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Hydrogeophysics and Remote Sensing for the Design of Hydrogeological Conceptual Models in Upper Gadilam River Basin Tamil Nadu, India

KEYWORDS: Hydrogeophysics, hydrostratigraphic layers, groundwater exploration, hard rock, Upper Gadilam River Basin, Vertical Electrical Sounding, Remote sensing and GIS

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ABSTRACT *A geoelectrical resistivity survey has been carried out in the Upper Gadilam river basin in Vizhupuram district of Tamil Nadu. With the purpose of delineating the geologic setting and its impact on the groundwater occurrence. The study involved measuring Vertical Electrical Sounding (VES) at twenty-Five locations using the Schlumberger Array. The results showed that the geoelectrical succession in the study area consists of four geoelectric layers which were grouped into three main zones. The first zone consists of four geoelectric layers corresponding to the dry upper surface layers. The second one is composed of four geoelectric layers that constitute the Eocene weathered zone of the study area. The third zone is consists of three and fourth geoelectric layers and corresponds to Pleistocene water bearing zone the study area. In line with a general conceptual model of hard rock aquifers, we identified two main hydrostratigraphic layers: a saprolite layer and a fissured layer. Both layers were intersected and drained by fault zones that control the hydrogeology of the catchment. The spatial discontinuities of the saprolite layer were well defined by RS techniques while subsurface geometry and aquifer parameters. By using conventional GIS method, the spatial distribution maps for different layer thicknesses were prepared. The geoelectrical approach was successfully applied in the study area and can be therefore easily adopted for similar environments. The area was found to be affected by a group of normal faults. The results showed, also, that the lithological changes and thickness of the saturated zone have their effect on the groundwater potentiality in the study area. Moreover, the detected faults contribute to seepage of runoff water to recharge in to the water bearing zone and control the flow.*

INTRODUCTION

Although groundwater resources throughout hard rock aquifers are generally limited throughout term of productivity, they are strategically ticks in many regions of the world because they constitute a great unique source water supply regarding population as well as agriculture. The Hard rock aquifers are characterized by high heterogeneity,which leads to difficulties in groundwater prospecting, boreholes implementation and water resources management. An overall layout of the general conceptual model of hard rock aquifers, both from horizontal extent and depth-wise structure, was described by e.g. Lloyd (1999). Its description includes from top to bottom: GIS has emerged as a powerful technology for instruction, for research, and building the stature of programs (Openshaw 1991; Longley 2000; Sui and Morrill 2004). GIS is an important technology for geologists (Baker and Steven 2000). Groundwater is the largest available source of fresh water. It has become crucial not only to find out groundwater potential zones, but also to monitor and conserve this important resource (Rokade et al., 2004). GIS Overlay analysis is highly helpful in locating the groundwater potential zones (Rokade et al., 2007). Schlumberger resistivity method is the most suitable method for groundwater investigations in hard rock area compared to other geophysical methods. Delineation of fracture zones in low permeability hard rock area is still a very challenging task. The VES sounding results of water bearing zones also fall in this favorable zone. Venkateswaran.S and P. Jayapal (2013

The resistivity of different layers and the corresponding thickness are reproduced by a number of inversions until the model parameters of all the VES curves are totally resolved with the fitting error. Venkateswaran.S and Ayyndurai.R (2014)

Geophysical surveys for groundwater exploration in hard rock areas have been attempted by many authors Bernard and Valla, 1991, Ronning et al., 1995, Kaikkonen and Sharma, 1997, Krishnamurthy et al., 2003, Sharma et.al., 2005, Zohdy, 1974, McNeill, 1990.

STUDY AREA

The upper Gadilam River basin is the most important agricultural production area. The fast growing population and increasing urbanization, consequently increasing water demand in the cities and industries. The study area covered 823.40 sq. km. The upper Gadilam river basin is in the Vizhupuram district of Tamil Nadu. Gadilam river basin originates from MayanurGarudan spring of garden rock and traverses via Pasarhill and Damal village before reaching the sedimentary contact near Thirunavalur. SeshaNadi is an ephemeral stream which is found almost to be dry throughout the year, excepting for surface water flow for a few days in a year during rainy season. Hard rock area falls under semi-arid climatic conditions with numerous surface water tanks and lakes with unseasonable, erratic and almost failure in monsoon. The study area lies between North Latitudes 11°40′ to 11° 58′ N and Longitudes 78° 58′ to 79° 26′ 35″ E. The drainage pattern in the area is dendritic to sub dendritic and at the tor complex as trellis type. National Highway (NH-45) passes in the eastern part of the study area in the NE-SW profile. The study area is characterized by gently undulating topography with low relief hills. (Fig.1)

