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Application of Electrical Resistivity Method for Assessment of Groundwater Potential in Semi-Arid region with Basalt Landform

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1.0 Abstract

The assessment of groundwater potential should be done, considering the aquifer properties .Hence, to study the layer properties, electrical resistivity method has to be deployed. In the current study, the application of electrical resistivity method for assessment of certain properties of aquifers in hard rock terrain has been discussed. The test is carried out using Schlumberger method with four electrode configuration, at 15 test sites, near to the drainages, covering different litho unit's representatives. Data obtained from the test, was analysed in IPWIN-12 software. The graphs of the test show, 3 to 6 layers presence below ground level. Few curves of H type which is groundwater potential curve and few curves show A type which is hard rock terrain curve. Fractures are found at 40 meters to 50 meters depth and weathered basalt and jointed basalt are found between 15 meters to 25 metres depth below ground level and these are considered as good aquifer systems. Top overlain soil thickness ranges from 3 meters to 5 meters. For the assessment of saturated aquifer thickness, Daroo-Zarrok parameters are used. It is found that, the longitudinal conductance varies from 0.6 per ohm to 4 per ohm. The eastern side and western side of the study region have 3 to 4 per Ohm of longitudinal resistance, which represent fresh groundwater potential in these zones at depth 5 meters to 12 meters. For assessment of aquifer depth and thickness of overlain layers, 2D pseudo-electric cross sections are developed in IPWIN-12 software. The obtained results from electrical resistivity test, were verified with trail boreholes data at 3 locations and it was found to that, the observed stratum types and obtained results of resistivity test are analogues.

Key Words: Aquifer, Daroo-Zarrok Parameter, Groundwater Potential curve, Electrical Resitivity test, electrode configuration, Schlumberger method, IPWIN-12 software

2 Introduction

The assessment of groundwater availability should be done considering the aquifer properties and ground conditions. The assessment is difficult particularly in hard rock terrain such as basalt landform, since here, varied scale of weathered, fractured zones and random distribution of lineament density, with soil type in mixed fine and clay forms, are found. GIS can be used in such conditions, but the underlying aquifer properties assessment cannot be done through this approach. So, to evaluate the actual aquifer properties, groundwater flow direction and saturated aquifer thickness and thickness of overlying layer and types, geophysical methods are useful, since these methods consider the scientific relevance of materials behaviour under different conditions of shocks, heat, electricity etc... Electrical resistivity method is one such geophysical method, which can be used for groundwater exploration work. In the current section, the application of electrical resistivity method has been illustrated for ground water explorations. The IGIS resistivity meter MODEL SSR-MPL1 and its accessories were used in the present study.Schlumberger method is adopted to record the resistivity readings, since; in this method only 2 electrodes shall be moved to note te readings (Masadi Krishnamurthy et al-2021). DZ parameters are used to assess aquifer recharge and transmissivity Pseudo cross sections are developed by combining Vertical Electrical Sounding (VES) curves at different positions, which indicate the saturated thickness of the aquifer and thickness of various layers at the subsurface level. Aquifer mean, it is the layer at the subsurface level that contains free or surplus water and facilitates the water movement at the subsurface level likewise it happens for the flowing surface water bodies.

Robert Egwu Otu Iduma et al (2002) has discussed the application of DZ parameters tools application for assessment of well performance and location. Here, it is described that as the transverse resistance increases, the transmissivity and recharge of the aquifer will increase. Here it is found that, fractured layers were found at 30 meters depth below ground level, with good aquifer deposits. Further, here, the transmissivity increases from south to north direction, which also indicates that, the ground water flow direction is from South West to North East, in the study area (Ethiopia country)

Krishnamurthy Masadi Patel et al (2021), has delineated groundwater potential zones using electrical resistivity method in Kanavihalla Sub watershed, Belagavi district, Karnataka state, India. Here, the values of the resistivity test are also validated by physical observation of trial boreholes data. Here, the authors have found that, at the jointed and weathered basalt, there is good formation of aquifer systems, but may get collapsed during extraction or drilling, so proper protection works are to be provided, and using the data of the pseudo cross sections, the authors suggest the possible ground water potential zone depths, where yield is feasible. Further, the layer thickness of different substratum layers is found by resistivity values.

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Mahad Abdullahi Hussein et.al (2023), has used electrical resistivity test to find groundwater potential zones in villages located in the Galhareri district of the Galgaduud region, central Somalia. Here, ER IS USED to find ground water quality and depth of aquifer location and spatial extent of aquifer. According to the study conducted at coastal belt with sand stone land form and quaternary deposits, the aquifer systems are located at depth of 25 meters to 125 meters below ground level. The saturated thickness of aquifer Ranges from 6 meters to 25 meters.

Babatunde R. Onawola et.al. (2020), has used electrical resistivity test to quantify the aquifer parameters
The data, processed with computer software *IPI2WIN*, indicated three to four geo-electric layers, namely; topsoil, clayey (wet to dry), weathered or fractured basement and fresh basement with resistivity values ranging from 130 to 1469 Ωm, 52.6 to 8552 Ωm, 46.2 to 249 Ωm and 454 to 5022 Ωm, respectively. The depth to aquifer ranges between 6.17 m and 24.9 m and the overburden thickness ranges between 4.1 m and 22.7 m.
Ahamefula U. Utom used electrical resistivity test for carrying out the geo-electric investigation involving vertical electrical sounding was carried in parts of Enugu town, Enugu state, Nigeria. The survey was aimed at extrapolating the result of pumping tests over an area. Using the Dar Zarrouk parameter, a β constant of 0.32 was found to translate resistivity to transmissivity with clay content as the primary factor controlling the hydraulic conductivity. Results of the study show a strong correlation between aquifer transmissivity and longitudinal conductance (R^2 = 0.82).
Central Groundwater Board (CGWB), India, has conducted National Aquifer Mapping in many cities across the nation. As a part of the mapping procedure, electrical resistivity tests were conducted in different location t he sub watershed level sorrounding the cities. According to the report on electrical resistivity test conducted in many places of Chikkodi taluk, the fresh water aquifer zones are located at depth of 25 meters below ground level, in the Basalt terrain. Further, the semi confined aquifers are located at depth more than 50 meters , these are overlain by thick clay to depth of 15 meters below ground.

