International Journal of Research in Engineering, Science and Management
Volume 5, Issue 1, January 2022
https://www.ijresm.com | ISSN (Online): 2581-5792

Electrical Resistivity Data Interpretation for Groundwater Detection in Manimuktha River Basin, Tamil Nadu, India

B. Karthik[1*], K. Sankar[2], R. Rajasekar[3], D. Santhi[4], R. Suresh[5]
[1,2,3,4]*Department of Industries and Earth Sciences, Tamil University, Thanjavur, India*
[5]*Department of Earth Sciences, Annamalai University, Annamalinagar, Chidambaram, India*

***Abstract*: This study deals with Geoelectrical resistivity surveys to delineate fresh water pockets in Manimuktha river basin, Tamilnadu. The study area chiefly consists of hard crystalline rocks. Vertical Electrical Soundings (VES) were conducted at 46 different locations using Schlumberger configuration with maximum current electrodes spread up to 200m. The measured resistivity data were interpreted using IPI2WIN software. The resistivity result shows the first minimum and maximum value is 3.37 to 123Ωm similarly second layer resistivity value is 0.709 to 4465Ωm, third layer value is 12.1458 to 1458Ωm and finally fourth layer resistivity values 1.74 to 2086Ωm respectively. In the thicknesses of first layer is 0.544 to 4.39 m, second layer thickness is 1.2 to 82.6m and finally third layer thickness values 2.73 to 36.3m respectively. The favorable resistivity value 20 to 160Ωm was observed in first layer seven VES locations like 1 to 7, second layer four VES locations 3,7,12,13, third layer six VES locations 1,5,6,7,8 and13 and the fourth layer there no favorable resistivity value 20 to 160Ωm respectively. Hence, these three locations were identified to develop shallow fresh water potential pockets from the interpretation analysis.**

***Keywords*: Hard rock aquifers, Electrical resistivity survey, VES, Potential zone.**

1. Introduction

Groundwater is the major source of drinking water in the world. Besides, it is an important source of water supply for the agriculture and industrial sectors. Groundwater demand has increased over the years which have led to water scarcity in many parts of our country. Availability of freshwater potential is becoming a serious issue in the coastal regions. This crisis of ground water scarcity is not the result of natural factors but by human actions. During past two decades, water level in several parts of the country has been failing rapidly due to increase in extraction. The number of wells drilled for irrigation has rapidly and indiscriminately increased. In this scenario, geophysical methods are widely useful to solve the problem of water scarcity by determining potential zones of groundwater in any type of terrains. Geoelectric resistivity method is one of the important geophysical methods used to investigate the nature of subsurface formations by studying the variations in their electrical properties. The technique has been successfully utilized to delineate fresh water zone in sedimentary terrain (Land, et al (2004). The conventional Schlumberger configuration of resistivity sounding is used by Yadav, G.S, et al, 1997 for groundwater investigations in alluvial and hard rock terrain. In this work electrical survey is carried out to identify fresh water potential zones in a Manimuktha river basin, Tamilnadu.

2. Study Area

The study area lies between $78^0$42'to $78^0$59'E longitude and $11^0$42'to $11^0$59'N covering a total area of 497.11 km2 in which hilly area occupies 187.19 km^2. Western side the study area covered by Kalvarayan hills which divide the Salem and Villupuram districts are seen to the extreme west of Kallakurichi Taluk. The average annual rainfall of the study area is 1070 mm bring the groundwater recharge in the area. The climate is moderate to hot, with the maximum temperature being 38 °C and the minimum at 21 °C. The study area chiefly consists of hard crystalline rocks of Archean age. The depth of dug wells and water table ranges from 15 to 20 m and 8 to 18 m, respectively (Venkateswaran and Deepa 2016). The flow of water in the river is reduced during the period from February to June, and as a result, in the region depends on groundwater for their use. A major part of the study area fall in the agricultural activities, where sugarcane, paddy, and groundnut are being cultivated. The upper reaches of the river basin comprises the precambrian peninsular Gneiss and its retrograded products (Krishna Kumar et al. 2008) the area mainly underlain by chornockites, fissile hornblende gneiss, hornblende biotite gneiss, pink granite and ultrabasic rocks. The depth of bore holes in upper ranges of Manimuktha basin from 90 to 150 ft (Krishna Kumar et al. 2008). The study area map is shown in Fig. 1.