GEOLOGICAL SETTING

The upper Gadilam river basin is characterized by different geological formations, reflecting the various geological eras. The study area Major portion of the hard rock area is covered by granites and granitoid gneisses. The granites, which comprises of both grey and white granites are of Ar-

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chaean age. NE-SW trending major fault found along hard rock with sedimentary contact. Based on the mineral composition granites can be classified as alkali-feldspar granites and Biotite granitic gneisses. Fig.2. At places these are out cropped while at other places there are underlain by weathered formation as evinced from the lithology of wells in the area.

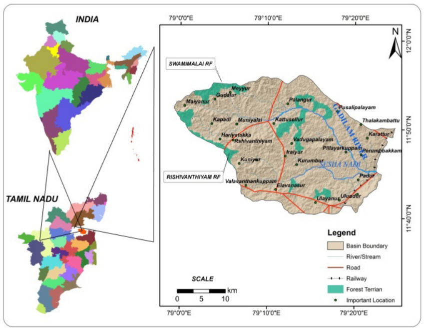

Figure 1: Study Area Map

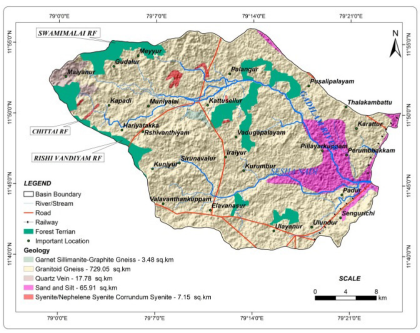

Figure 2: Geology Map

METHODOLOGY

The study area base map was prepared from toposheets and registration in Geographical Information System (GIS) environment with a 58 M/1,2,5, and58/M 6, of 1:50,000 scale. Schlumberger Vertical Electrical Soundings (VES) survey was carried out at 25 locations (Fig. 1), with the maximum electrode spacing of 200 m. The current electrode (AB/2) spacing varied from 1 to 200 m and the potential electrode (MN/2) spacing varied from 0.5 to 20 m. Each datum was plotted in the field to check the quality and to avoid mistakes. The field data was interpreted by curve-matching techniques. For this work, the computer software IPI2WIN was also used. The degree of uncertainty of the computed model parameters and the goodness of fit in the curve fitting algorithm are expressed in terms of curve fitting error (less than 5). The resistivity of different layers and the corresponding thickness are reproduced by a number of inversions until the model parameters of all the VES curves are totally resolved with the fitting error. These results are taken into GIS Platform; their attributes are added and analyzed in Arc GIS version 9.3.1 software. Spatial analysis tools were used for the preparation of interpolation map.

RESULTS AND DISCUSSION

VERTICAL ELECTRICAL SOUNDINGS

A total of 25 VES were carried out to study the groundwater conditions in the study area. The data obtained from the field were processed by using the one-dimensional inversion programme IPI2WIN Software. The obtained layer parameters viz. resistivity and thickness are shown in Table 1, and these results are correlated with the nearby known

