

Delineation of shallow aquifer zones using electrical resistivity and bore hole litholog details in the Northwestern part of Bhuvanagiri, Chidambaram Taluk, Cuddalore District, Tamilnadu

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ABSTRACT

Five Vertical Electrical Soundings were carried out in the northwestern part of Bhuvanagiri, Chidambaram Taluk, Cuddalore District, Tamilnadu to identify the shallow fresh water zones and understand the sub-surface lithological sequence. The maximum electrode separation used is 100m by Schlumberger configuration. Geologically, sedimentary rocks of cretaceous and Mio-Pliocene with alluvium are present. The resistivity data was interpreted by using IPI2WIN software. The maximum error percentage observed was 4.3. The interpreted result shows four layer strata. The resistivity and layer thickness of the first layer are 2.82 ohm m to 10.9 ohm m and 0.9m to 4.77m respectively. The resistivity and layer thickness of the second layer varies from 1.66 ohm m to 17.7 ohm m and 3.61m to 12.0m respectively. The VES number 1 and 4 results indicate the shallow aquifer zones. The interpreted results have been compared with the subsurface strata to validate the results.

INTRODUCTION

Ground water is a precious natural resource for several vital functions such as public, industries and agricultural water supply. The demand of this natural resource is increasing many folds due to irregularity in the monsoon pattern and human activities. Due to natural and man-made activities the water level also is declining, particularly, in arid and semi arid regions. To understand the subsurface lithology and delineate the groundwater potential zones the vertical electrical sounding (VES) survey has been proved useful and cost-effectiveness. The Schlumberger array is found to be more suitable and common in ground water investigations (Zhody, Eaton & Mabey 1974). Besides, the technique has been utilised successfully to solve groundwater problems by many researchers (Karanth 1978; Janardhana Raju, Reddy & Naidu 1996; Balasubramanian, Sharma & Sastri 1985; Jagadeeswara Rao et al., 2003; Ranjit Kumar Majumdar & Das

Debabrata 2009; Yadav et al., 2010). As the study area comes under the high ground water demand category, an attempt has been made to delineate the potential fresh water aquifer zones.

STUDY AREA

The study area Bhuvanagiri lies between the latitude 110 25' and 110 31' and the longitude between 790 36' and 790 40' (Fig.1). Physiographically, the area has a gentle slope. A number of minor irrigation channels are present in this zone. Geologically it comprises alluvium on the top, followed by Mio-Pliocene and cretaceous formations (Fig.2). Geomorphologically it is concealed by flood and alluvial plains. The average rain fall of the district is 544.6mm and the average temperature is 82.7°F. Agriculture is the major activity of the study area. The surface and groundwater are used for both domestic and irrigational purposes. The pre-monsoon water level varies from 2.59m to 7.99m.

