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EVALUATION AND MAPPING OF THE GROUNDWATER POTENTIAL ZONES BY USING ELECTRIC RESISTIVITY SURVEY OF DINDI RESERVOIR CATCHMENT AREA GRANITIC TERRAIN OF MAHBUBNAGER AND NALGONDA DISTRICTS OF TELANGANA STATE, INDIA

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ABSTRACT

43 vertical electrical soundings (VES) were carried out at selected locations in the study area in order to infer the potentiality of the groundwater in the subsurface. About 43 VES were carried out using a NGRI make D.C Resistivity meter wherein the current and potential readings are displayed for calculating the resistance. The interpretation of the resistivity data shows that the resistivity of the top layer generally varies from 10.56 Ohm-m to 30.0 Ohm-m. The thickness of the top layer extends up to 2 meters depth, followed by weathered zone varying from 30 Ohm-m to 50 Ohm-m up to 40 meters depth; resistivity of highly fractured zone varies from 60 Ohm-120 Ohm-m and was identified between 60 to 80 meters followed by hard granite. The pseudo cross sectional profiles revealed that at VES 39 aquifer can be encounter at the depth of 51.8 meters which shows the low resistivity values, at VES 26, the depth of the aquifer might be 23.7 meter, at VES 23, VES2, VES 18, VES7 groundwater potential zones could be encounter at 26.8 meters depth. At VES3, VES5 and VES 42 secondary porosity is occurred at 19.3 meters and 13.3 meters depth respectively. Weather to highly weathered rock at shallow depths i.e. up to 10 meters depth followed by hard granitic formation available at VES numbers via, VES32, VES40, VES37, VES6, VES15, VES20, VES29 and VES14. Hard mantle with high resistivity values were observed at VES31, VES11 and VES 28.

KEYWORDS

Electric resistivity survey, Granitic survey, Dindi reservoir, Schlumberger array

Introduction

Integrated geophysical tools, especially resistivity, electromagnetic and, more recently, nuclear magnetic resonance methods, are commonly used in groundwater exploration, mainly due to the close relationship between electrical conductivity and some hydrological parameters [1]. In hard-rock areas, especially granitic terrain, even within small areas the nature and extent of weathering may vary considerably, depending mostly on the presence of fractures at depth and geomorphological features at the surface [2]. Using Vertical Electrical Sounding (VES) depth and thickness of various subsurface layers and their water yielding capabilities can be inferred [3, 4]. Two popular traditional DC electric techniques use to image the shallow subsurface are the vertical electric sounding (VES) and the electric profiling [5, 6, 7]. The purpose of electrical surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface. From these measurements, the true resistivity of the subsurface can be estimated. The ground resistivity is related to various geological parameters such as the mineral and fluid content, porosity and degree of water saturation in the rock [8, 9, 10].

Location

Geographically the study area is located longitude between 78°19'31.2"E and 78°54'35.8"E to latitude between 16°50'40.6"N and 16°11'24.9"N; covering survey of India toposheet numbers 56L/5, 56L/6, 56L/7, 56L/10, 56L/11, 56L/14, 56L/15. Figure 1 shows the location map of study area. The study area lies at the north and south of Dindi reservoir covering part of Dindi River catchment which is tributary of Krishna River. Geographical area of the study area is 14, 840 sq.m. Administratively it could be found in Mahabubnagar district of Telangana state, India which is about 115 km by the road from the Hyderabad to Kalvakurthy at Dindi Village, boarder of Nalgonda district on east.

Geology

Large portions of the study area consist of Peninsular Gneissic Complex of granite, gneisses and migmatites of Archean Era laid under most geological formations. Table 1 shows the geological succession of the study area. There are three types of hard and massive intrusives present above the granitic gneisses including closepet granites, dolomite basic intrusives and quartz reef/vein of palaeo to Mesoprotorozoic era. Pinkish to white closepet granites are the oldest formations occurring north of the area; above this, dolerite dykes and with quartzite veins occurs. There is an unconformity called Eparchean unconformity formed above the quartz vein followed by whitish to brownish massive/flaggy quartzite with shale of Srisailam quartzite of Cuddapah super group of Mesoprotorozoic era formed along south and east of the study area.