2.1 **Region of Study**

The region of study is a sub water shed (4D5D4) lies in Ghataprabha sub basin, Belagavi district, and it is surrounded by Raibagh, Hukkeri, Chiccodi, Gokak taluks. The research area's average yearly rainfall is 600 mm. Population of the study region is around 2 lakhs. Sugar cane is the main crop. The sub watershed name is Hirehalla sub water shed with geographical area of 435 square kilometres.
Slope in the region of study varies from 0.5 % near 4^{th} order streams to 15 % at the peripherals. About 70 % of the study area is covered under flat slope between 0. 5% to 3 %.
Geomorphic classes in the region of study indicate that, the majority portion of the region is covered under plateau formations, with traces of pedi plains at the west portion of the region, with canal command portion in the eastern side of the region. Geomorphology plays important role in groundwater recharge and potential, the location of fractured zones and weathered zones is also described by geomorphology.

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Soil types of the region include, fine and clayey soil types near the drainages, 30% of the study region is covered under loamy soil, 20 % region is covered under clayey soil, 35 % region is covered under loamy skeletol soil and 5% is covered under very fine soil

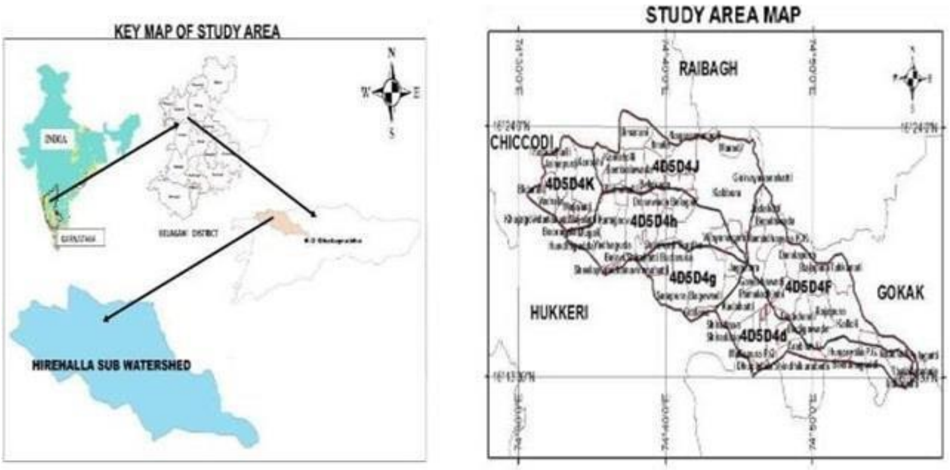

Figure-1-Location Map of Study Area

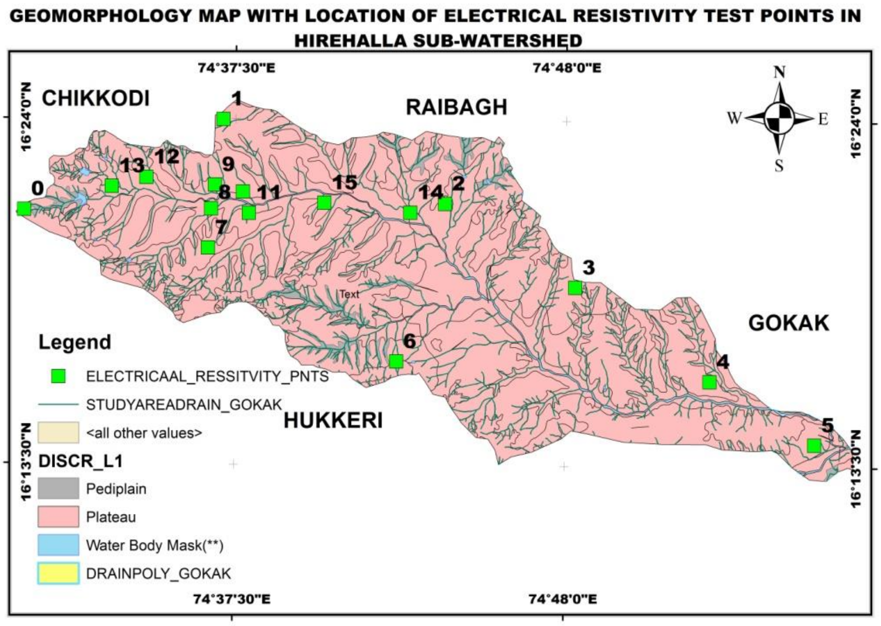

Figure-2-Geomorphology Map of Study Area

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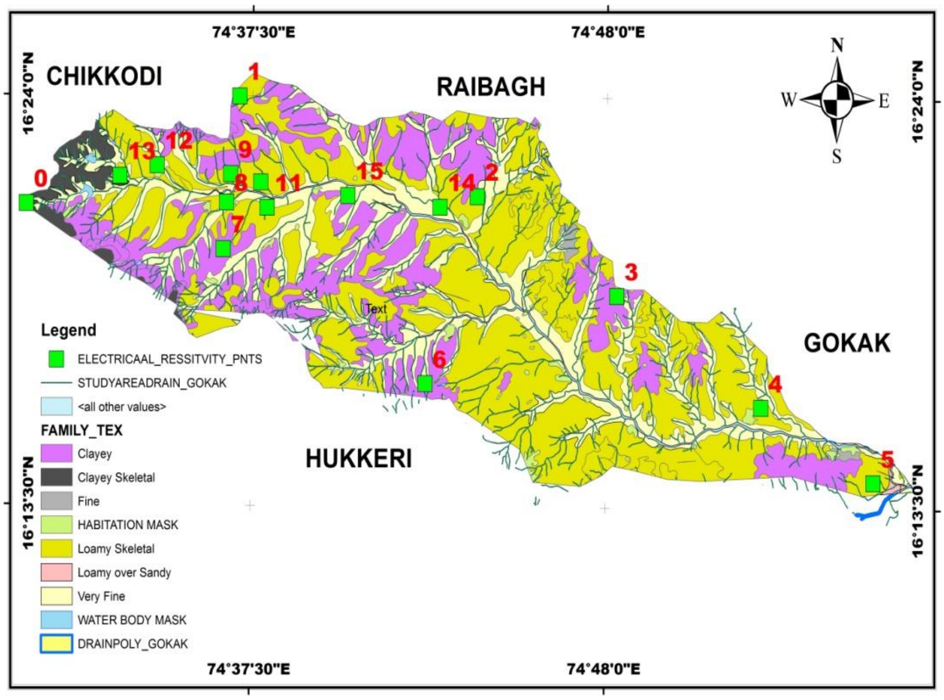
SOIL MAP WITH

LOCATION OF ELECTRICAL RESISTIVITY TEST POINTS IN HIREHHALLA SUBWATERSHED



SLOPE MAP WITH LOCATION OF ELECTRICAL RESISTIVITY TEST POINTS IN HIREHALLA SUB-WATERSHED

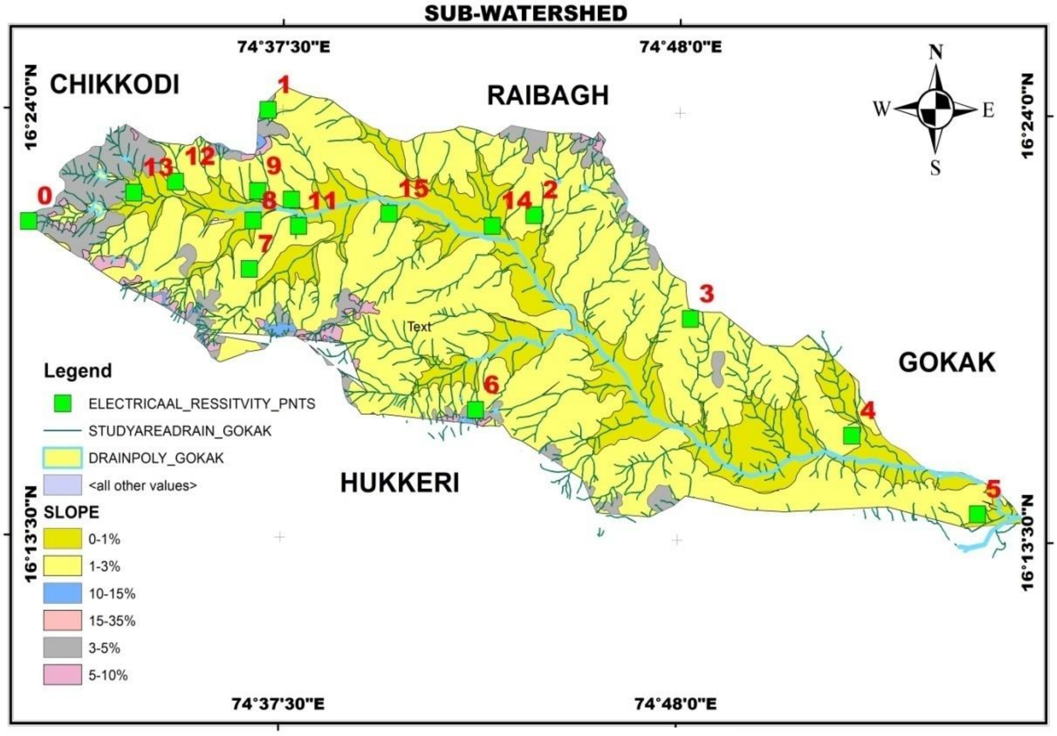


Figure-4- Slope Map of Study Area

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2.2 Objectives:

i. Exploration of groundwater potential and thickness of different layers at the substratum level using electrical resistivity method.

