ettaiyapuram	19	1.5	11.97	6.25	6.358877
Correlation Coefficient of .Archeaen Complex = 0.97							
4	T-14/S-6	Sankaraperri	20	3.3	6	5.06	4.0388
5	T-16/S-20	Mauthan	12.5	1	7	3.47	4.5854
6	T-36/S-28	Vadakku Silukkanpatti-2	35	1.9	17.85	10.61	10.51601
Correlation Coefficient of Tertiary Formation = 0.97							
7	T-44/S-14	Pandarampatti-Milavittam	2.16	6.4	0.33	5	4.986076
8	T-52/S-9	PNT-Colony	2.3	3.3	0.75	6.4	6.0517
9	T-57/S-24	Mappilai Urani-3	2.5	1.6	1.47	7.8	7.878484
10	T-58/S-21	Mappilai Urani-2	2.14	4	0.53	5.21	5.493516

Correlation Coefficient of Recent Formaton = 0.95

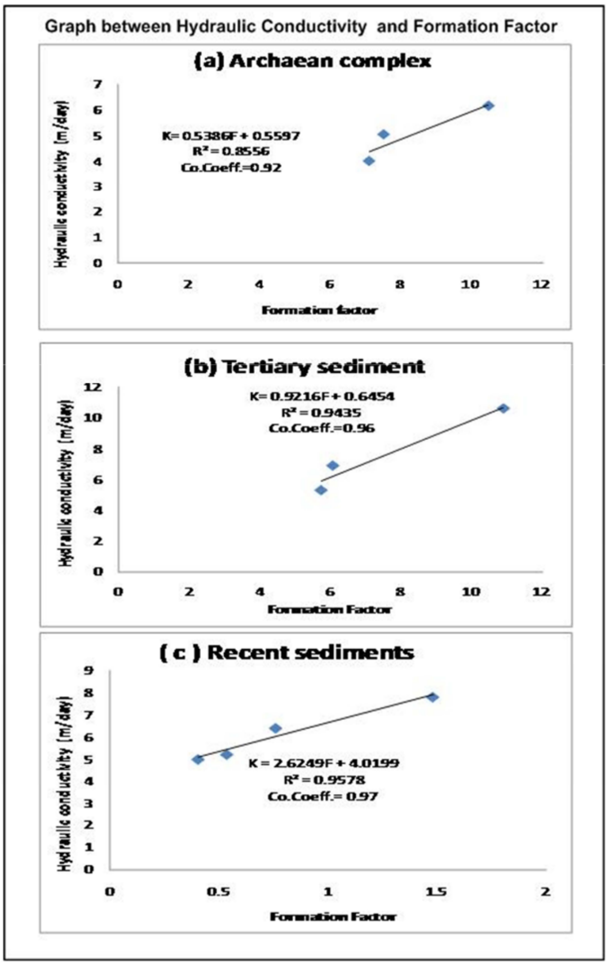

Fig.4. Correlation between Formation Factor and Hydraulic conductivity in different geological formations (a) Archeaen Complex (b) Tertiary formation and (c) Recent formation