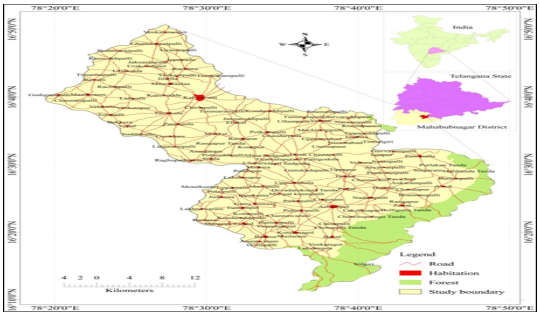


Figure : Location map of the study area

Table 1: Geological succession of the study area

Age	Formation	Geology	Nature of the rock Characteristics
Meso protorozoic	Cuddapah Super Group	Srisailam Quartzite with shale	Whitish to brownish massive/ flaggy
Eparchaean unconformity			
Palaeo-to-Mesoprotorozoic	Intrusives	Quartz reef/vein	Hard and massive
		Basic intrusive (Dolerite)	Hard and massive
		Closepet granite	Pinkish to whitish, hard massive
Archaean	Peninsular gneissic complex	Granite, gneisses and migmatites	Hard massive

Methodology

Basic principle - Resistivity survey

The resistivity method is based on measuring the potentials between one electrode pair while transmitting DC between another electrode pair. The depth of penetration is proportional to the separation between the electrodes, in homogeneous ground, and varying the electrode separation provides information about the stratification of the ground. The measured quantity is called apparent resistivity. Interpreting the

resistivity data consists of two steps: a physical interpretation of the measured data, resulting in a physical model, and a geological interpretation of the resulting physical parameters [11]. Resistivity determinations are usually made by injecting a specified amount of electric current into the ground through a pair of current electrodes and then, with the aid of a pair of potential electrodes, measure the potential difference between any two points at the surface caused by the flow of the electric current in the subsurface. From the measured current (I) and the voltage (V) values, the ensuing resistivity is determined [12].

Electrical properties of geological formation

The electric resistivity of a rock formation limits the amount of current passing through the formation when an electric potential is applied. It may be defined as the resistance in ohms between opposite faces of a unit cube of the material. If a material of resistance "R" which has units of has resistivity are ohm-m^2/m, or simply ohm-m can be expressed as

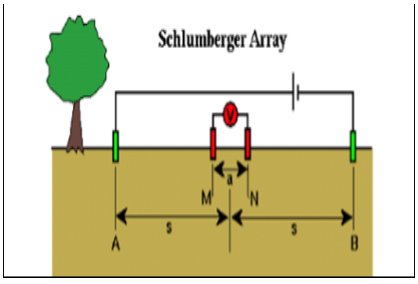


Figure 2: Electrode arrangement of Schlumberger array configuration

Survey and data interpretation:

A total of 43 vertical electrical soundings (VES) were carried out at selected locations in the study area located as shown in figure 3, in order to infer the subsurface conditions along the Profiles. The entire VES were carried out with a maximum current electrode separation (AB/2) as started with 1.5 meters to maximum depth of 100 to 180 m covering entire study area. The induced current passes through progressively deeper layers at greater electrode spacing. Apparent resistivity values calculated from measured potential differences can be interpreted in terms of overburden thickness, water table depth, and the depths and thicknesses of subsurface strata. There are four basic types of the sounding curves depending upon the resistivity distribution with depth.