*Corresponding author: karthik_baskaran@yahoo.co.in

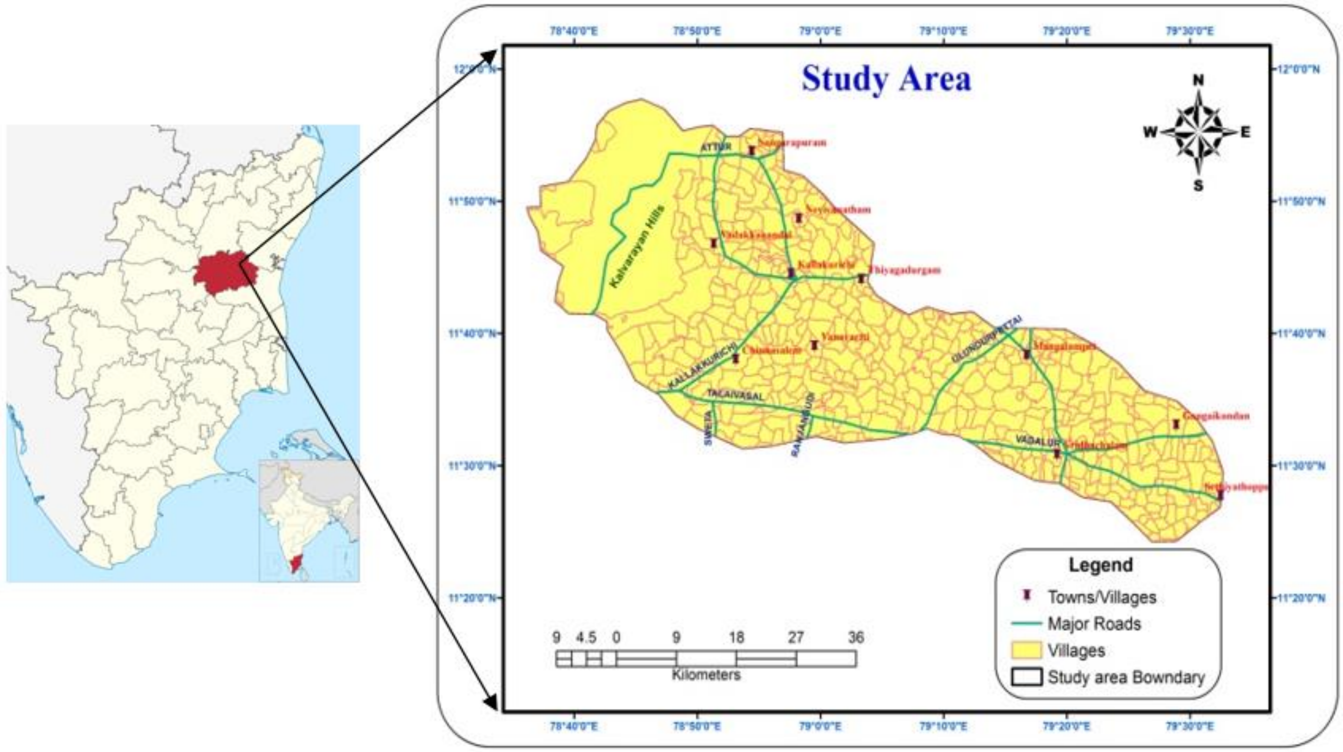

Fig. 1. Study area

3. Methods and Materials

Electrical resistivity method has gained considerable importance in the field of groundwater exploration because of its low cost, easy operation and efficiency to detect the water bearing formations. In the present study, 13 Vertical Electrical Soundings (VES) using Schlumberger configuration were carried out at different Locations of the study area (Fig.2). The AB/2 separations have been up to 200 m. The observed apparent resistivity signal values have been interpreted through curve matching technique using IPI2WIN software. The resistivities of the rock types at different depth levels are used to determine depth, thickness and boundary of an aquifer (Zohdy, 1969; and Young et al. 1998), interface of saline water and fresh water zone (El-Waheidi, 1992; Yechieli, 2000; and Choudhury et al., 2001), porosity of aquifer (Jackson et al., 1978), water content in aquifer (Kessels et al., 1985), hydraulic conductivity of aquifer (Yadav and Abolfazli, 1998; Troisi et al. 2000), transmissivity of aquifer (Kosinski and Kelly, 1981).

4. Result and Discussion

Fresh water aquifer potential zones are identified from the resistivity range 20 to 60 Ω-m. In general, resistivity response being controlled by number of parameters in a same formation. While Zohdy et al., (1974) have delineated the resistivity range of 15 to 600 Ω-m for freshwater aquifers, Melanchton et al., (1988) put the resistivity range of 20 to160 Ω-m for the same. Further, Balasubramanian, 1985 has determined and recognized saline water at ≤ 10 Ω-m and freshwater zone between 20 to 60 Ω-m in the coastal zone of the Thoothukudi District. Hence, resistivity range of 20Ω-m to 60 Ω-m has been considered to delineate fresh water zones in this present study.

True resistivity has been obtained from the apparent resistivity data interpretation. The resistivity range of 20 Ω-m to 60 Ω-m was noticed in 13 VES locations in first layer and 5 VES locations in second layer. Similarly, resistivity value of 60-120 Ω-m observed in 3 VES locations in first layer and 04 VES locations in second layer whereas resistivity of <20 Ω-m was observed in 13 and 15 VES locations first and second layer respectively. The resistivity range of 20 Ω-m to 60 Ω-m was noticed in all most all the interpreted layers of the VES. In order to locate the fresh water zone, the resistivity range of 20 to 60 Ω-m has been considered in second, third, fourth layers, irrespective of interpreted depth from ground level. Accordingly, the resistivity range of 20 to 60 Ω-m was observed mostly in the 3rd and 4th layers of the study area.