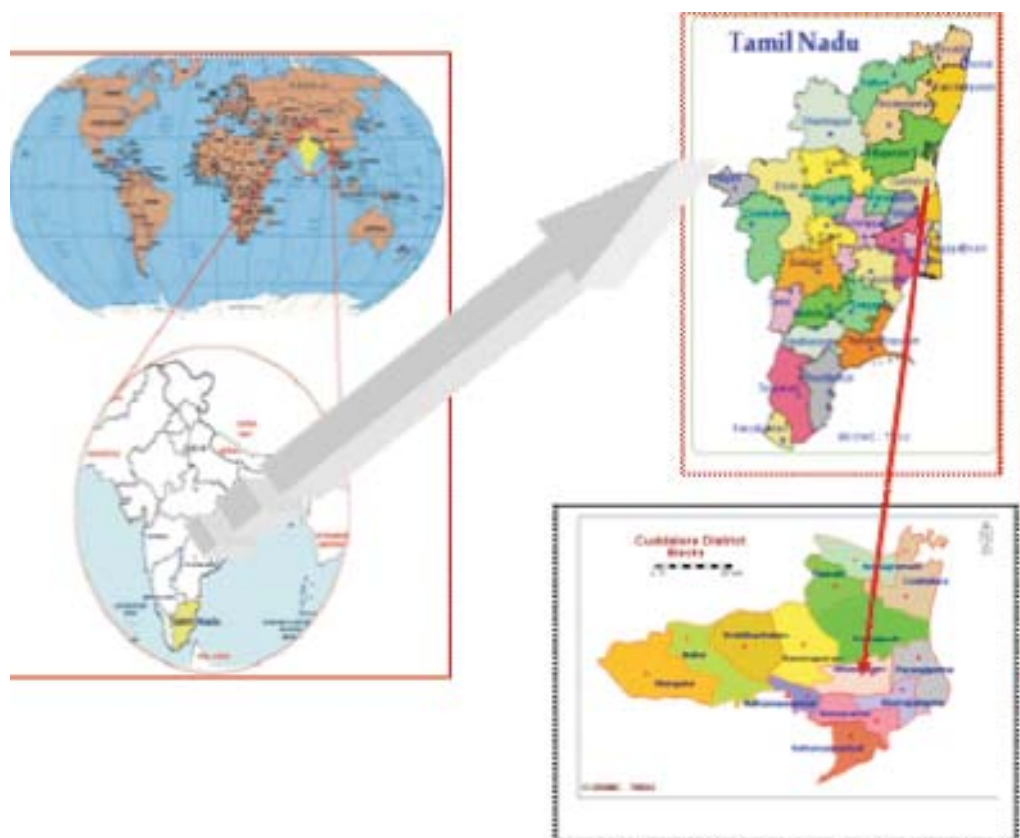


Figure 1. Map of study area.

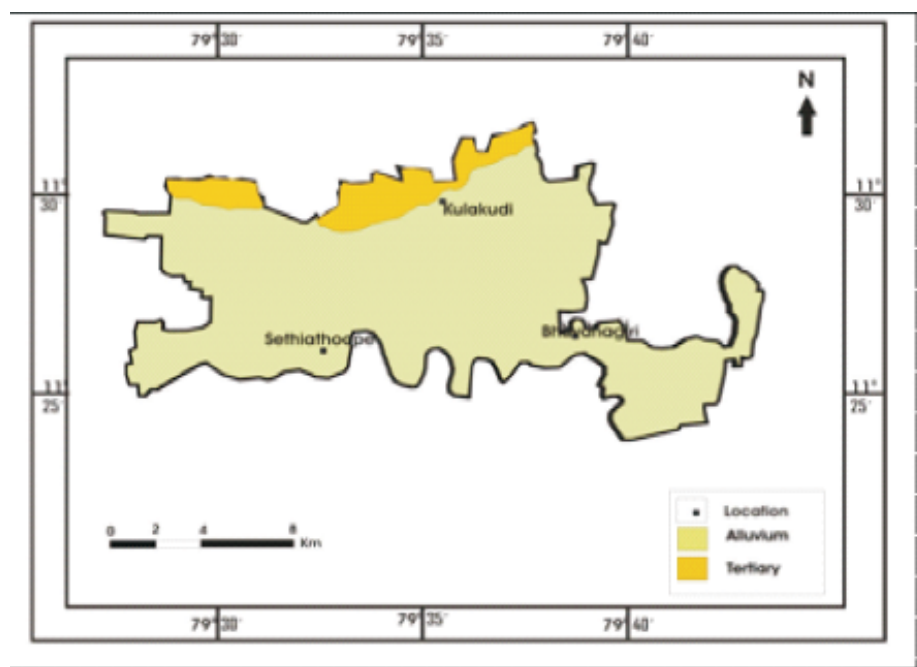


Figure 2. Geology map of huvanagiri Block.

METHODOLOGY

In the present study, the groundwater potential, at shallow level, has been evaluated by surface electrical resistivity technique. To understand the subsurface lithology and layer thickness, five vertical electrical soundings (VES) were carried out on different locations. The resistivity signal measurements were collected by using SSR-MP-AT-ME model resistivity

meter. A maximum of 100m AB/2 spacing is used by employing Schlumberger configuration. The obtained data were analyzed by using IPI 2WIN software. From the interpreted data the iso-resistivity and iso- layer thickness spatial maps were generated to delineate the shallow groundwater potential zones. The interpreted layer thickness is compared with the existing bore lithology of the nearby location of Annamalainagar.

