Identification of Shallow Fresh Groundwater Potential Zones Using Electrical Resistivity Sounding Along the Coastal Region of Bhuvanagiri Block of Chidambaram Taluk, Cuddalore District, Tamil Nadu

Jeyavel Raja Kumar T.[1], Dushiyanthan C.[2], Karthikeyan K.[3]

[1]Department of Earth Sciences, Annamalai University, Annamalainagar – 608 002, Tamil Nadu, India
Email: *tjeyavel[at]rediffmail.com*
Email: *jeyavelgeo[at]gmail.com*

[2]Department of Earth Sciences, Annamalai University, Annamalainagar – 608 002, Tamil Nadu, India

[3]Department of Civil Engineering, Annamalai University, Annamalainagar, Tamil Nadu, India

Abstract: ***Fresh groundwater potential zones have been identified using electrical resistivity sounding along the coastal region of Bhuvanagiri block of Chidambaram Taluk, Cuddalore District. 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 annual rainfall over the district and the region varied from about 1050mm to 1400mm. Seven vertical electrical soundings (VES) were carried out in different locations to understand the subsurface lithology and layer thickness along the coastal region. The resistivity 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. The curve types obtained are K, HQ, QA, KQH and KKH with 4 and 5 layers. A maximum error percentage of 7.5% wass observed in the VES location7. The overall resistivity and layer thickness varied from <1 ohm m to 851 ohm m and <1m to 14.8m respectively. The study reveals that the coastal region is represented with possible presence of freshwater to a depth of 2.5m bgl and less possibility below 20m bgl.***

Keywords: Coastal groundwater potential, Electrical resistivity sounding, Freshwater aquifer zones, Subsurface lithology, Coastal hydrogeology

1. Introduction

In the society, water is a major theme of economic, scientific, political, social, and human debate, which is a widespread concern in the globe. The future of peace and prosperity in a finite earth will depend on our civilized ability to share the limited water resources of the world. In the recent past, the resources of groundwater being attained higher level and its requirement also drastically increased. In many developed and developing countries there is not only a heavy reliance on ground water as a primary drinking supply but also as a supply of water for both agriculture and industrial use. This heavy reliance on ground water has shown the need of its development and investigation.

Now a day, geophysical methods are widely used to determine the groundwater resources in any type of terrains. There are several geoelectrical sounding techniques for the groundwater investigations described in literature (Al'pin,1950; Keller and Frischknecht,1966; Koefoed, 1979 etc.). Geoelectric Resistivity method is one of the important methods used to investigate the nature of subsurface formations by studying the variations in their electrical properties. The vertical electrical sounding (VES) survey has been proved useful and cost-effectiveness and schlumberger array is found to be more suitable and common in ground water investigations (Zhody et al., 1974). In this context, an attempt has been made to identify shallow fresh groundwater potential zones along the coastal region of Bhuvanagiri block of Chidambaram Taluk, Cuddalore District, Tamil Nadu using vertical electrical sounding technique. Besides, the technique has been utilised successfully to solve groundwater problems by many researchers (Karanth, 1978; Janardhana Raju et al ,1996; Balasubramanian etal ,1985; Jagadeeswara Rao etal, 2003; Jeyavel RajaKumar,2007; Ranjit Kumar Majumdar and Das Debabrata,2009; Yadev et al,2010; Sarma,2014, Kasidi, 2017; Shaik Saleemmiya et al,2022 and Som Nath et al, 2024).

2. Study Area

The study area Bhuvanagiri block lies between the latitude 11^0 25′ and 11^0 31' and the longitude between 79^0 36' and 79^0 40' (Figure.1). Physiographically, the area has a gentle slope. The district as well as the study area is more or less a plain terrain with small elevated tertiary upland hills and laterite hillocks occur in the Cuddalore sandstone formation. Geologically it comprises alluvium on the top, followed by Mio-Pliocene and cretaceous formations (Figure- 2). Geomorphologically it is concealed by flood and alluvial plains. The pattern of precipitation over the study area is a tropical monsoon type where the effect of the winter monsoon is dominant. In this area precipitation is the main source of groundwater and is mainly due to northeast monsoon (October to December) and Southwest monsoon (June to September). The annual rainfall over the district varies from about 1050mm to 1400mm against the annual rainfall of 942.8mm, Tamilnadu state. The normal annual rainfall of Northeast and Southwest monsoons is 716.5mm and 373.6mm respectively.The surface and groundwater are used for both domestic and irrigational purposes. The monsoon water level varied from 2.59m to 7.99m.