5. Interpreted Resistivity Layers

The interpreted resistivity shows that the resistivity and thickness values for the first layer varied from 3.37 to 123 ohm and 0.544 to 4.39m respectively. In the first layer the low resistivity value of lowest value is noted in VES-10 (Vijayamanagarm) and the higher value is observed in VES-04 (Melnariyappanur). Minimum layer thickness has been indicated in VES-11 and maximum layer thickness is noted in VES-08. The spatial map of first layer resistivity and layer thickness is shown in Figure 2 and 3 respectively. It is observed that low resistivity of < 20 Ohm m is observed in eastern part of the study area followed resistivity range of 20-60 Ohm m occupied in the western and central part of the area. Besides small patches of 60-160 Ohm m resistivity range is observed in north and south part of the study area. Attributed by wet black soil and alluvial soil whereas 20-160 Ohm m could be dry soil condition or highly weathered formation. The layer thickness of first layer varied from 0.544m to 4.39m where minimum thickness is found at VES-12 and maximum thickness found in VES-08. The spatial variation of layer thickness represent 1-3 m was noted as most of the study area and >3m thickness noted in small spots in the central part of the study area.

The second layer resistivity varied from 0.709 Ohm m to 4465 Ohm m where high resistivity found in VES-04 and low resistivity found in VES-10. Spatial variation of second layer resistivity is shown in Figure 4 indicates that resistivity of 20-60 Ohm m is observed in small patches in southern and northern part of the study area. Major part of the study area, particularly in the central part of east-west direction and eastern part represented by 500-1000 Ohm m. The second layer thickness is varied from less than 1.2m to 82.6m and less thickness is found in VES-02 and high thickness found in VES-06. The spatial map of second layer thickness is shown in the Figure 5 and it shows that <5 m is observed in some patches of the area followed by 5-10m thickness were observed in western zone and also few patches in eastern part. Whereas >50m is observed as small spot in the central part and small spot in eastern part of the study area. The high thickness could be alluvial deposit and less thickness due to weathered formation.