Table 1. Interpreted resistivity data of the study area.

VES No	No. of layers	Resistivity Value (Ohm m)	Layer thickness (m)	Error Percentage
1	1	3.04	0.9	4.28
	2	1.66	9.15	
	3	6.54	41.7	
	4	3317		
2	1	9.08	0.9	2.5
	2	5.78	3.61	
	3	18	18.1	
	4	9.08		
3	1	10.9	1.05	3.19
	2	17.7	12	
	3	5.3		
4	1	2.82	1.571	1.73
	2	10.95	5.092	
	3	6.33	53.28	
	4	121		
5	1	3.94	4.77	4.3
	2	13.5	5.58	
	3	3.28		

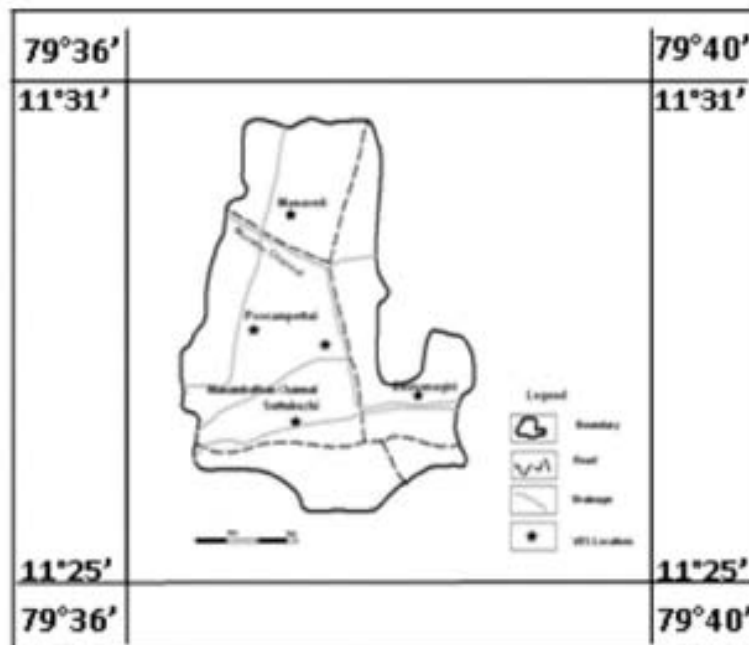


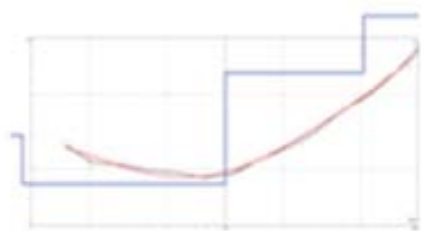
Figure 3. VES locations map of the study area.

RESULTS AND DISCUSSION

The interpreted resistivity data is presented in Table 1. In this attempt a total of 5 VES were conducted on different locations of the study area as in Fig.3. The curve types obtained are H, HK.K, AA, and K with 4 layers except in the VES-3 and VES-5. A maximum error percentage of 4.3% is observed in the

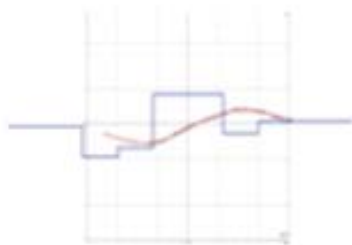
VES location5. The overall resistivity and layer thickness vary from 1.66 ohm m to 121 ohm m and 0.9m to 53.28m respectively. The output of the interpreted data by using IPI 2WIN is presented in the Fig.4 (a,b,c,d,e).