3. Methodology

In the study, delineation of shallow fresh groundwater potential zones have been evaluated by surface electrical resistivity technique. To understand the subsurface lithology and layer thickness, seven vertical electrical soundings (VES) were carried out on different locations along the coastal region. 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.

4. Results and Discussion

The interpreted resistivity data is presented in Table –1. In this attempt a total of 7 VES were conducted on different locations of the study area as in Figure-1. The curve types obtained are K, HQ, QA,KQH and KKH with 4 and 5 layers. A maximum error percentage of 7.5% wass observed in the VES location7. The overall resistivity and layer thickness varied from <1 ohm m to 851 ohm m and <1m to 14.8m respectively. The output of the interpreted data by using IPI 2WIN is presented in the Figure- 3.

The study analysis shows that the resistivity and layer thickness values of the first layer are varied from 4.5 ohm to 528 ohm and 0.9m to 2.5m respectively. In the first layer the low resistivity value of 2.8ohm m is noted in VES-4. The higher value is observed in VES-3 and low resistivity observed in VES-7. Less layer thickness of 0.9m was indicated in VES- 5 and 6 whereas high thickness of 2.5m is noted in VES-3. The low and high resistivity 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 second layer resistivity and layer thickness varied from <1 ohm m to 851ohm m and <1m to 19m respectively. The resistivity value of <1 ohm m of the second layer is observed in VES location 3. The high resistivity value of 851 ohm m is noted in VES location 7. The layer thickness of <1m is observed in VES- 6 & 7, whereas it is 19m in VES -3. The underlying formation resistivity generally depends on 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.

In third layer, the resistivity and layer thickness value are ranged from <1 ohm m to 92 ohm m and 2.8m to 50m respectively. Less layer thickness is observed in VES- 1 and high thickness of 50m is noted in VES-2.The fourth layer resistivity varied from <1 ohm m to 36 ohm m. The low value was obtained due to the presence of sandy clay and clayey formations. The low resistivity found in VES locations 2 and 6 are due to fine sand mixed with clay. The determined resistivity difference could be attributed to the textural and compositional variations of the sandy formation.

5. Conclusion

The study reveals that subsurface lithology and layer thickness of the study area. The interpreted data represent very low resistivity to high resistivity in the first and second layers whereas low resistivity represented in the third and fourth layers. It indicates the coastal region is consist sandy formation followed by clay in most of the VES locations. However, very low resistivity also noted in the top layer and it could be presence of clay rich sandy layer. From the resistivity value range and layer thickness obtained, the coastal region is represented with possible presence of freshwater to a depth of 2.5m bgl and less possibility below 20m bgl. Besides, high and very low resistivity obtained could be influenced by human error during the resistivity field survey and topographical condition in certain locations. Overall, this study helped not only for fresh groundwater assessment and development but also to monitor and conserve the resources.

References

[1] Al'pin, L.M., 1950. The Theory of Dipole Sounding. In: Al'pin, L. M., Berdichevskii, M. N., Vedrintsev G.A., Zagarmistr, A.M.(Eds.), Dipole Methods for Measuring Earth Conductivity (1966). Consultants Bureau, New York, NY, pp. 1-60.

[2] Balasubramanian, A., Sharma, K.K., and Sastri, J.C.V, (1985) Geoelectrical and Hydrogeochemical Evaluation of Coastal Aquifers of Tambraparni Basin, Tamil Nadu, Geophys. Res. BulL, 23, 4, pp. 203-209.

[3] Jagadeswara Rao. P, Suryaprakasa Rao. B, Jagannadha Rao. M, and Hari Krishna. P (2003) Geoeletrical Data Analysis to Demarcate Groundwater Pockets and Recharge Zone in Champavathi River Basin, Vizianagaram District, A. P, J. Ind. Geophysis Union, Vol.7, No.2, pp.105-113

[4] Janardhana Raju.N, Reddy.R.V.K, and Naidu.P.T (1996) electrical resistivity survey for Groundwater in the Upper Gunjanaru Catchment, Cuddapah District,A.P, Jour.Geo.S.c india, V.37, pp.705-716

[5] Karanth, K.R. (1987). Ground Water Assessment, Development and Management, Tata Mc Graw Hills Publications Company Limited, New Delhi. Pp-720.

[6] Kasidi S (2017) Groundwater Exploration Using Electrical Resistivity Method- A Case Study in Federal Capital Teritory (FCT) Abuja. Nigeria, International Journal of Engineering and Applied Sciences (IJEAS) ISSN: 2394-3661, Volume-4, Issue-10, p.1-8.