ii. Assessment of Daroo-Zarrok parameters and the applicability of the parameters for the prediction of aquifer transmissivity and recharge potential

3 Methodology:

The main aim of conducting electrical resistivity test, is to find the sub surface resistivity, porosity and degree of water saturation, ie, thickness of saturated aquifer (Vekatesh Gouda et.al) and also, to predict the depth of groundwater table location.

Electrical Resistance (in Ohms) = R = V/I, V→Voltage or electrical potential difference (in volts).

I→ current (Ampere). Here resistance R means, the resistance offered by the material for flow of electric current through it.

Electrical Resistivity (Ohm m^2) = R X Cross sectional Area of the material or section through which current flows, here R refers to the electrical resistance of the material for the current flow (I)

Test Specifications: The IGIS resistivity meter MODEL SSR-MPL1 instrument set and its accessories were used in the present study. The accessories include stainless steel electrode, cables, hammers and tape of 200 meters and rope also is used. The electrodes diameters were 30 mm and height of the electrodes was 0.75 m. 4 number of electrodes was used.

i. Selection of sites near to drainage or water resource, this is done to trace the probable direction of movement of groundwater, and establish the relation between aquifer thickness and distance of the test site from the surface water resource. In the current work, Schlumberger method of electrical resistivity is adopted.

ii. Now, at a particular site to conduct electrical resistivity, Place the electrodes at a distance of AB/2 = 60 meters (maximum, inner electrode spacing) and electrode spacing end to end distance shall be 150 meters. (MN electrodes)

Iii The direct current is passed through MN electrodes and the resistivity offered by each of the substratum layer is recorded by A and B electrodes, at different depths of the substratum layers.