If $_1$, $_2$ and $_3$ are the resistivity of the three subsurface layers beginning with $_1$ at the top, then $_1 > _2 < _3$ is defined as H-type, $_1 < _2 < _3$ as A-type, $_1 < _2 > _3$ as K-type and $_1 > _2 > _3$ as Q-type. In multilayer earth, a number of these combinations can exist. The interpretation of the field data in the form of a sounding curve, a Bi-logarithmic plot of apparent resistivity () versus half current electrode separation (in case of Schlumberger soundings) is conventionally done by matching it with a theoretically computed curve for assumed layer parameters, resistivity and thickness. In spite of the availability of a large number of theoretical curves, it is often difficult to find a right set of curves to fit a variety of situations present in nature. It is, therefore, desirable that one should be able to compute a sounding curve that best fits the field situation. Employment of an algorithm, which directly yields the layer parameter, would be a better choice.

Results and interpretation

Geophysical data interpretation: The VES data was analyzed initially with the curve matching using various master curve manuals (Stafenesco 1930; Compagnie Generale de Geophysique 1963; Orellene and Mooney 1966; Rijzkswaterstatt 1969) for obtaining the initial models. Iterative inversion algorithms developed by Gupta Sarma, (1982), Zohdy (1974) are available using different inversion codes. The sounding curves were interpreted using the software WINSEV (UGSS) a program based on the steepest decent method. Table 2 provide the interpreted layer parameters such as thickness (h) of formation and electrical resistivity (r) and depth (H) at locations of 43 VES. The curves shows maximum of five layers was identified. The maximum depth of information of 240 m is obtained at VES 10. Majority of the sounding curves are found as 'H&A' type (increasing the electrical resistivity with depth) as it indicates the typical zones of the study area.

The apparent resistivity data obtained from the VES survey were presented as depth sounding curves by plotting the apparent resistivity along the ordinate axis and the half current electrode spacing (AB/2) along the abscissa on bi-logarithm paper (figure 4). The resistivity depth sounding curves were classified based on layer resistivity combinations. In the study area the resistivity of the top layer like top soil generally varies from 10.56 Ohm-m to 30.0 Ohm-m. The thickness of the top layer extended up to 2 meters depth, followed by weathered zone varies from 30 Ohm-m to 50 Ohm-m up to 40 meters depth which is effectively useful for the recharge of groundwater; resistivity of highly fractures or groundwater zone like present hard rock terrain varies from 60 Ohm-120 Ohm-m identified between 60 to 80 meters followed by hard granitic formation which is principle geological formation of the area.

Geological profile:

IPI2WIN software is used for interpretation of VES soundings and to construct the pseudo-cross section and resistivity cross section projecting along a particular straight line to understand the geological profile of the earth. It is designed for automated semi-automated interpreting of vertical electric sounding and /or induced polarisation data obtained with any of variety of the most common arrays used in the electrical prospecting [19, 20, 21, 22, 23]. Seven geological profiles were prepared covering entire study area projecting all directions. The profile lines were named as AA1, BB1, CC1, DD1, EE1, FF1 and GG1 as shown in figure 3.

In each profile representing three VES points falling on straight line such as AA1 has VES31, VES32 and VES39; BB1 has VES40, VES37 and VES26; CC1 has VES23, VES37 and VES06; DD1 has VES05, VES03 and VES11; EE1 has VES28, VES02 and VES15; FF1 has VES20, VES18 and VES07; and GG1 has VES29, VES42 and VES14 as shown in figure 3. In the profile the model parameters for the VES point such as resistivity (ρ), the thickness (h), depth (d) and altitude of the VES are presented in table 3. The pseudo cross sectional profiles revealed that at VES 39 aquifer can be encounter at the depth of 51.8 meters which shows the low resistivity values, at VES 26, the depth of the aquifer might be 23.7 meter, at VES 23, VES2, VES 18, VES7 groundwater potential zones could be encounter at 26.8 meters depth. At VES3, VES5 and VES 42 secondary porosity is occurred at 19.3 meters and 13.3 meters depth respectively. Weather to highly weathered rock at shallow depths i.e. up to 10 meters depth followed by hard granitic formation available at VES numbers via, VES32, VES40, VES37, VES6, VES15, VES20, VES29 and VES14. Hard mantle with high resistivity values were observed at VES31, VES11 and VES 28.