In the third layer low resistivity of 12.6 found in VES-09 and high resistivity of 1458 found in VES-03. Spatial variation of third layer resistivity is shown in Figure 6. 20-60 Ohm m is noticed in eastern part of the study area. The resistivity range from 60-160 Ohm m was noted from few spots in central part. The resistivity of 60-120 Ohm m due to water saturated weathered and fractures/jointed rock formation. Layer thickness of the third layer is varied from 2.73m to 36.3m where less layer thickness found in VES-05 and high thickness found in VES-09. Spatial variation of layer thickness of third layer is shown in Figure 7. The western part of the study area and some spots in eastern part represented to a layer thickness of <5m. The thickness range 5-10m was noticed in eastern part and most of the area occupied in eastern part. Similarly, 10-20 m small patches in central part of the study area. The high layer thickness could be attributed by poorly fractured/ jointed rock formation and low layer thickness could due to weathered and fractured/jointed rock formation.

The fourth layer curve resistivity varied from 1.74-ohm m to 2086-ohm m. The high resistivity was observed in VES-07 whereas the low resistivity was observed in VES-09. The spatial variation of fourth layer resistivity is shown in Figure 8.

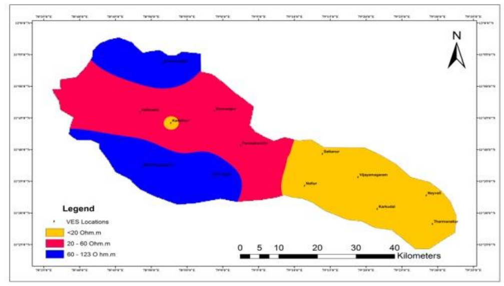

Fig. 2. Spatial variation of resistivity- First layer

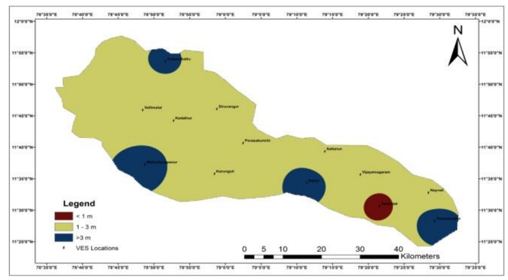

Fig. 3. Spatial variation of thickness -First layer

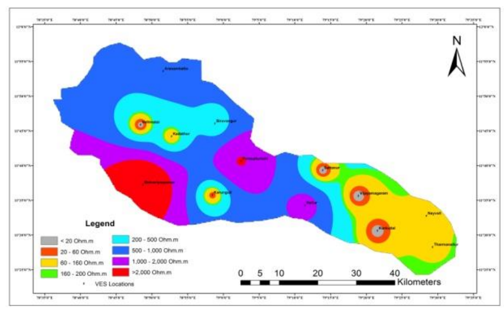

Fig. 4. Spatial variation of resistivity -Second layer

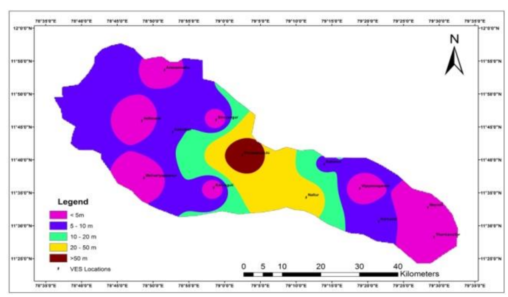

Fig .5. Spatial variation of thickness- Second layer

Table 1
Interpreted Electrical Resistivity and Layer Thickness of the Study Area ('ρ' in Ohm m, 'h' in m)