Iv The data recorded in the memory chip of the instrument set, was transferred to the IP-WIN12 software. And VES curves are generated (Vertical Electrical Sounding curves) for each test site.

V By combining VES curves in IPWIN-12 software, the 2-D pseudo-cross sections are generated and by interpretation of the pseudo cross sections, the depth of ground water table, and layer thickness of substratum layers in different directions are determined. From layer thickness, the aquifer saturated thickness is also known (objective-1) . The VES curves are AKQH type and the average RMS error of VES curve is 20 %.

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Vi. Knowing the resistivity values and layer thickness, the transverse unit resistance (T) and longitudinal conductivity (S) will be determined (DZ parameters). Higher S values indicate lower aquifer sustainability and lower percolation of runoff to the aquifer, thus, low ground water potential (**Vekatesh Gouda et.al-2021). Higher T values indicate higher transmissivity values, thus indicate higher ground water potential.**

Vii The T and S values are calculated for every test site and then raster interpolation is carried out (Natural neighbors method) , in ARC GIS-10.8 software, to obtain , spatial distribution of T and S throughout the entire study region. Using these maps, the groundwater potential zones are demarcated, using the principle property of S and T, where, lower S values in the map are identified which indicates that, these are the regions with good groundwater potential and regions with higher T value indicate higher GWP zones along with good transmissivity.

4 Results

4.1 VES CURVES

The average RMS error of the Vertical Electrical Soundings (VES) is 20 %. The VES readings are taken nearer to the drainages. In each site, where, VES readings are taken, the top layer is loamy, clayey or fine soil to a depth 3 meters followed by loose basalt, jointed basalt, weathered basalt and finally, fractured zones, are expected to be located. The blue lines indicate resistivity variation WRT depth (AB/2). The VES curves are H type, HAQ type, AQ type curves. X axis of the VES curve indicate, depth, Y axis indicate resistivity.

For VES-1 curve, initially, as the depth increases till 30 meters, there is drop in resistivity value, but after 30 meters until 90 meters; there is increase in resistivity vales from 80 ohm-m to 980 ohm-m. This is due to the presence of soil to depth of 5 meters below ground level, then, at a depth 10 meters, there is presence of jointed basalt and weathered basalt, which is indicated by low resistivity values. This is the indication of unconfined aquifer presence, which is extended till 30 meters depth BGL and further, from 30 meters, to 90 meters depth, there is presence of different types of basalt layers in weathered and jointed form, followed by compact basalt. Hence, here, the GWT is located at shallow depth.

VES-2, curve, the electrical resistivity value increases, above 100 ohm-m, WRT depth until 50 meters below ground level (BGL), but after, 50 meters, there is drop in resistivity values, this indicates the aquifer location in the form of jointed and weathered basalt. This indicates the presence of aquifer system at depth BGL of 50 meters. Here, bore wells can be drilled at a depth more than 50 meters. The entire depth of the aquifer consists of basalt formation.

Same kind of resistivity variation WRT depth is observed for VES-3, VES-4, VES-5 . At VES-6, as the depth increase, the resistivity also increases, this indicates that, the aquifer system are almost, absent at this location. Hence, there is low groundwater potential in this zone. Same kind of trend is observed at VES-7 and VES-8 locations. At VES-9, 10, 11, the aquifer system is extended to a depth of 30 meters, from ground level. This is due to the presence of the test sites near to the 1st order drains. Here, the aquifer systems are deemed to be sustainable, since the aquifers are located at shallow depth.

VES Readings at Different Locations in the Study region.

All the test locations are within 200 meters from drain and nearby open wells.

Table-1- Vertical Electrical Soundings (VES) Readings for Test Sites

VES NO	VES Readings and Layer Thickness												Total Depth
	H1	**$\dot{\rho}1$**	**H2**	**$\dot{\rho}2$**	**H3**	**$\dot{\rho}3$**	**H4**	**$\dot{\rho}4$**	**H5**	**$\dot{\rho}5$**	**H6**	**$\dot{\rho}6$**	
	m	**Ωm**	**m**	**Ωm**	**m**	**Ωm**	**m**	**Ωm**	**m**	**Ωm**	**m**	**Ωm**	**m**
1	3	100	15	140	25	80	33	140	90	60			90
2	2	140	18	300	35	160	38	140	90	100			90
3	2	80	20	160	8	380	8	210	62	700			90
4	10	140	78	400	68	600	12						90
5	10	60	30	210	5	220	5	180	15	800			90
6	20	100	30	180	15	264	15	230	10	500			90
7	15	100	30	210	10	90	20	180	30	800			90
8	25	90	40	130	12	150	18	100	10	140			90
9	6	80	30	120	15	100	10	190	40	600	45	620	90
10	7	30	14	130	11	110	15	100	5	200	10	500	90
11	5	11	5	16	1	23	10	104	10	136			90
12	5	4	4	4	35	17	10	57	10	59	10	37	90
13	3	66	5	53	8	90	10	218	10	481			90
14	10	60	30	100	35	359	25	639	35	819	20	985.6	90
15	10	90	30	150	30	539	20	819	20	956			90

4.2 D-Z Parameters.

The D-Z parameters are useful for determining the aquifer transmissivity and location of fresh groundwater zones. The D-Z parameters include, Transverse resistance (T), Longitudinal Conductance (S), Electrical Anistrophoy. Root Mean Square Resistivity (Masadi Patel et al).

4.2.1 T –Transverse Resistance

To determine T value, $\mathbf{T} = \sum_{k=0}^{n} \mathbf{h1}\dot{\rho}\mathbf{1} + \mathbf{h2}\dot{\rho}\mathbf{2} + \mathbf{h3}\dot{\rho}\mathbf{3} + \cdots \ldots. + \mathbf{hn}\dot{\rho}\mathbf{n}$ **--→ [1]**

h—Thickness of layer (m), $\dot{\rho}$--Electrical Resistivity of layer, n→ nth layer or number of layers.