The study analysis shows that the resistivity and thickness values, for the first layer, have been determined and they vary from 2.82 ohm to 10.9



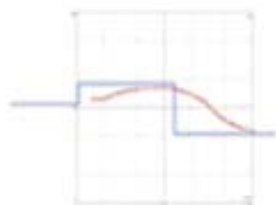
Village : Elowanagel
Error Percentage : 4.7%

N	ρ	h	d	AR
1	3.04	0.9	0.9	-0.9
2	1.66	9.15	10	-10.05
3	6.54	41.7	51.7	-51.75
4	3317			



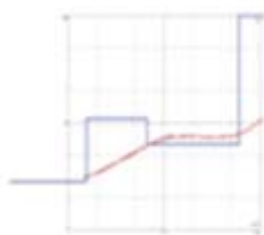
VILLAGE NAME: SUTTURULI
ERROR: 2.5%

N	ρ	h	d	AR
1	9.00	0.9	0.9	-0.9
2	5.70	3.61	4.51	-4.51
3	10	18.1	22.6	-22.61
4	9.00			



VILLAGE NAME: POORAMPETTAI
ERROR : 3.19%

N	ρ	h	d	AR
1	10.9	1.00	1.00	-1.00
2	17.7	12	13.1	-13.1
3	5.3			
4				



VILLAGE NAME: MANAVELI
ERROR : 1.731%

N	ρ	h	d	AR
1	2.826	1.571	1.571	-1.5707
2	10.95	5.092	6.663	-6.6631
3	6.333	53.28	59.95	-59.940
4	121			



VILLAGE NAME: POORAMPETTAI-2
ERROR : 4.3%

N	ρ	h	d	AR
1	3.94	4.77	4.77	-4.767
2	13.5	5.58	10.3	-10.35
3	3.70			
4				

Figure 4. Interpreted resistivity curve of the study area.

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ohm and 0.9m to 4.77m respectively. In the first layer the low resistivity value of 2.8 ohm m is noted in VES-4. The higher value is observed in VES-3. Smaller layer thickness of 0.9m has been indicated in VES- 1 and 2.the high thickness of 4.77m is noted in VES 5. The low and high resistivities of first layer could be influenced by soil characteristics of the study area. The loamy soil could be the reason for low resistivity and the loosened dry top soil could be for higher resistivity. The spatial variation of the first

layer resistivity and layer thickness is shown in Fig,5 (a & b).

The second layer resistivity and layer thickness varies from 1.66 ohm m to 17.7 ohm m and 3.61m to 12m respectively. The resistivity value of 1.66 ohm m of the second layer is observed in VES location 1. The resistivity value of 17.7 ohm m is noted in VES location 3. The layer thickness of 3.6m is observed in VES- 2, whereas it is 12m in VES -3. The underlying formation resistivity generally depends on