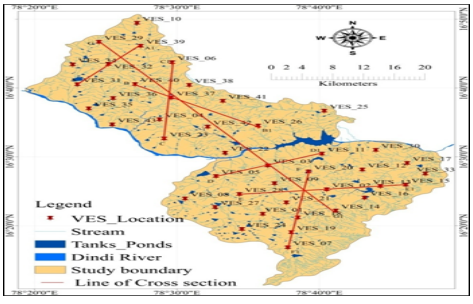
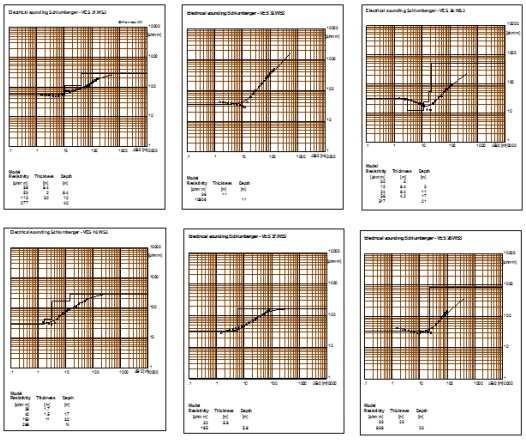


Figure 3: Location map of Vertical Electrical Survey



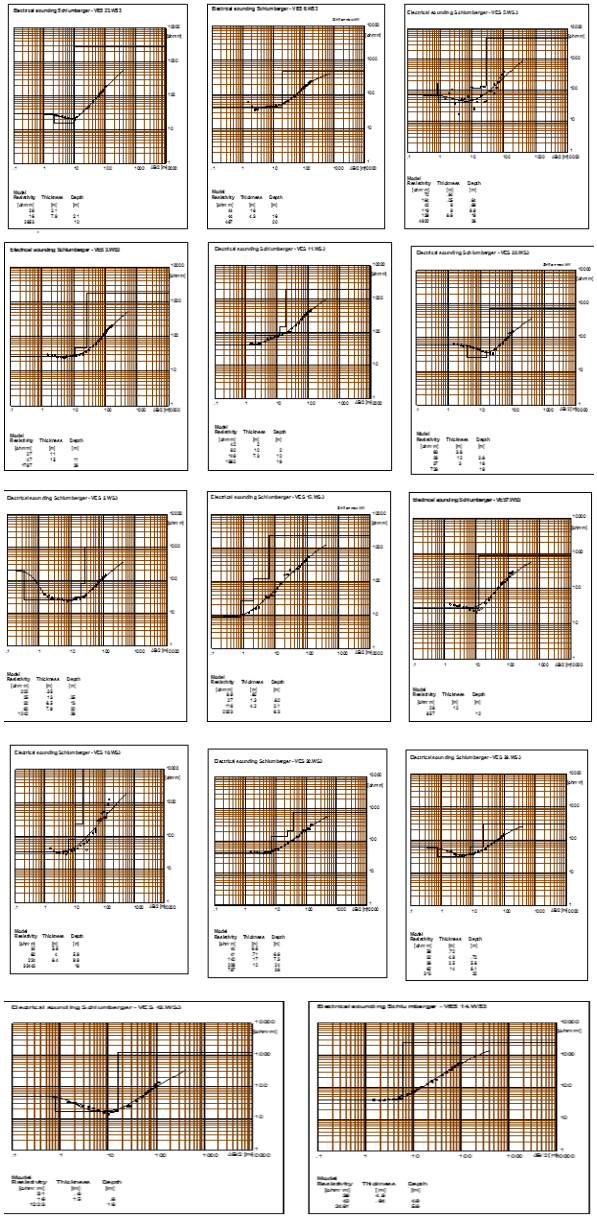
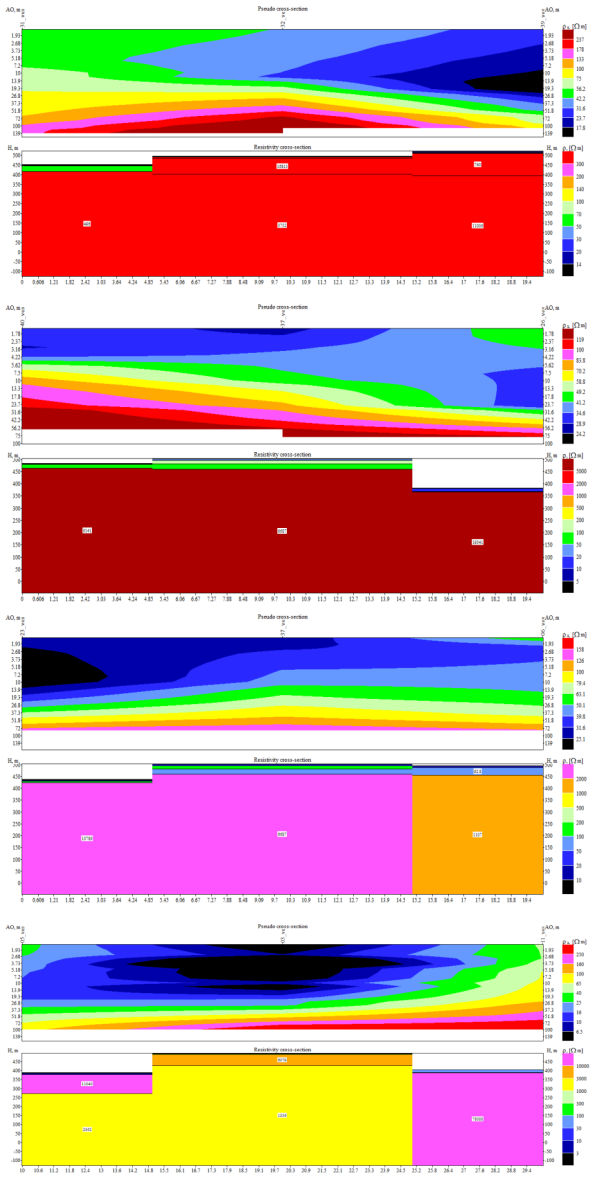