Here, it is known that, the value ranges from 3568 ohm-m^2, (VES-12) to 55000 ohm_m^2, (VES-15), from west to east. This indicates that, the transmissivity is higher in the east part of the study area and lesser in the west part of the study comparatively. But, the total transmissivity value distribution throughout the study area reveals that, there is good natural recharge and higher transmissivity to the aquifer. But, when the individual, fractured zone thickness aquifer is considered, alone, then transmissivity varies significantly low from west to east. Also, it is noted that, there is good recharge to the aquifer due to higher transmissivity values except Umaraini and Bidarahlli VES. But, here, due to the fact that, overburden clay and low hydraulic conductivity (average value is 0.6 cm/ hour). of overling rock mass and clay, the observed transmissivity is much lesser than the calculated value from electrical resistivity. But aquifer behavior and ground water flow direction indicates that, the ground water flow is from west to east, the recharge can be improved, replacing clay soil by permeable soil. Hence, this indicates that, the transmissivity prediction using electrical resistivity method is not reliable.

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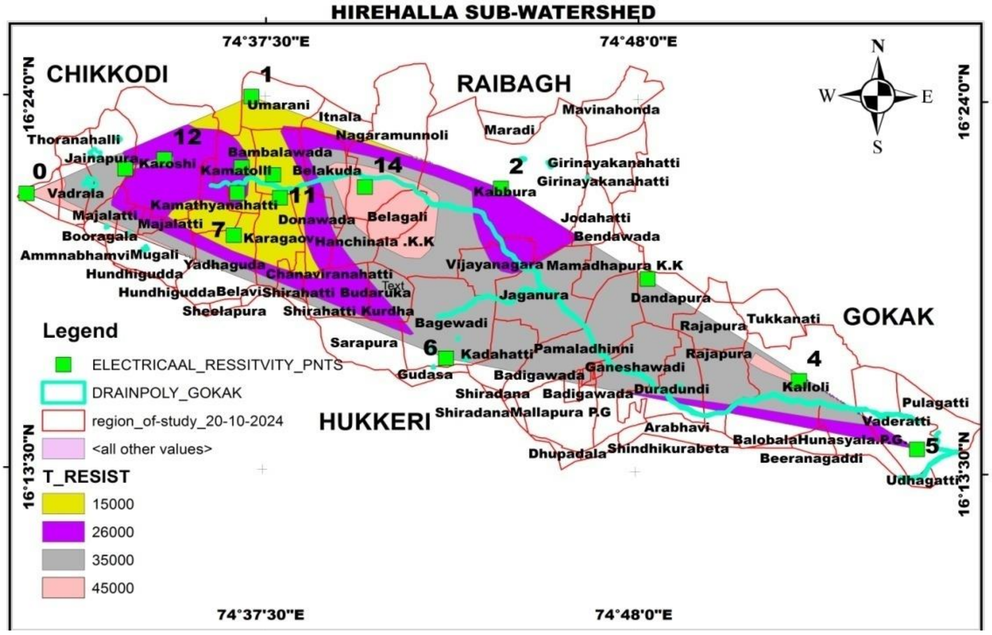
4.2.2 S-Longitudinal Conductivity

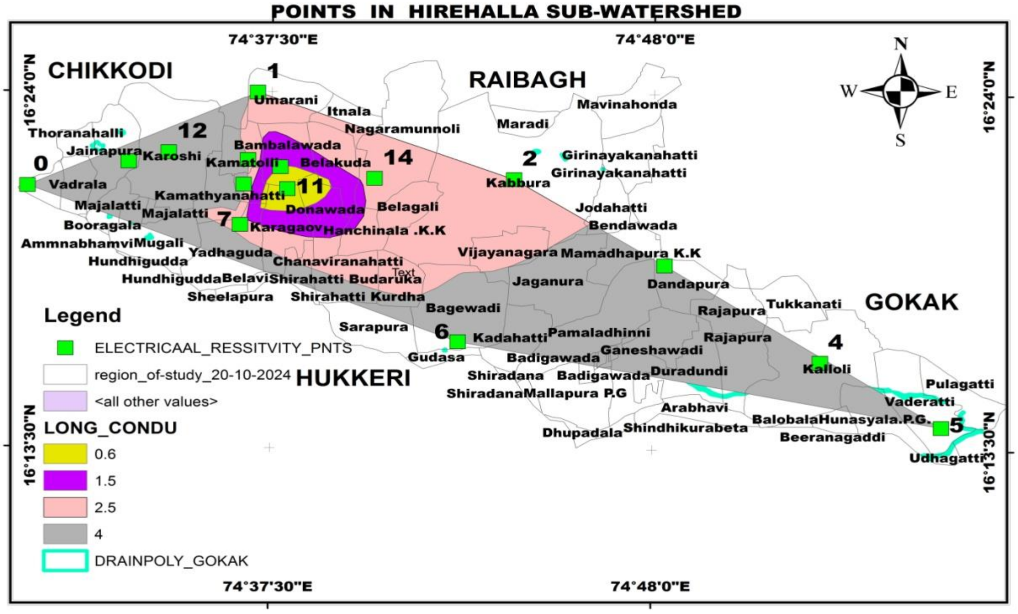
S= ∑ (h1/ρ́1) + (h2/ ρ́2) + (h3/ ρ́3) + ……… hi/ ρ́i→(2).

Longitudinal conductivity indicates the conductance per cross sectional area along a direction. If at any VES location, the S value > 6, then, it contains higher groundwater potential at shallow depth. For VES-1, VES-12, VES-15, the S value is 2 to 6 /ohm, hence, here, there is good storage of potential of groundwater potential. For remaining VES positions, the S value is 0.1 to 4 /ohm. The clay overburden controls the recharge to aquifer system. Here, the electrical resistivity is 800 ohm –m , which can be a basalt formation.

