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Groundwater Subsurface Investigations in Pachipenta Mandal, Andhra Pradesh Using Vertical Electrical Sounding Resistivity Surveys

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Abstract: This study was carried out with the aim of demonstrating the application of vertical electrical sounding method of investigation in the exploration for groundwater in Pachipenta Mandal and environs. A total of 9 VES points were probed located in 4 settlements spread at a distance of 200-300 m apart. ABEM SAS 300 C terameter was used to generate field data. The Schlumberger soundings were carried out with current electrode spacing (AB) ranging from 2-300 m (AB/2 = 1-150 m). The distance used for potential electrode spacing (MN) ranged from 0.3-10 m (MN/2 = 0.15-5 m). The field data were simulated using Winsev software. VES 1 and VES 5 sites show higher potentiality of the groundwater occurrence. The recommended unconfined aquifer as a source of ground water is capable of delivering adequate supply of water to the borehole at perceptible rate by virtue of its thickness since it recharges rapidly. Area of probable groundwater sources have been detected for future drilling operation.

Key words: VES, Schlumberger soundings, potential electrode spacing, unconfined aquifer, probable groundwater, India

INTRODUCTION

Groundwater is one essential but necessary substitute to surface water in every society. It is no doubt a hidden, replenishable resource whose occurrence and distribution greatly varies according to the local as well as regional geology, hydrogeologic setting and to an extent the nature of human activities on the land (Mondal *et al*., 2010; Muthuraj *et al*., 2010). Geophysical electrical resistivity methods were developed in the early 1900's and have been extensively used for groundwater investigation by many workers (Majumdar *et al*., 2000; Bhattacharya and Patra, 1968; Olorunfemi and Fasuy, 1993; Selvam *et al*., 2011) and considered to be the most suitable method for groundwater investigation in most geological occurrence due to simplicity of technique. Among various geophysical studies, researchers have selected Vertical Electrical Sounding (VES) to carryout groundwater potential studies in the present study area. The Vertical Electrical Sounding (VES) method is a depth sounding galvanic method and has proved very useful in ground water studies due to simplicity and reliability of the method. The electrical resistivity of rock is a property which depends on lithology and fluid contents. The resistivity of coarse-grained, well-consolidated sandstone saturated with fresh water for example is higher than that of unconsolidated silt of the same porosity, saturated with the same water. Similarly, the resistivities of identical porous rock samples vary according to the salinity of the saturating water. Vertical Electrical Sounding method was chosen because the instrumentation is simple, field logistics are easy and straight forward while the analysis of data is less tedious and economical (Zhody *et al*., 1974; Ekine and Osobonye, 1996; Ako and Olorunfemi, 1989). With this method, depth and thickness of various subsurface layers and their water yielding capabilities can be inferred. These measurements have been used to solve groundwater and its related problems; notably in determining suitable site for drilling of boreholes and in studying groundwater contamination. This study is a report of the findings of an investigation carried out to establish the role and significance of vertical electrical resistivity method in groundwater exploration in Pachipenta Mandal, Andhra Pradesh, India and environs.

Study area: Pachipenta Mandal is situated to the Northwestern part of Vizianagaram district Andhra Pradesh, India included in Tribal sub-plan area and it lies between North latitudes 18°20' and 18°34'26" and East longitudes 83°02'43" and 83°13'29" and extends over an area of about 287 km^2 covering 54 villages (Fig. 1). The population density is 227 km^2. Mostly hill ranges and forests occupy the area at 45% to the total geographical area. The important rock types are Peninsular Gneissic complex, Dharwar supergroup associated with younger intrusive of archaean age separated by unconformable with overlying basaltic flows of late cretaceous to early eocene age with sub-recent to recent alluvium along