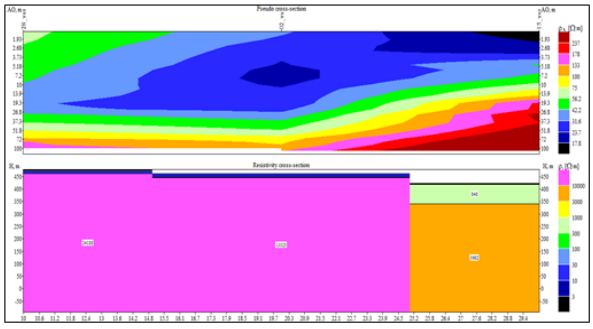


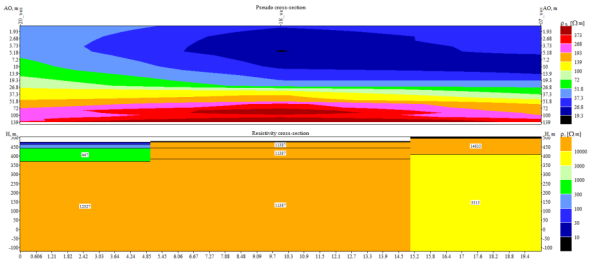
Figure 4: typical sound curves

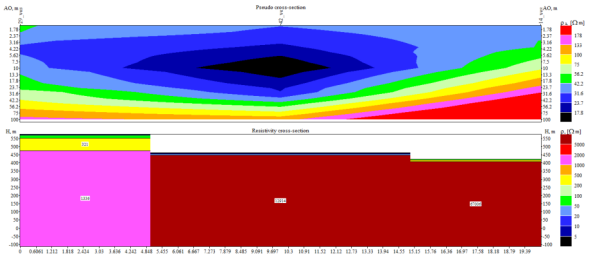
Table 2: Layer thickness and electrical resistivity