VES no.	Location	ρ1	ρ2	ρ3	ρ4	ρ5	ρ6	H1	H2	H3	H4	H5	Curve Type	Error %
1	Arasambattu	98.4	635	65.2	1032			3.31	2.91	4.84		2	KH	2.27
2	Vellimalai	39.7	6.93	436.1	219			1.34	1.2	7.75		3	AK	9.07
3	Kadathur	14.7	72.9	1458				2.51	9.79			1	A	4.35
4	Melnariyappanur	123	4465					4.06				1	A	12.1
5	Siruvangur	40.8	313	38.3	242	2951		1.2	1.31	2.73	17.9	6	KHA	3.33
6	Porasakurichi	27.5	2060	29.7				1	82.6			8	K	6.15
7	Karunguli	104.2	37.7	190.4	2086			1	1.222	12.27		9	HA	1.861
8	Nallur	11.1	1223	25.9	2.26			4.39	29.1	3.31		8	K	13.9
9	Sattanur	3.53	2.72	12.6	1.74	632		1	8.76	36.3	50	12	HKH	2.28
10	Vijayamagaram	3.37	0.709	14				1.22	1.26			5	H	6.11
11	Karkudal	12.7	4.34	34	3.12	-	-	0.544	6.15	9.03	-	11	HK	7.49
12	Neyveli	8.51	101	15.3	-	-	2.51	1.77	-	-		8	K	5.52
13	Tharmanallur	4.997	146.2	27.3	-	-	3.12	3.882	-	-		8	K	1.86