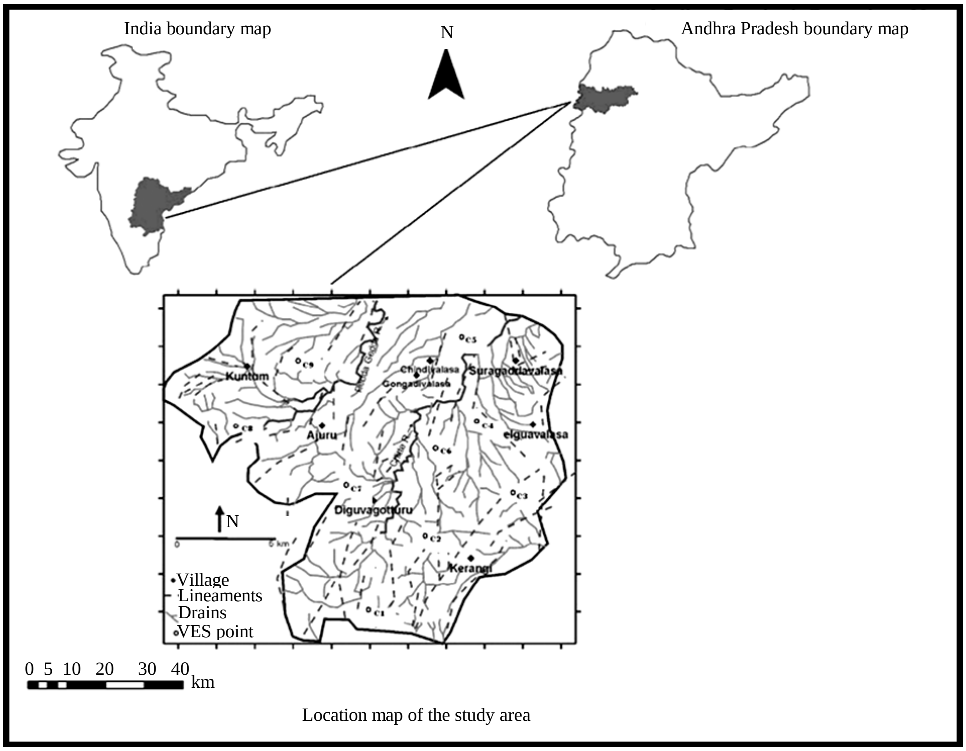

Fig. 1: Location map of the study area

with stream courses. Geologically Deccan basalt whose age is about 65 m.y., occupies most part of the study area. The district receives an average rainfall of 873 mm which increases from South to North. The mean maximum and minimum temperature vary from 40-26°C. The pre-monsoon groundwater level depth varies from a minimum of 4 to a maximum of 20 m below ground level. Most of the area is having water levels <5 m. In the Eastern part the of the district, groundwater level ranges from 5-10 m. The post-monsoon depth to water level ranges from a minimum of 1.8 to maximum of 14.5 m.

MATERIALS AND METHODS

Electrical prospecting make use of a variety of principles, each based on some electrical properties or characteristics of the materials in the earth. In this study, Vertical Electrical Sounding (VES) Method has been applied. VES survey was carried out in 26 locations (Fig. 1) using schlumberger electrode configuration. The Schlumberger Method was adopted for this study because of the fieldwork is faster, easier and economically save the money and software's are readily available for its interpretation (Todd, 1980; Selvam *et al*., 2010). The resistivity values of the layers were measured using the ABEM SAS 300B terameter.

The Schlumberger soundings were carried out with current electrode spacing (AB) ranging from 2-300 m (AB/2 = 1-150 m). The distance used for potential electrode spacing (MN) ranged from 0.3-10 m (MN/2 = 0.15-5 m). At each VES station electrodes were placed in a straight line and the inter-electrode spreads were gradually increased about a fixed center. The current was sent into the ground and the potential difference (V) due to this current was measured and recorded against the electrode spacing. With these values of currents (I) and potential (V) of the electrode configuration adopted one can get the apparent resistivities (pa). The apparent resistivity values were plotted against AB/2 on double-log graph sheets. The manner in which apparent resistivity values increase or decrease with electrode separation forms the basis for choosing the shape of the field curve that can perform quantitative interpretation of the sub surface resistivity distribution (Singh *et al*., 2002). The field data are interpreted by a 1 D inversion technique followed by forward modeling by Winsev software was used.