LATERAL RESISTIVITY MAP WITH LOCATION OF ELECTRICAL RESISTIVITY TEST POINTS IN HIREHALLA SUB-WATERSHED



LONGITUDINAL CONDUCTANCE MAP WITH LOCATION OF ELECTRICAL RESISTIVITY TEST POINTS IN HIREHALLA SUB-WATERSHED



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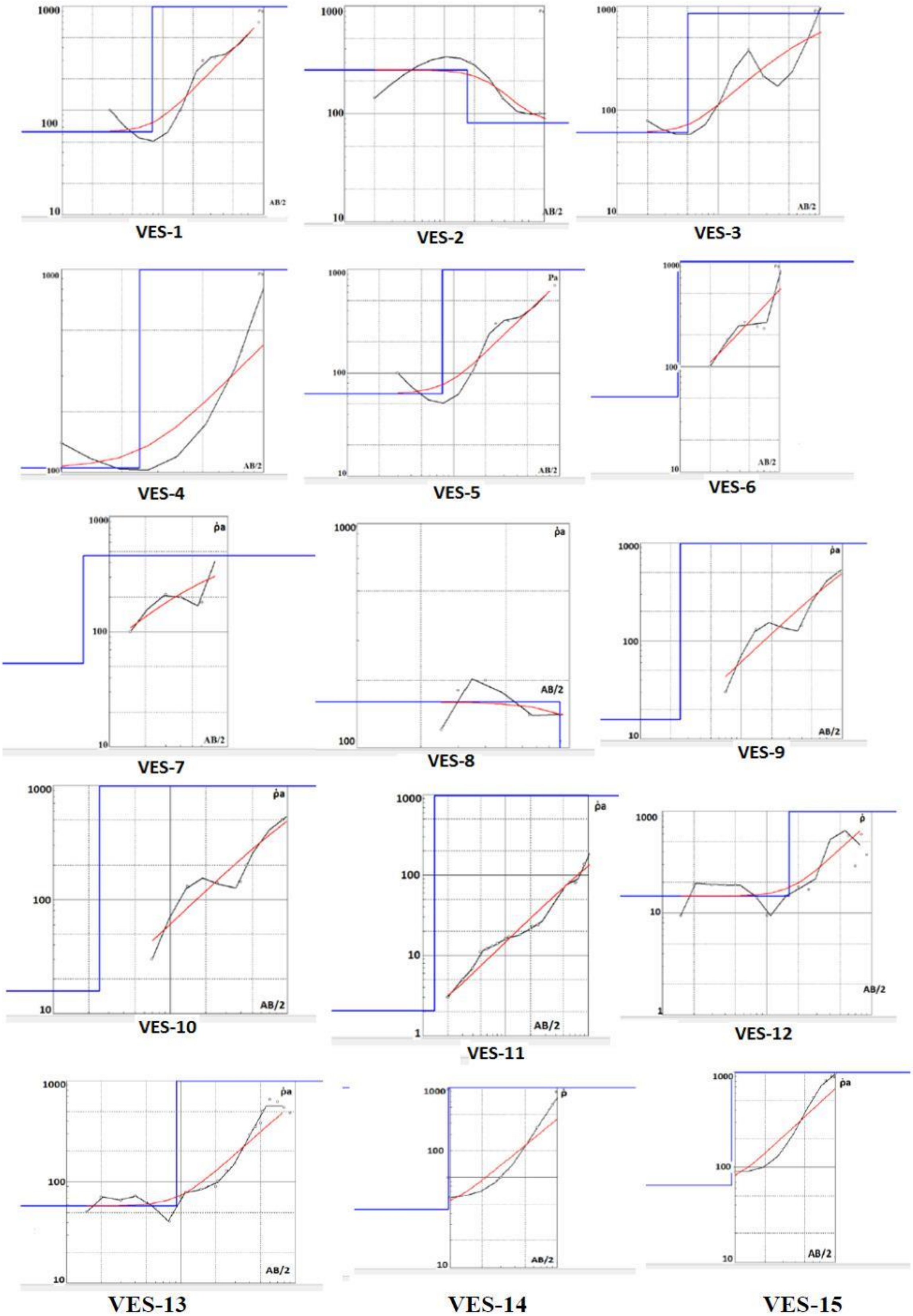