TABLE-1
GEOPHYSICAL SURVEY INTERPRETATION RESULTS

S.NO	Geophysical Survey Locations	Resistivity Ohm-m /Thickness m and Aquifer				Curve Type
		h_1&ρ_1	h_2&ρ_2	h_3&ρ_3	h_4&ρ_4	
1	Rishivanthiyam	0.56/2.36	0.76/0.68	0.49/2.85	15.10.35	HK
2	Hariyattaka	0.5/0.71	0.21/16.5	1.69/0.83	2.63/2.63	KH
3	Karattur	0.53/0.1	0.01/511	0.43/2.01	0.47/0.38	KQ
4	Thalakkampattu	0.5/0.09	0.08/20.9	2.67/85	0.38/4.96	AA
5	Pillayarkuppam	2.24/6.1	3.35/26.6	2.14/0.16	10/6.06	KH
6	Perumpakkam	0.5/4.72	0.01/5376	0.65/54.3	1.85/1.55	KQ
7	Ulundur	0.5/0.94	4.58/13.2	0.41/82.5	0.68/91.9	AA
8	Padur	1.59/0.9	0.01/430	0.48/18.9	2.08/0.13	KQ
9	Sengurichi	0.5/5.05	0.18/4152	0.78/0.63	4.75/68.1	KH
10	Olaiyanur	1.27/10.4	1.16/491	1.03/0.01	6.96/19.2	KH
11	Elavanasur	0.66/0.97	0.42/0.23	0.13/82	1.01/1.91	HK
12	Layur	1.32/0.3	0.01/0.02	1.17/2.8	0.04/0.05	HK
13	Meyyur	0.65/0.11	0.01/3.53	0.01/25.2	1.71/104	KH
14	Maiyanur	0.5/1.71	0.08/0.01	0.38/162	9.42/0.43	HK
15	Gudalur	0.51/1.81	0.06/1.37	1.54/1.89	2.45/18.9	HA
16	Kabadi	0.5/0.51	0.01/22.6	0.24/0.14	0.33/0.13	KQ
17	Muniyalai	0.5/1.17	0.01/0.05	0.16/6.43	0.59/104	HA
18	Kuniyur	0.5/0.55	0.23/0.07	0.5/1.12	0.27/7.57	HA
19	Valavanthankuppam	0.5/1.45	0.03/0.02	0.27/4.16	1.73/104	HA
20	Anganur	0.5/0.26	0.05/0.05	0.18/14.7	0.34/1.42	AK
21	Kurumbur	0.62/0.08	0.01/0.09	0.01/1.58	0.35/98.5	AA
22	Vadugapalayam	0.5/1.67	0.23/0.03	0.06/0.6	0.18/6.17	HA
23	Sirunavalur	0.5/0.08	0.02/0.01	0.2/0.02	1.14/30	HA
24	Kattuselur	0.56/0.28	0.01/0.09	0.41/15.6	1.05/0.06	HK
25	palangur	0.5/1.09	0.01/653	0.31/29.2	5.9/114	KH

Thicknesses of the geoelectric layers; h_1, h_2, h_3 and h_4, Resistivity's of the geoelectric layers ρ1, ρ2, ρ3 and ρ4

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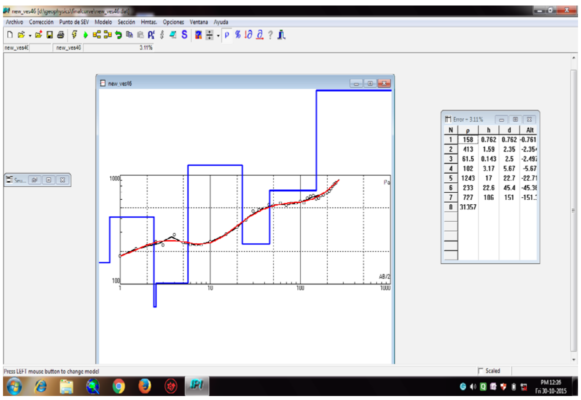
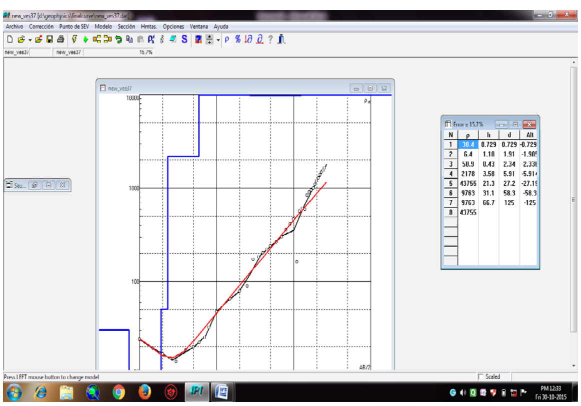
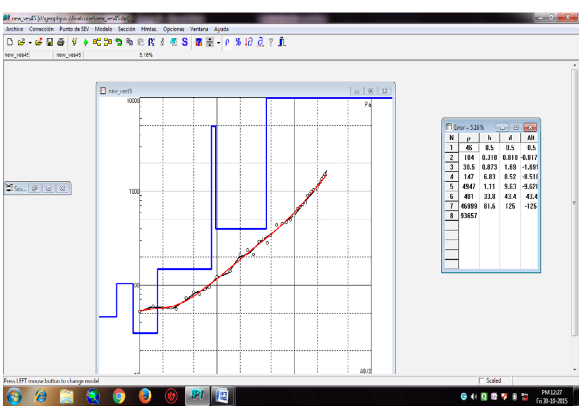
lithlog data to obtain better results. Some of the selected VES curves along with the layer parameters are given in Fig. 3. Three to five geoelectric layers were interpreted from the observed VES data.