[7] Koefoed, O., 1979. Geosounding Principles 1, Resistivity Sound-ing Measurements. 1st Ed. Elsevier, Amsterdam.

[8] Ranjit Kumar Majumdar and Das Debabrata, (2009) Hydrological Charterisation and Groundwater Resource Studies in Coastal Areas, Sagon Island Region, West Bengal, India, Proceeding of Symposium JS.3 at Joint International Convention of IAHS and IAH-AISH, Hyderabad, IAH-AISH publication Vol 330, pp123-129.

[9] Sarma, V. S (2014) Electrical Resistivity (ER), Self-Potential (SP), Induced Polarisation (IP), Spectral Induced Polarisation (SIP) and Electrical Resistivity Tomography (ERT) prospection in NGRI for the past 50 years-A Brief Review J. Ind. Geophys. Union, v.18, no.2, pp:245-272.

[10] Shaik Saleemmiya, I. Panduranga Reddy and Sreenu Kunsoth (2022) Groundwater Exploration by using Electrical Resistivity Meter in Granitic Terrain of Hyderabad Region, Telangana State, India, International Journal of Innovative Research in Technology, vol. 8, Issue 12, pp.1316-1322.

[11] Som Nath, Jayant Nath Tripathi, V.K. Upadhyay, and Harsh Kumar Verma, "Ground Water Potential Zone Estimation Using Vertical Electrical Sounding (VES) in Some Parts of Bundelkhand Region of Jhansi District of Uttar Pradesh, India." American Journal of Water Resources, vol. 12, no. 3 (2024): 77-85. doi: 10.12691/ajwr-12-3-2.

[12] Yadev. G. S, Dasgupta. A.S, Sinha. R, Lal. T, Srivastva. K. M, and Singh, S.K (2010) Shallow Subsurface Stratigraphy of Interfluves Inferred from Vertical Electrical Sounding in western Ganga Plains, India, quaternary international Vol.207, issue 2, pp.104-115.

[13] Zohdy, A. A. R. Eaton. G. P. and Mabey., D. R., (1974), Application of Surface Geophysics to Groundwater Investigations, in Techniques in Water Resource investigation, U. S. G. S, Book2, CD 1,116 p.

Table 1: Interpreted resistivity data of the study area

S.no	Station Name	ρ1	ρ2	ρ3	ρ4	ρ5	h1	h2	h3	h4	Error %	Curve type
1	Vayallur	15.5	1.48	38.3	6.82	-	1.2	1.33	2.8	-	2.1	HQ
2	Melmungiladi	9.38	0.92	11.3	0.885	-	1.2	1.33	50.1	-	2.39	HQ
3	Palathangarai	528	28.7	3.32	-	-	2.57	19.4	-	-	2.19	QA
4	Kilmungiladi	6.68	0.41	0.29	36.16	-	2.47	9.58	9.34	-	1.44	QA
5	Anuvampattu	38.64	156	92.12	1.13	16.84	0.9	3.60	5.53	12.36	1.31	KQH
6	B Mutlur	15.2	1.24	53.4	0.85	470	0.98	0.98	3.54	14.8	5.33	HKH
7	Thittampalayam	4.53	851	4	-	-	1.0	0.23	-	-	7.52	K