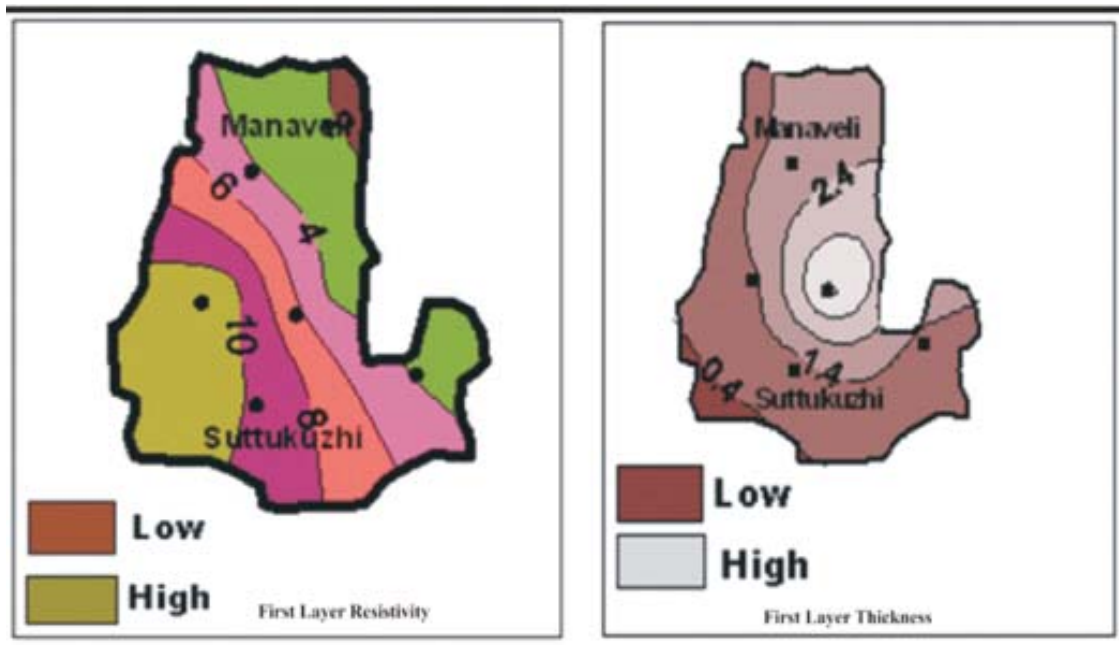


Figure 5. Iso-resistivity and Iso-thickness Map

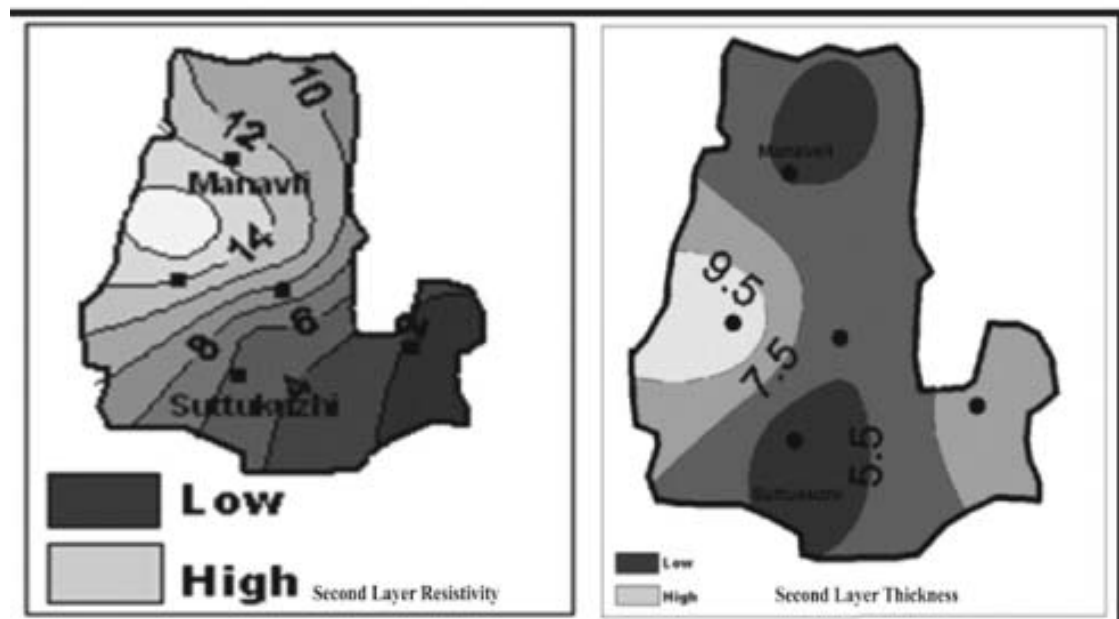


Figure 6. Iso-resistivity and Iso-thickness Map



Figure 7. Iso resistivity map of Third layer.