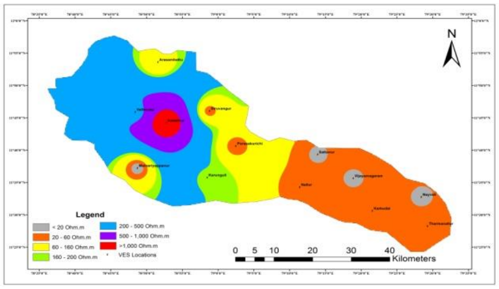

Fig. 6. Spatial variation of resistivity- Third layer

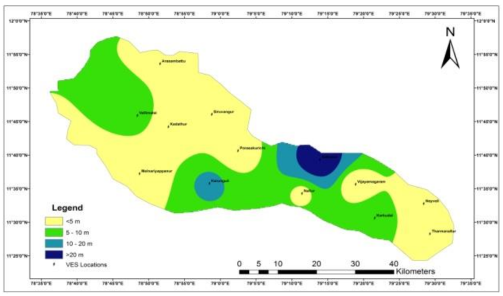

Fig. 7. Spatial variation of thickness -Third layer

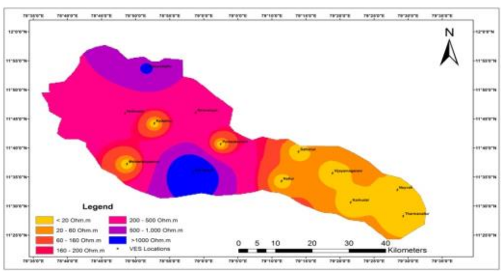

Fig. 8. Spatial variation of resistivity - Fourth layer

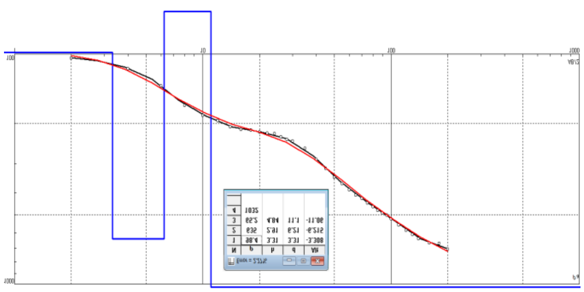

Fig. 9. VES.1. Arasambattu

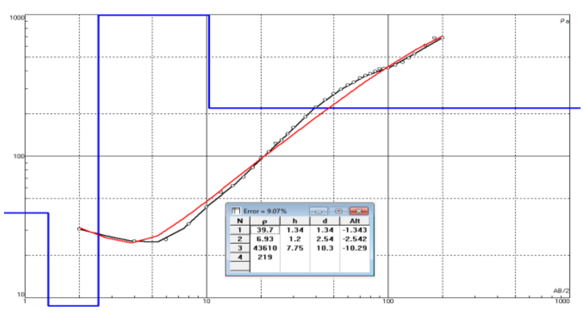

Fig. 10. VES.2. Vellimalai

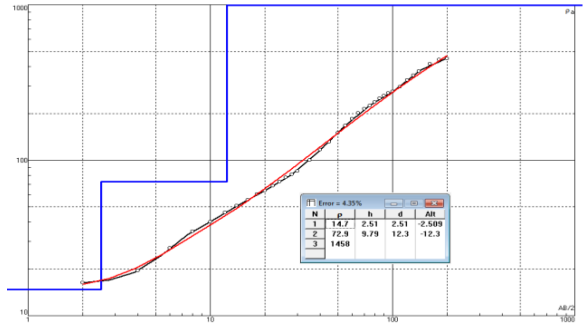

Fig. 11. VES.3. Kadathur

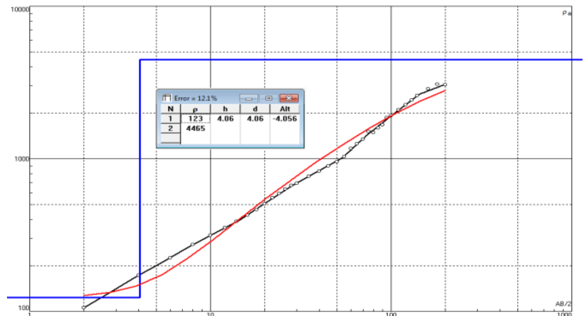

Fig. 12. VES.4. Melnariyappanur

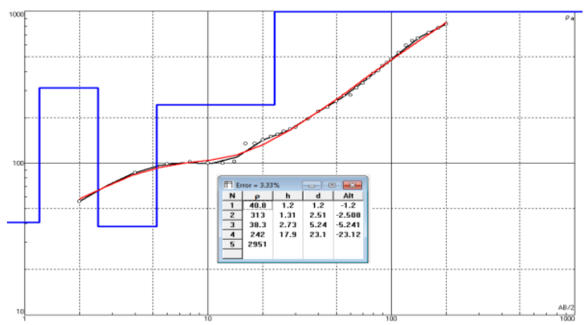

Fig. 13. VES.5. Siruvangur

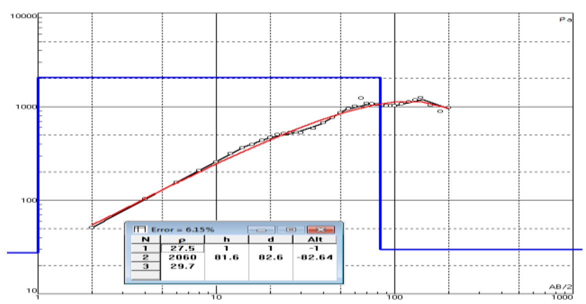

Fig. 14. VES.6. Porasakurichi

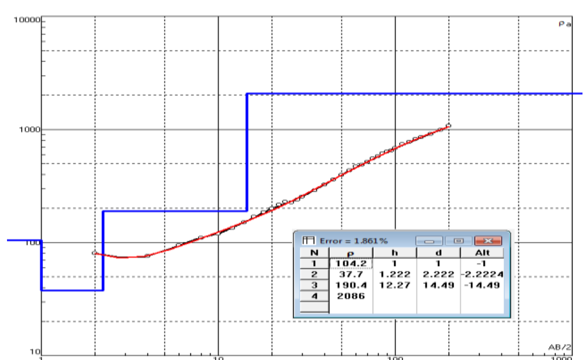

Fig. 15. VES.7. Karunguli

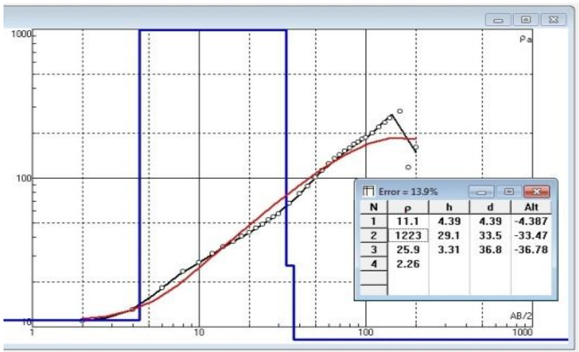

Fig. 16. VES.8. Nallur

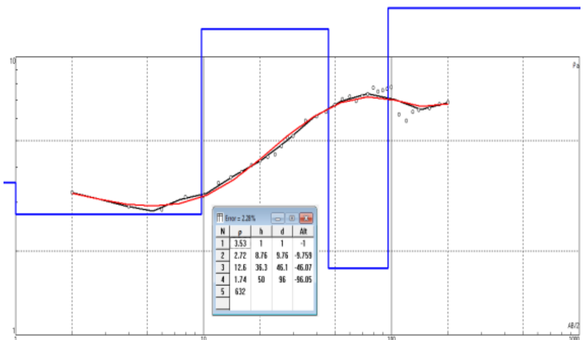
Fig. 17. VES.9. Sattanur

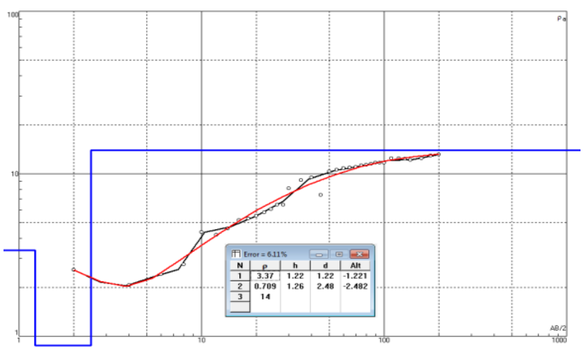

Fig. 18. VES.10. Vijayamagaram

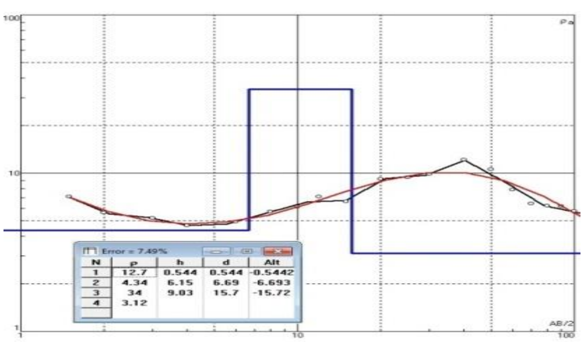

Fig. 19. VES.11. Karkudal

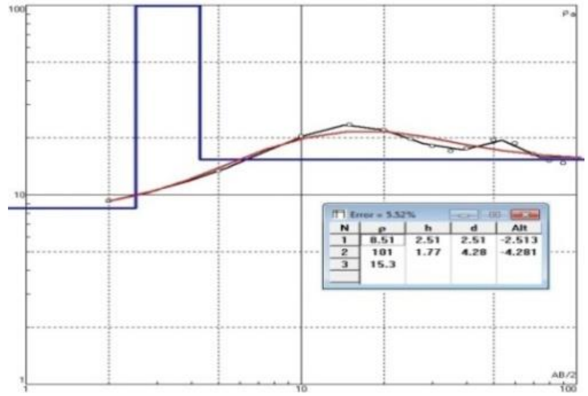

Fig. 20. VES.12. Neyveli

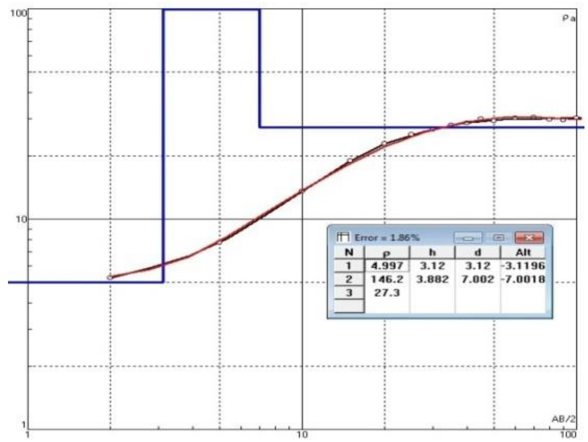

Fig. 21. VES.13. Tharmanallur

6. Conclusion

The geophysical resistivity method is widely used for the ground water exploration. In the present study, the demarcation of suitable ground water potential zones has been carried out using the geophysical resistivity values