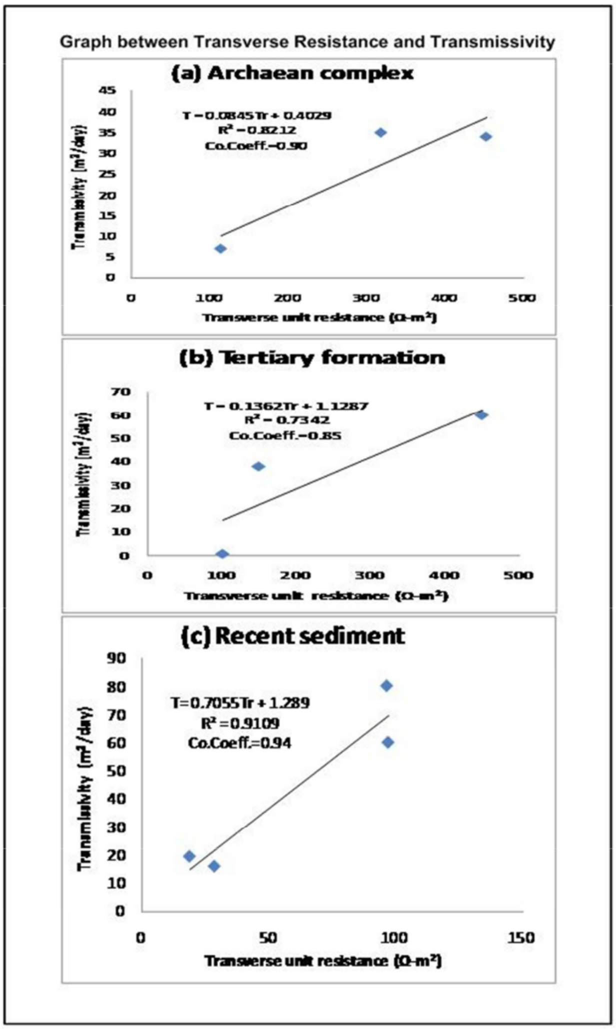

Fig.5. Correlation between Transmissivity and Transverse resistance in different geological formations (a) Archeaen Complex (b) Tertiary formation and (c) Recent formation

Correlation between Transmissivity and Transverse Resistance

In hydrogeological investigations, transverse unit resistance (Tr) has been found to be functionally analogous to transmissivity (T). The values of Tr are computed from VES using following equation (Patra and Nath, 1999).

$$Tr = \rho h$$

The transmissivity of the aquifer computed from pumping test data at ten locations are presented in the Table 5. The plot of Tr along abscissa and T along ordinate is presented in Fig.5. This shows the linearity between T and Tr in the different geological formation i.e., Archaean complex, Tertiary Formation and recent sediments in the form as:

$T = 0.0627Tr + 1.4319$,

$T = 0.0645Tr + 0.04029$ and

$T = 0.136Tr + 1.1287$ respectively.

Correlation between Aquifer Resistivity and Hydraulic Conductivity

The relation obtained between aquifer resistivity and hydraulic conductivity is shown in Fig.6. This shows the linearity between ρ and K in the different geological formation like as Archeaen complex, Tertiary Formation and Recent sediments in the form,

$\rho_0 = 2.3977K + 2.6162$,

$\rho_0 = 3.0343 + 3.141$ and

$\rho_0 = 0.1278K + 1.4952$.

Hydraulic conductivity and Transmissivity values at 18 VES locations where pumping test data are not available are computed using the obtained linear equations in different geological formations using above expressions. The T and K values are contoured using the krigging method

Table 5. Transmissivity from ten sites

S. No.	Well No./ VES No.	Location	Thickness h(m) from VES data	Resistivity of the aquifer ρ_0 (Ωm)	Transvers resistance (Tr) in Ω m^2	Transmissivity T(m^2/d) from the pumping test	Predicted transmissivity (m^2/d)
1	T-5/S-3	Kumaragiri	6.95	16	579.5	35	37.76655
2	T-9/S-16	Nayinapuram	1.15	16	103.4	7	7.91508
3	T-31/S-25	Kumar Ettaiyapuram	5.25	19	461.02	34	30.33785
Correlation Coefficient of Archeaen Complex=0.97							
4	T-14/S-6	Sankaraperri	7.5	20	957	38	28.44447
5	T-16/S-20	Mauthan	0.23	12.5	156.87	0.8	6.680934
6	T-36/S-28	Vadakku Silukkanpatti-2	5.65	35	2249	60	63.58687
Correlation Coefficient of Tertiary Formation=0.96							
7	T-44/S-14	Pandarampatti-Milavittam	16	2.16	96.6	80	69.4403
8	T-52/S-9	PNT-Colony	2.5	2.3	28.75	16	21.57213
9	T-57/S-24	Mappilai Urani-3	2.5	2.5	19	19.5	14.6935
10	T-58/S-21	Mappilai-Urani-2	11.5	2.14	97.11	60	69.80011
Correlation Coefficient of Recent Formaton=0.95							