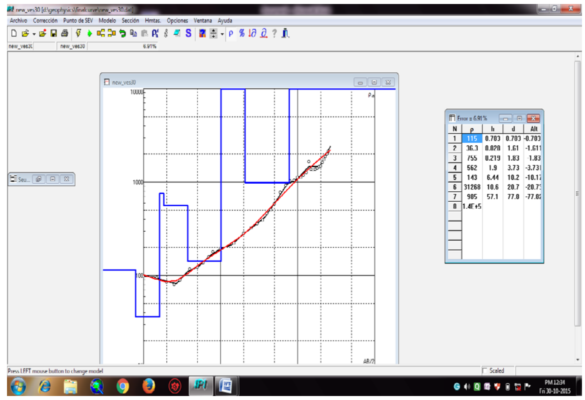
GROUNDWATER POTENTIAL ZONES

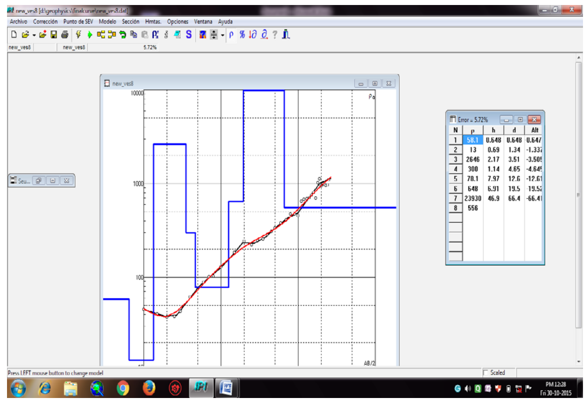
Various thematic layers have been generated and overlay analyses were carried out in GIS, platform among the 125 combinations the best five combinations will be identified as best groundwater potential zones with field validation. The five combinations have been ranked as 1.The Very High thickness and low resistivity with granitoid gneisses rock combination as a very good with an aerial extent of 46.07.sq.km. 2. Low thickness and low resistivity granitoid gneissic rock, sand and silt area combination as a good zone fall inthe175.68 sq.km. 3. Medium thickness and Medium resistivity