and layer thickness parameters. The favorable zone has been delineated with respect to the recommendable resistivity of 60 Ωm to 160 Ωm. Apart from the resistivity value, the layer thicknesses are also considered for long term development. Hence the zone which has more depth to basement (thickness>5m) been considered for ground water development. With this interpretation, the zone around VES-3 and VES-9 were identified as favorable zones for ground water development.

References

[1] Yadav, G.S., and Abolfazli, H. (1998) Geoelectric soundings and their relationship to hydraulic parameters in semiarid regions of Jalore, northwestern India. Journal of Applied Geophysics 39: 35-51.
[2] Venkateswaran S, Deepa S (2016) Evaluation of groundwater quality for drinking purpose inart of Villupuram District, Tamil Nadu. Indian J Appl Res 6(2):318–321.
[3] Zohdy, A.A.R. (1969): Application of deep electrical soundings for groundwater exploration in Hawaii, Geophysics, 34, 584-600.
[4] El-Waheidi, M.M., Merlanti, F., and Pavan, M. (1992) Geoelectrical resistivity survey of the central part of Azraq basin (Jordan) for identifying saltwater/freshwater interface. J. Applied Geophysics 29: 125-133.
[5] Yechieli, Y. 2000. Fresh-saline ground water interface in the western Dead Sea area. Ground Water 38, no. 4: 615–623.

[6] Choudhury K., Saha, D.K., and Chakraborty, P. (2001) Geophysical study for saline water intrusion in a coastal alluvial terrain. Journal of Applied Geophysics 46: 189-200.