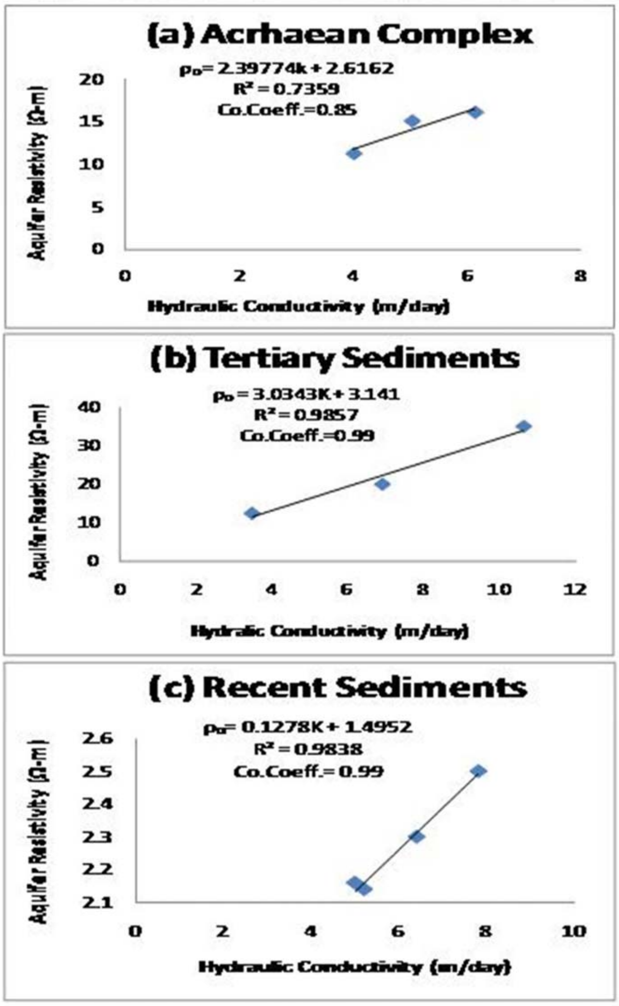

Fig.6. Correlation between Aquifer resistivity and Hydraulic conductivity in different geological formations (a) Archaean Complex (b) Tertiary formation and (c) Recent formation

(deMarsly, 1984) and corresponding contouring maps are prepared for T and K (Figs. 7a and 7b) respectively.

RESULTS AND DISCUSSION

The Hydraulic conductivity and transmissivity thematic contour maps are shown in Figs 7a and 7b.

The hydraulic conductivity distribution is categorized into three zones namely less than 10 m/d, 10 to 30m/d and more than 30m/d. The low value of hydraulic conductivity can be seen near the coastal side towards the east of the study area. The zone lies in recent sediments and this condition is also found in the some parts of Tertiary Formation. The middle range of values occupies Tertiary Formation and Archaean Formation. The high value of Hydraulic conductivity can be seen in western part in Archaean complex of the study area.

Similarly the distribution of transmissivity is made into three categories i.e. less than 60 sq.m/d, 60 to 120 sq.m/d and more than 120sq.m/d. The low value is found in all three types of geological formations. The middle range values are localized in two pockets as shown in Fig. 7b. The high values are found only in the middle of the study area.

CONCLUSION

Based on the above results, VES is not only used for groundwater exploration or delineation of aquifer geometry, but also used to estimate other hydraulic parameters such as hydraulic conductivity and transmissivity. VES can also be used not only for qualitative estimation, but also for

Table 6. Aquifer resistivity from ten sites

S. No.	Well No./ VES No.	Location	Conductivity K(m/d) from pumping test	Resistivity of the aquifer ρ_0 (Ωm)	Predicted resistivity (Ωm)
1	T-5/S-3	Kumaragiri	5.03	15	14.67683
2	T-9/S-16	Nayinapuram	6.08	16	17.19446
3	T-31/S-25	Kumar Ettaiyapuram	6.47	19	18.12958
Archeaen Comlex=0.85					
4	T-14/S-6	Sankaraperri	5.06	20	18.49456
5	T-16/S-20	Mauthan	3.47	12.5	13.67002
6	T-36/S-28	Vadakku Silukkanpatti-2	10.61	35	35.33492
Tertiary Formation=0.99					
7	T-44/S-14	Pandarampatti-Milavittam	5	2.16	2.1342
8	T-52/S-9	PNT-Colony	6.4	2.3	2.31312
9	T-57/S-24	Mappilai Urani-3	7.8	2.5	2.49204
10	T-58/S-21	Mappilai Urani-2	5.21	2.14	2.161038
Recent Formaton=0.99					