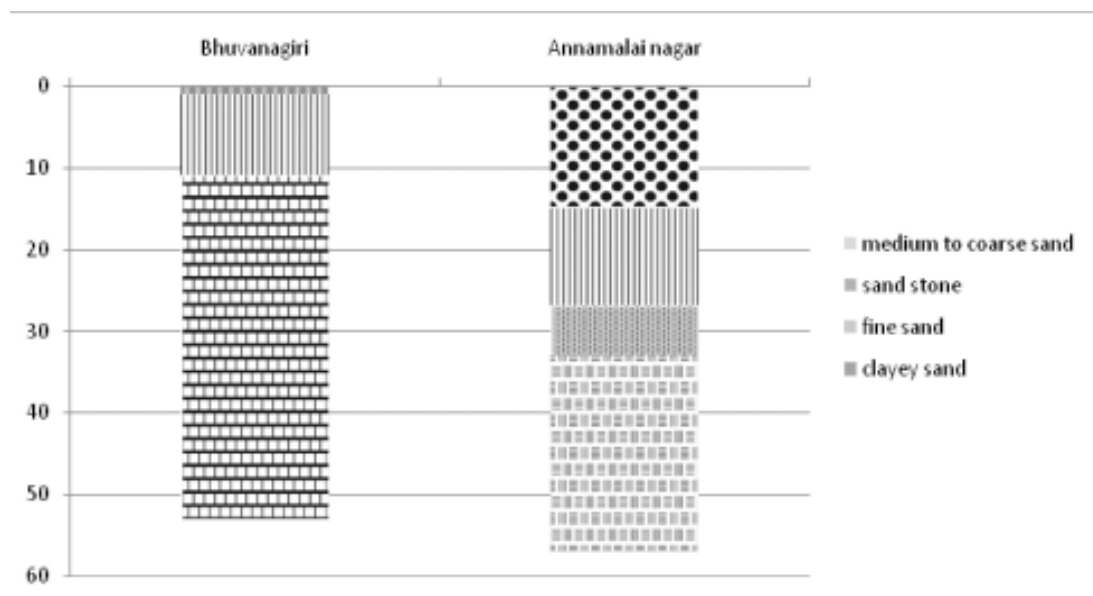


Figure 8. Correlation diagram of layer thickness.

the compaction and water saturation stage. The low resistivity could represent presence of sandy clay formation. In the study the very low resistivity value was obtained due to higher percentage of clay admixture. The spatial variation of second layer resistivity and layer thickness spatial map is shown in Fig.6 (a & b).

In third layer, the resistivity and thickness value ranged from 3.28 ohm m to 18 ohm m and 18.1m to 53.28m respectively. The spatial variation of third layer resistivity is shown in Fig.7. The fourth layer

resistivity varied from 9.08 ohm m to 3317 ohm m. In the third and fourth layers, the low resistivity was observed in most of the VES locations. The low value was obtained due to the presence of sandy clay and clayey formations. The high resistivity found in VES locations 1 and 4 are due to coarse sand mixed with gravel or pebbles. Normally, these coarse sand formations are the potential aquifers. In the fourth layer both the low and high resistivity were noted in VES locations 2 and 1. It shows no perceptible variations in the third and fourth layer resistivities.

The determined resistivity difference could be attributed to the textural and compositional variations of the sandy formation.

To establish the point that the data validity of resistivity determined layer thickness, it is correlated with the existing borehole lithology of Annamalai nagar, which is nearer to the study area. Actually, the borehole drilled to a depth of 300m. In this correlation the maximum depth derived from the resistivity interpretation has been taken for validation. Accordingly, the maximum depth of 60m is taken from resistivity interpretation for correlation, which is noted in VES-4. In the bore hole lithology, top layer of clayey sand is found up to 15m followed by 12m thickness of fine sand. Subsequently a 6 m thick sandy formation was present and below 24m thickness of medium to coarse sand was encountered. In the resistivity result, 1m thickness of top layer and followed by 10m clayey sand formation was interpreted. These two layers represent the first layer of bore hole lithology. Below the 1st two layers a 42m thickness of third layer was derived. This 42m thickness represents the three layers of the bore hole lithology. In bore-hole lithology the formations were fine to coarse sandy formations. From this interpretation it is not able to differentiate fine, medium and coarse sand layers. However, the interpreted data of thickness with 60m is relatively matched with the existing borehole lithology in a satisfied level. The thickness diagram of VES-1 and lithology of Annamalai nagar location is shown in Fig.8.

CONCLUSIONS

The study reveals the fact that subsurface lithology and layer thickness can identify shallow groundwater potential zones of the study area. The results suggest that the VES number 1 and 4 are favorable for shallow groundwater development. The promising high resistivity value of $>100\Omega\text{m}$ and subsurface layer thickness ($>40\text{m}$) have been observed in these two VES locations. Hence, the high resistivity value could be possible because of the presence of coarse sand or sand formation. Moreover, the existing

borehole lithology up to 60m also is closely related to the interpreted resistivity results of the present study. The geophysical electrical resistivity technique for identifying feasible shallow groundwater positional zones has been proved successful in this sedimentary terrain. The interpretation results of the subsurface lithology and thickness of the layer, using resistivity cross section, is very much helpful to develop and construct wells to explore sufficient quantity of groundwater.

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