RESULTS AND DISCUSSION

The combination of all type of curves recorded in the study area indicate the presence of multilayered in homogenous formation. In the above classified curve

Table 1: Interpreted results of VES data

Resistivity layers 1st	2nd	3rd	4th	5th					
ρ1 (Ω m)	ρ2 (Ω m)	ρ3 (Ω m)	ρ4 (Ω m)	ρ5 (Ω m)	h1 (m)	h2 (m)	h3 (m)	h4 (m)	Depth to basement (m)
21.4	8.49	4.09	32.8	6168	0.48	3.87	4.18	28.9	37.40
18.1	41.10	8.37	7691.0		0.91	0.72	19.70		21.40
50.5	4.49	18.00	99.6	5576	0.52	0.55	4.46	66.0	71.50
36.7	8.48	141.80	3783.0		0.53	3.81	60.97		65.32
8.9	2.90	3.80	678.0		0.78	2.50	4.20		7.50
14	1.70	4.70	15.0	1430	0.46	0.55	2.30	8.1	11.00
26	4.30	301.00	-		0.57	6.50	-		7.10
14	5.80	18.00	285.0		0.89	2.70	1.90		5.50
31.9	14.80	107.00	1216.0	6.6	1.07	1.22	18.80	17.3	38.50

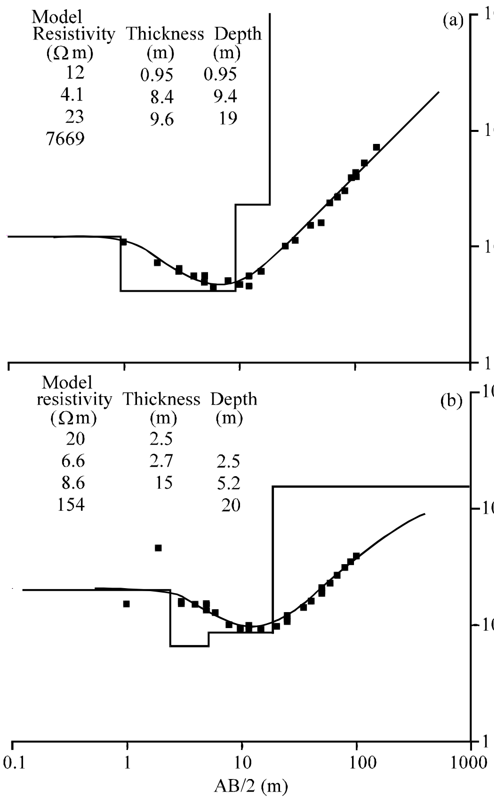

Fig. 2: Field curve and the layered resistivity model of VES 1 and 2 at Pachipenta Mandal

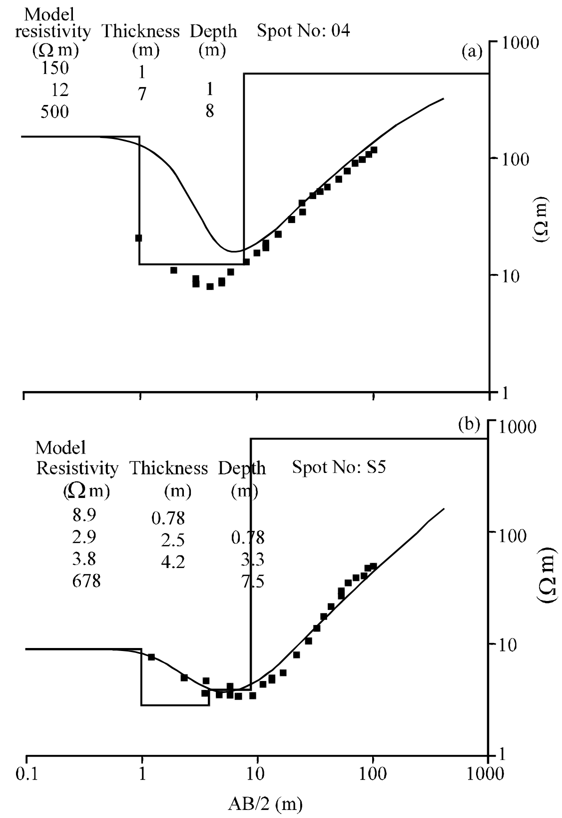

Fig. 3: Field curve and the layered resistivity model of VES 4 and 6 at Pachipenta Mandal