[7] Yadav, G.S., and Abolfazli, H. (1998) Geoelectric soundings and their relationship to ydraulic parameters in semiarid regions of Jalore, northwestern India. Journal of Applied Geophysics 39: 35-51.
[8] Troisi, S., Fallicos, C., Straface, S., and Migliari, E. (2000) Application of kriging with external drift to estimate hydraulic conductivity from electrical resistively data in unconsolidated deposits near Montato Uffugo, Italy. Hydrogeology Journal, 8: 356-367.
[9] Kossinski, W.K., and Kelly, W.E. (1981) Geoelectric sounding for predicting Aquifer Properties. Ground Water 19: 163-171.
[10] Zohdy, A. A. R., Eaton, G.P., Mabey, D.R., 1974. Application of surface geophysics to Ground-water investigation: techniques of Water-resources Investigations of the U.S. Geological Survey, book 2, Chapter Dl, 116.
[11] Melanchthon, V.J., V. N. Raju, A. Ramakrishna and A. N. Bhowmick; 1988. Resistivity survey for mapping fresh water pockets. J. Assoc. of Expl. Geophys. 9(2): 71-78.
[12] Krishna Kumar S, Rammohan V, Dajkumar Sahayam J, Jeevanandam M (2008) Assessment of groundwater quality and hydrogeochemistry of Manimuktha Riverbasin, Tamil Nadu, India. Environ Monit Assess 159:341–351.
[13] Young, M.E., De Bruijin, R.G.M., and Salim Al-Ismaily, A. (1998) Reports: Exploration of an alluvial aquifer in Oman by time-domain electromagnetic sounding, Hydrogeology Journal, 6: 383-393.