Figure-7- VES Curves of Study Area

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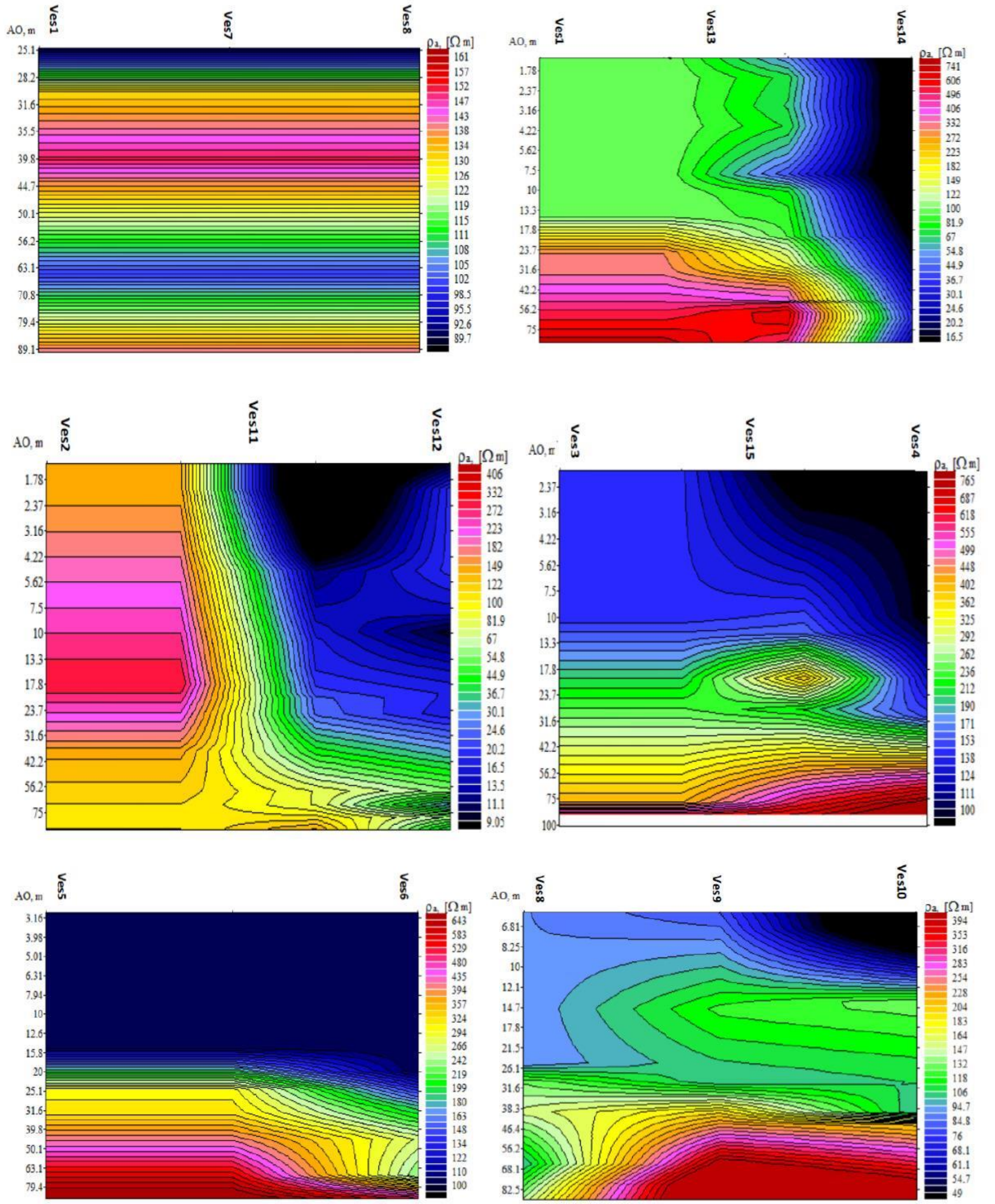

Figure-8- Pseudo Cross-Sections of Combined VES Curves of Study Area

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4.3 Pseudo Cross Sections

Pseudo cross-section VES-1, 7, 8

Here, at VES-1, 7, 8, the depth of aquifer is 28 meters, including thickness of the top soil of 5 meters. At the depth 28.2 meters, the resistivity value is 128 ohm-m, this indicates the presence of weathered and jointed basalt. Further, as the depth increases, thee resistivity values also have increased until 63 meters, but between 63 meters and 73 meters, the resistivity values are in the range of 102 ohm-m to 1110 ohm-m, which indicate the presence of semi confined aquifers at greater depth of 63 meters.

Pseudo cross-section VES-1, 13, 14

Here at VES-1, the depth of aquifer is 23 meters and at VES-14, the depth of the aquifer has extended to 75 meters. This may be due to the presence of test sites near to the drain. This section has higher ground water potential and sustainability. This is followed by massive basalt on the south west side of the section, where the resistivity value ranges from 606 ohm-m to 741 ohm –m.

Pseudo cross-section VES-2, 11, 12.

Here the resistivity values between VES11 and VES 12 are from 2 ohm –m to 89 ohm-m , extended till the depth of 75 meters below ground level. This indictes the sustainability of aquifer between these 2 sites, and also there are fresh and good groundwater potential zones in this section, these are located 80 m away from Hirehalla an 120 meters away from 2nd order drain. Further, to the depth of 5 meters, the value of resistivity is 9 ohm-m, which is extremely low, this indicates moist soil with jointed and weathered basalt presence. But this is not sustainable, as draw down increases, the moisture content may decrease automatically and also, there is a jointed basalt zone, which indicates the presence of aquifer zone between 7.5 meters to 11 meters depth BGL. But, here, the jointed basalt are collapsible in nature, bore wells or open wells should be provided with casings or proper masonry protection works. At location 2, the substratum is comprised with moderately weathered basalt mixed with compact rocks to a depth of 75 meters below ground level; this indicates that, the aquifer systems potential is low at this site, this may due to the presence of the site at the elevated position.

Pseudo cross-section VES-3, 15,4

At VES-3, the depth of jointed basalt is 10 meters below ground level, but this is mixed with slightly fissured compact rocks. So, the resistivity value is more than 100 ohm-m. But here, as the depth progresses, the resistivity values increase, thus, there is no indication of any deep or semi confined aquifer at the depth of 90 meters. But between the depths of aquifers extends to 15 meters below ground level, except top 5meteres depth of soil. This is because, the test locations of VES-4 and VES 15 are within 100 meters range of Hirehalla, which indicates that, there is interaction between ground water movement and surface water. At location VES-15, the resistivity values vary from 100 ohm –m to 267 ohm-m, between 13 meters depth to 31 meters depth below ground level, this indicates the presence of moderately weathered zone

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with medium compact basalt, but this is not the indication of presence of aquifer system. Further, at depth more than 31 meters, there is no indication of aquifer system presence till 90 meters depth. Hence, the aquifer system at this site is sustainable only under limited utility conditions.

Pseudo cross-section VES-5,6

The weathered basalt is extended to the depth of 15 meters below the ground level. The aquifer system here is not sustainable since, due to drainage density 1.2 km / Sqkm. Further, the values of resistivity increase with respect to depth, indicating the absence of ceased presence of aquifer at greater depths. These are not suitable locations for drilling or hand pumps, open wells or bore wells and aquifer systems in these regions are not sustainable.