types, A and H type curves indicate the presence of three layers followed by combination of curves (AK, HA, KH, QH) indicating the four layer sub-surface medium. These curves were interpreted using the partial curve matching technique using two and three layer master curves (Rijkwaterstata, 1966; Orellana and Mooney, 1966) and corresponding auxiliary curves to obtain the resistivity and thickness of each of the layers delineated. The results of the 09 VES points are shown in Table 1. The simulated of results of the 09 VES points reveal the presence of 2-4 geoelectric layers. These layers are grouped as: topsoil (clayey, sandy or lateritic), weathered basement (clays/sandy clays), slightly weathered/fractured basement (clayey sand) and fresh bedrock. The resistivity of the topsoil varies from 8.9-31 Ωm while the thickness varies from 0.47-2.5 m. The resistivity and the thickness of the weathered Basement range between 15 and 7669 Ωm and 11-8.1 m, respectively (Fig. 2-4). The resistivivity of the fresh bed rock is in the range of 173 Ωm and above. The results further differentiate 3 basic resistivity zones: very low resistivity zone (15-69 Ωm), very high resistivity zone (294-1543 Ωm) and the zone of intermediate resistivity (89-173 Ωm). The three zones correspond to;

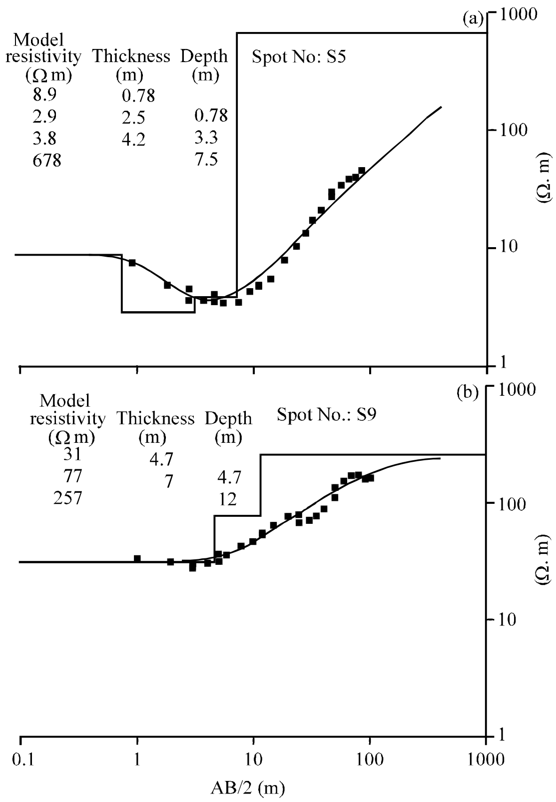

Fig. 4: Field curve and the layered resistivity model of VES 4 and 6 at Pachipenta Mandal

highly weathered kasement, fresh bed rock and slightly weathered/fractured basement, respectively. The aquifer in the study area is therefore defined by the highly weathered and the slightly weathered/fractured zones which are in agreement with Ariyo (2007)'s observation that common aquifers in typical basement Complex are composed of weathered and fractured basement. The variation recorded in the resistivity and thickness of the aquiferous materials is due to the different rates at which different rocks respond to weathering from one location to another.

CONCLUSION

The results of geoelectric investigation carried out over hard rock environment, Vertical Electrical Sounding (VES) have proved to be very reliable for underground water studies and therefore the method can excellently be used for shallow and deep underground water geophysical resistivity investigation. The method of investigation adopted by this study has helped in the identification of the aquiferous units and has provided an understanding of aquifer dimensions, especially the thickness of the weathered mantle, the depth to bed rock and fractured zones which are required for locating points with high potentials for groundwater occurrence. The results clearly show that the downstream part of the study area (Southwest) is the most preferable and favorable location for drilling and for further detailed studies. VES 1 and 5 sites show higher potentiality of the groundwater occurrence. Hence, they are strongly recommended locations for drilling.

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