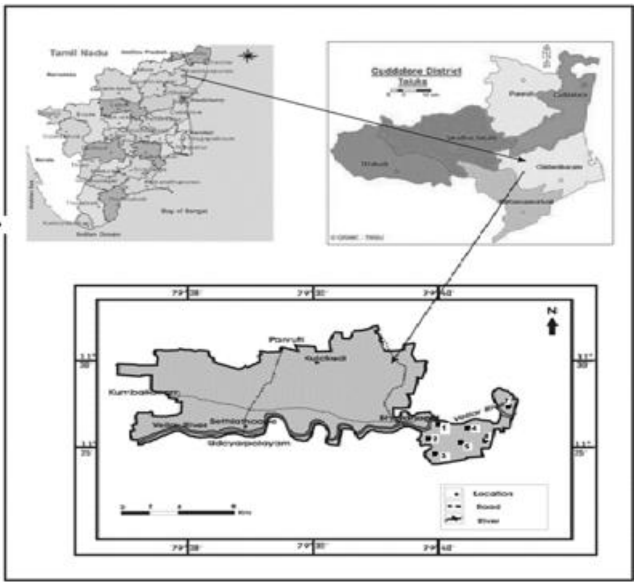


Figure 1: Study Area and VES locations Map

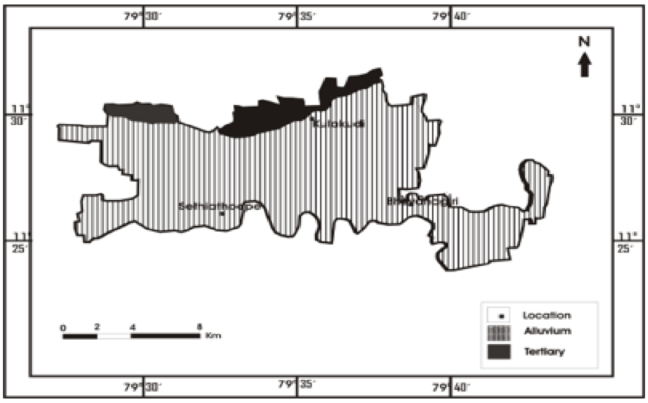
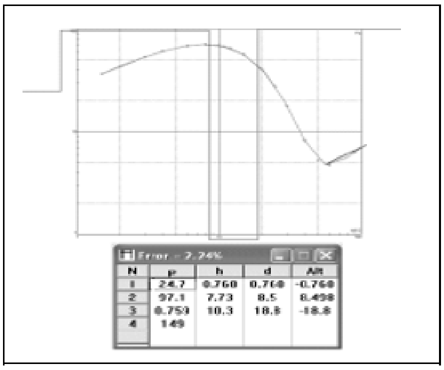
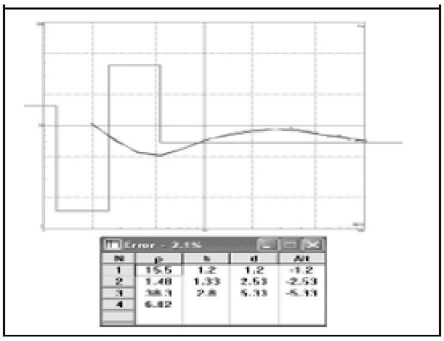


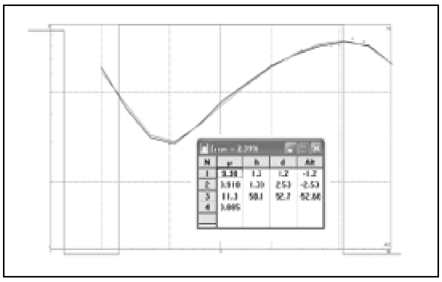
Figure 2: Geology map of Bhuvanagiri Block



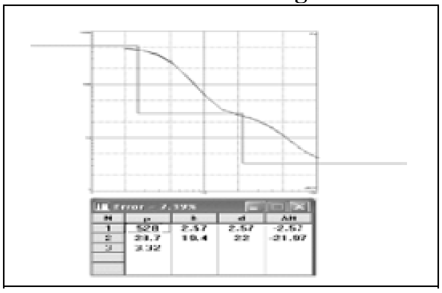
VES 1- Vayailur



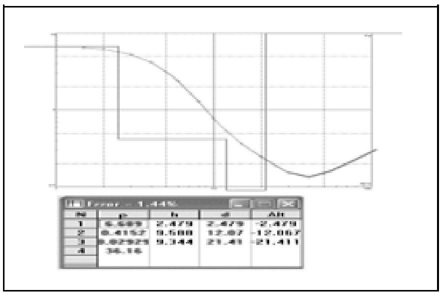
VES 2 - Melmungiladi



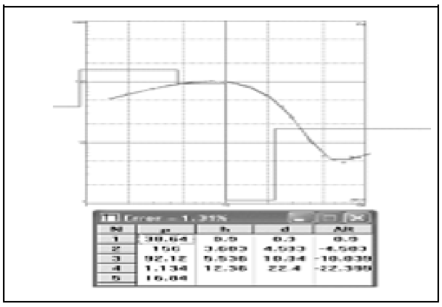
VES 3— Palathangarai



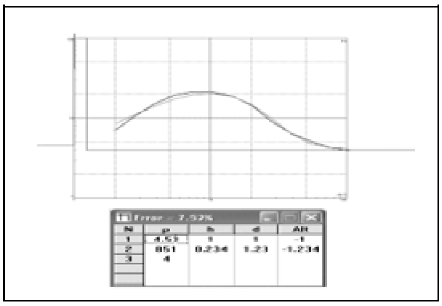
VES 4- Kelmungiladi



VES 5-Anubampattu



VES 6- B.Mutlur



VES 7- Theethampalayam

Figure 3: Interpreted Resistivity data