Pseudo cross-section VES-8, 9.10

Here the resistivity values are between 49 ohm-m to 118 ohm-m, at a depth extended till 26 meters from ground level at VES -8 location. At VES -10 location, this value ranges between 3 meters to 10 meters depth, This is because at VES-10, the test point is locate at elevated point above the stream level and it is 300 meters away from 3rd order drain. Even at VES-8 and VES-10, the resistivity values indicate that, the jointed basalt and weathered basalts are mixed with moderate compact rocks. In these areas, open wells may dry up in summer season i,e in pre monsoon period (February to June)

4.4 Observed Transmissivity at VES Points

Table-2- Observed Transmissivity Values at (VES) Test Sites

Sl .no	**VES point**	**Transmissivity (m^2/day)**
1	VES-1	15.48
2	VES-2	10.2
3	VES-3	42
4	VES-4	10
5	VES-5	10.5

Sl .no	**VES point**	**Transmissivity (m^2/day)**
6	VES-6	10
7	VES-7	31.2
8	VES-8	52
9	VES-9	45.5
10	VES-10	8
11	VES-15	5

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The above value of transmissivity indicate that, the DZ parameters are not correlated to the transmissivity of the aquifer, since, the transmissivity depends on hydraulic conductivity and aquifer saturated thickness I,e T-=KD

4.5 Saturated Hydraulic Conductivity

This was done at 8 locations near to the test sites, using Gulp Permeameter. The average value of saturated hydraulic conductivity was found to be 1 **cm /hour.**

4.6 Verification of Test Readings

To verify, test readings, trail bore holes are identified near to three sites ves-1,2, and VES-3.

Village Name: Bidarahlli, VES-1

Table-3- Borehole Details of Testsite VES-1

sl. no	Stratum Type	Depth BGL(M)	OHM-M ῥ
1	soil + weathered basalt	3	100
2	moderately weathered basalt	15	100
3	hard basalt	25	300
4	fractured Jointed basalt	33	70
5	hard basalt	**90**	700

Village Name:Umarani , VES-2

Table-4- Borehole Details of Testsite VES-2

sl. no	Stratum Type	depth BGL m	OHM-M
1	soil+ compact	2	140
2	moderately hard basalt	18	300
3	fracturd zointed basalt	35	40
4	jointed basalt	38	140
5	highly fractured basalt	90	100

Village Name: Kabbur VES-3

Table-5- Borehole Details of Test site VES-3

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sl. no	Stratum Type	depth BGL m	OHM-M	Layer Depth m
1	soil + weathered basalt	2	80	2
2	moderately weathered basalt	12	160	10
3	hard basalt	20	380	8
4	weathered jointed basalt	28	210	8
5	fractured basalt	70	100	20

It is observed that, the resistivity values are less for fractured and jointed basalt, but high for hard basalt, hence the test readings are correct for VES-1 VES-2 and VES-3. The borehole data was extracted from the site and was physically examined for the type of stratum and depth BGL. The observed values were then compared with the obtained resistivity values as presented in the above table. This is also indicated by quick drying of wells before pre monsoon

4.7 Summary of Findings

I Groundwater is available at an average depth of 25 meters on the central and west side and at 45 meters depth on the east side.

ii. The jointed weathered zones, that contain groundwater, are of collapsible type, so protective measures should be undertaken

iii In some regions with electrical resistivity < 50 ohm-m, at depth more than 50 meters, indicate presence of semi-confined aquifer, but this is overlaid with clay.

iv. Electrical resistivity test is suitable for finding aquifer depth and saturated thickness and also layer thickness of subsurface stratum, but it is not appropriate to find transmissivity, but knowing the longitudinal conductivity, rechargability of aquifer assessment can be done

V Resistivity values are more for compact and hard rock’s than jointed, fissured or weathered rocks

vi. Collection of electrical resistivity test data of multiple periods, probably post and pre monsoon, the improvement in saturated thickness of the aquifer can be determined, which may be the effect of natural or artificial recharge to the aquifers.

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Vii In the current study, it was found that, near to drainages, the saturated aquifer thickness are 20 meter thick and are located at the depth of 5 meters below ground level, semi confined aquifers are located within range of 25 meters to 50 meters. This shows that, the average recharge percent is about 12 % of rainfall depth, which indicate that, the natural recharge effect on the shallow aquifer is within 150 meters range from streams or drains.

5.0 Conclusion

The electrical resistivity test was carried out was carried out at 15 locations and the locations were mapped using GPS hand held set. Schlumberger method is used to record electrical resistivity readings. The readings were imported to the IPWIN-12 software and VES curves were generated. By combing these curves, in the software, pseudo cross sections were generated. The results indicate that, the shallow aquifers are located at a depth of 5 meters to 25 meters below ground level. In 3 locations, the aquifers are identified in jointed or fissured form, which indicate that, these are of collapsible type, so protective measures are needed for open wells and bore wells. The test results indicate that, the recharge potential is higher near drainages at horizontal distance of 100 meters, which is represented by aquifers present at depth 5 meters below ground level. But, the fractured aquifers are located at depth 30 meters to 50 meters below ground level and are overlain by clayey soil. The predicted transmissivity in the region is from 10 m^2/day to 45 m^2/day. The jointed weathered zones, that contain groundwater, are of collapsible type, so protective measures should be undertaken. The resistivity at surface levels in case of hard rocks vary from 200 ohm-m to 700 ohm-m. 60 % of the test sites are dominated by H type of the VES CURVE and 40% of the VES curve is A type curve. Lastly, this is useful for layer thickness exploration. The present study conveys the relation between the hydro geological and geophysical parameters of groundwater. VES 6, 4, 5,0,1,2 have good groundwater potential zones.

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