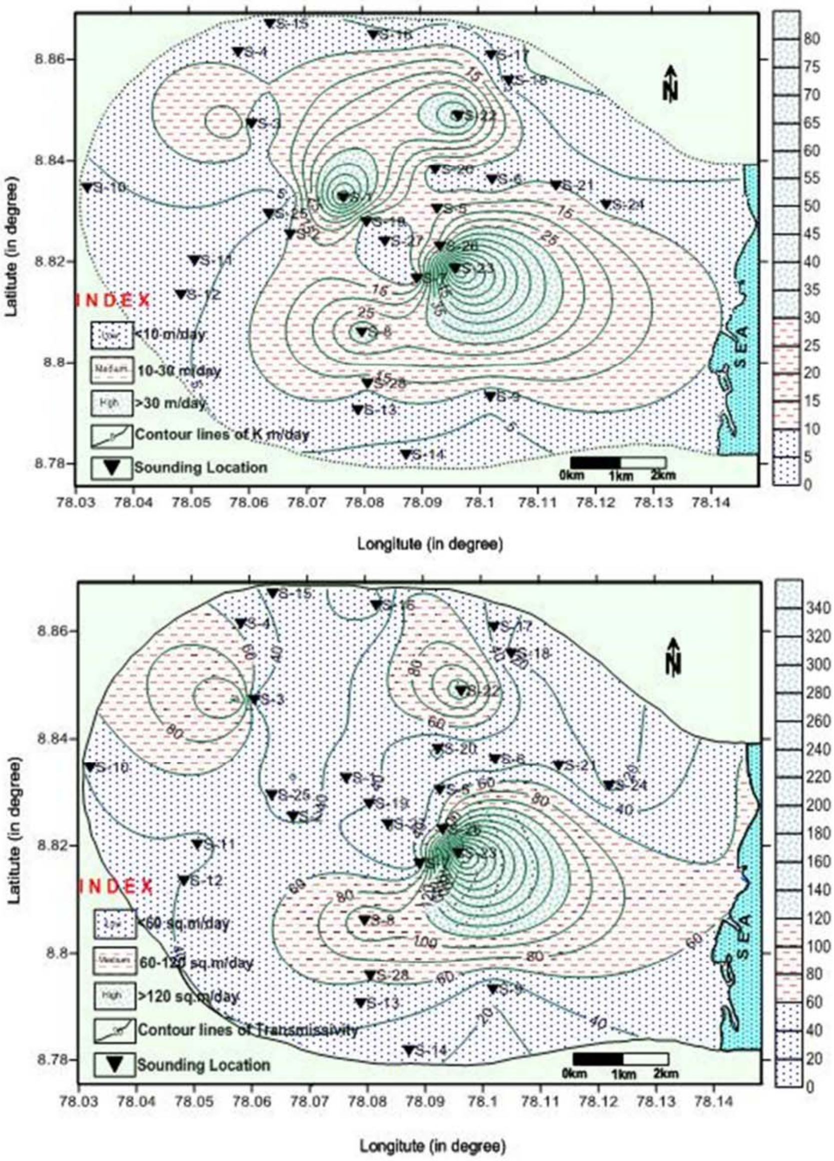

Fig.7. Contour map of **(a)** hydraulic Conductivity and **(b)** Transmissivity

quantitative estimates of aquifer parameter, which further reduces the additional expenditures of carrying out pumping tests and offers an alternate approach for estimating the hydraulic properties. The transmissivity in Archaean formations shows a wide range due to different degrees of weathering and heterogeneity of formation at different depths. Based on these calculated values of hydraulic conductivity, a map has been prepared which is very useful for further studies of the groundwater regime in the area. The map can also be used to derive input parameters for contaminant migration modeling and to improve the quality of model. The calculated aquifer parameters are well within the range of observed aquifer parameters.

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