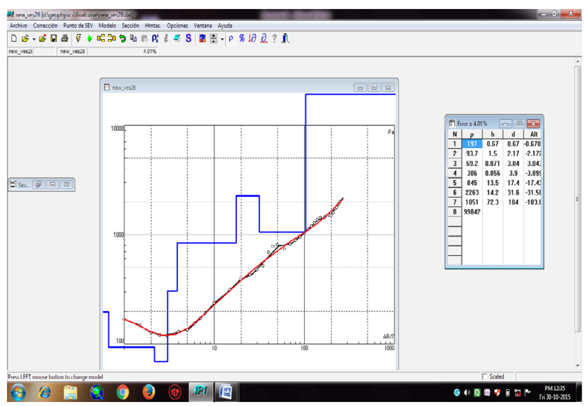


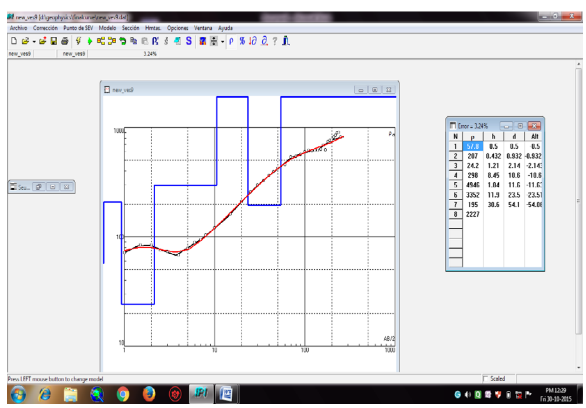












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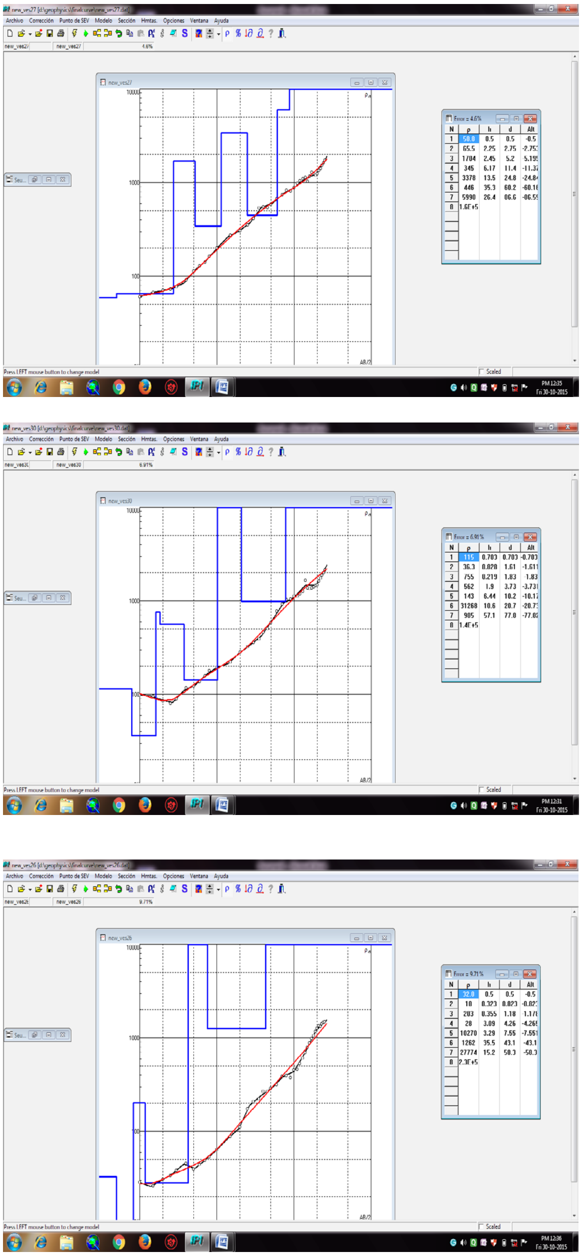

Figure 3: Selected VES Curves

granitoid gneisses rock, granites, sand as a moderate zone cover an area of 529.14.sq.km. 4. High resistivity and medium thickness granitoid gneisses rock, combination as a poor zone fall in the 46.50 sq.km. 5. Very poor potential zone fall in the high resistivity and high thickness with a geology combination of quartz veins and cover in an area of about 25.08 sq.km are shown in Fig.4

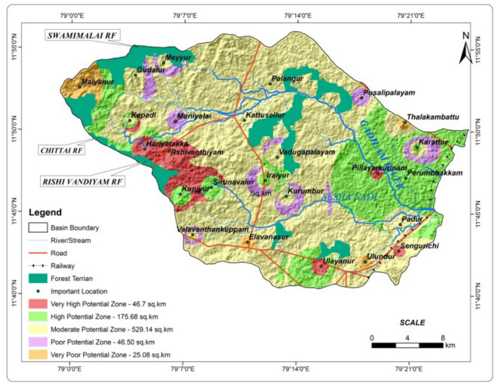

Figure 4:Groundwater Potential Zone Map

CONCLUSION

In this investigation electrical resistivity survey were carried out at 25 locations using the Schlumberger electrode array with a view to understand the subsurface geologic settings that could guide through the successful exploration of groundwater. Analysis of the interpreted results revealed the nature and composition of the subsurface lithologic units. This includes topsoil (Alfisols, Entisols and Inceptisols,) weathered zone/fracture zone, the dominant aquifer units. The aquifer's resistivity and thickness obtained were used to generate aquifer resistivity and overlying thickness maps for the area. The zones with thick overlying corresponding to basement depression have been identified as good groundwater potential zones that characterized most of the study area. Spatially interpreted results gives Topsoil thickness as follows: good category of 37.04%, weathered zone thickness of good category 27.75%, first fracture zone thickness of good category 34.12% and second fracture zone thickness of good category 37.27%. Thus, based on the resistivity surveys carried out, the groundwater prospective zones for the studied area had been identified with weathered/fractured basement as potential layers for good groundwater development. This basin needs to be constructed with artificial recharge structures to augment groundwater for sustainable groundwater management, for future.

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