Sl. No	VES No	ρ1/ h1	ρ2/ h2	ρ3/ h3	ρ4/ h4	ρ5/ h5	ρ 6/ h6	H (In m)
1	VES 1	38/3.5	28/5.2	66/3.4	148/7.5	466		20
2	VES 2	202/0.35	25/13	32/6.5	82/7.9	1042		28
3	VES 3	27/14	49/7.6	781				22
4	VES 4	36/0.56	37/0.84	14/15	389			16
5	VES 5	115/0.56	164/.05	42/9	125/9.5	208/13	3915	32
6	VES 6	74/0.66	37/6.7	58/11	153/11	422		29
7	VES 7	28/6	31/7.7	1469				14
8	VES 8	38/4.4	46/8.5	79/8.6	131/15	557		37
9	VES 9	69/0.78	26/3.5	24/8.3	339			13
10	VES 10	43/2.4	78/6.8	170/16	1916			25
11	VES 11	25/0.63	74/11	222/14	2389			26
12	VES 12	31/0.77	33/0.21	86/1.5	181/6.4	296/17	1569	26
13	VES 13	36/1.3	38/2.9	98/2.6	271/11	840		18
14	VES 14	38/3.5	94/3.7	279/8	5550			15
15	VES 15	11/1.1	26/1.2	220/4.8	4433			7.1
16	VES 16	51/4.1	109/6	348/13	3158			23
17	VES 17	57/5.3	124/5.9	3439				11
18	VES 18	36/7.3	104/2.6	296/9.7	37427			20
19	VES 19	27/6.4	85/9.8	3081				16
20	VES 20	44/3.4	41/2.6	90/7.8	209/26	813		40
21	VES 21	37/4.2	46/3.8	217/27	7894			35
22	VES 22	40/4.2	23/11	63/4.6	738			20
23	VES 23	24/5.2	20/4.8	87/11	2934			21
24	VES 24	46/1.3	31/2.7	19/9.2	49/6.4	750		19
25	VES 25	86/0.83	156/2.7	153/2.9	207/11	409		17
26	VES 26	59/0.71	29/7	29/10	98/7.3	986		25
27	VES 27	37/2.4	35/1.7	110/2.6	797			6.7
28	VES 28	70/1.7	37/21	498				23
29	VES 29	57/0.82	30/3.5	38/3	52/7.7	94/11	333	26
30	VES 30	26/6.7	21/5.8	73/7.4	1488			19
31	VES 31	52/3	59/2.1	80/23	116/15	312		43
32	VES 32	35/7.1	51/4.6	3081				12
33	VES 33	35/1.8	132/6.4	329/9.1	5722			17
34	VES 34	55/1.2	25/4.9	21/4	89/4.8	1039		15
35	VES 35	37/1.7	22/13	54/6.1	1407			21
36	VES 36	34/1.4	27/0.54	20/5.6	22/3.8	289		11
37	VES 37	28/1.1	39/1.3	48/3.9	71/5.1	109/1	314	24
38	VES 38	37/0.39	40/0.69	31/3	12/16	23/6.9	222	27
39	VES 39	35/0.93	27/2.6	12/8.1	25/5.7	51/5.8	562	24
40	VES 40	28/1.8	36/0.92	145/13	334			16
42	VES 41	11/0.77	23/0.22	156/4.9	197			5.9
42	VES 42	48/0.91	15/5.9	17/8.4	739			15
43	VES 43	82/0.73	102/0.33	109/1.1	136/12	124/21	271	35









Conclusion:

It was observed at pediplain and valley fill areas, the resistivity of earth material has low indicating the availability of groundwater is high in these areas, especially at southern and middle of the study area. Across the study area structural controlling features such as basic intrusives and quartz veins controlling the flow of groundwater resulting the low thickness of the soil and weathered layers in that VES points such as VES31, VES11and VES28.

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