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Applications of Vertical Electrical Sounding Techniques for Groundwater Investigation in Gul River Watershed of Chopda Taluka of Jalgaon District, Maharashtra

D.L. Chavhan[1], S.N. Patil[2], N.R. Kachate[3], S.B. Bhavsar[4], B.D. Patil[5], R.B. Golekar[6]

Author's Affiliations:
[1,2,3,4,5] School of Environmental and Earth Sciences, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, Maharashtra 425001, India
[6]Department of Geology, Khare Dhere Bhosale College, Guhagar, District Ratnagiri, Maharashtra 415703, India

***Corresponding Author: Prof. S.N. Patil**, School of Environmental and Earth Sciences, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, Maharashtra 425001, India
E-mail: drsnpatil9@gmail.com

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ABSTRACT
The Gul River watershed situated in the North-West region of district called Jalgaon in Maharashtra State has been explored with the help of VES method for identifications of groundwater locations. The vertical electrical soundings had been implemented in total 15 locations covering entire area understudy. This study played an important role in identifying potential groundwater zones and the behavior of aquifers in and around the trap rock. During the study, IX1Dv.3 software was used for interpretations and curve matching techniques were adopted using vertical electrical sounding data to develop each sound layer model. It has been observed that pseudo cross section and resistivity cross section were mapped using IPI2WIN software and big five cross sections were created.This paper consist comparison with the existing bore well along with tube well logging data.The observations noticed during the study indicated that, Tapi alluvium formation has been highly suitable zone as per compare to trap.

KEYWORDS: *Vertical Electrical resistivity, IPI2WIN Software,Groundwater potential zone, Tapi Alluvium, Jalgaon District*

INTRODUCTION

The demand for fresh water has increased rapidly due to population growth and intensive agricultural activities. Groundwater has become a major source of water for the domestic, industrial and agricultural sectors of many countries. It is estimated that approximately one-third of the world's population use groundwater for drinking (UNEP, 1999). Gul River watershed of Chopda taluka is present in the Northern part of Jalgaon District, Maharashtra. Around 37 villages are settled in this watershed, Adavad, Vardi are major population villages and Unapdev is hot spring location. Most of the areas of Gul River watershed of Chopda taluka are covered under agricultural practices but northern part of this region is covered by Satpuda mountain range (Patil, 2015). The study area has Geodiversity, northern part is covered by trap of Satpuda group, middle part is covered by bazada formation and southern part is covered by tapi alluvium therefore different aquifer behavior were seen. The Geophysical methods is widely used for groundwater investigation SSR MP-ATS model of instrument to obtained data from subsurface geological formations and it gives idea of occurrence and movement of groundwater. The Schlumberger array is used for detection of underground conditions, is easy to operate and electrodes are available for high signal-to-noise ratio, good horizontal layers resolution and depth sensitivity. (GSI, 2001).

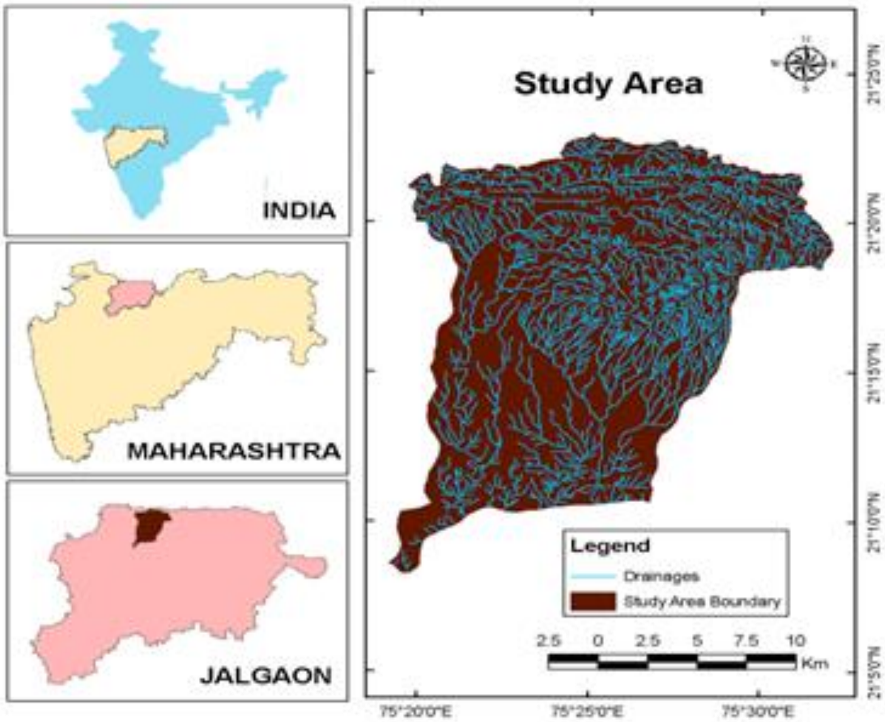

Figure 1: Location map of study Area

GEOLOGY OF STUDY AREA

The study area is connected to the Deccan Trap (Cretaceous to Lower Usain) to the north, and the southern part of the study area is covered with aloe vera (quadrant). The geothermal water area in the study area is also found at the foot of the Seven Plant Mountain Range (GSI, 2010).

Deccan Trap:

Deccan trap found almost northern part of study area it exposed at the Satpuda mountain ranges and foot Hill of Satpuda Mountain which shows alternate simple and compound basaltic flows. The basaltic flow of the area shows different set of joint and fractures. (Patil, 2005) Some part of Deccan trap is covered by bazada zones. This bazada zone is found between Satpuda mountain ranges to tapi alluvium belt. This bazada zone is admixed of boulder, pebble, cobble, gravel, sand, silt and clay material (GSI, 2001).

Alluvium:

Alluvium found towards southern part of the study area, Alluvium layers are composed of yellowish-brown sand, silt and clay with intercalation of gravel and with "kankar" (Stanley, 1990). It consists of clay, silt, sand, gravels and boulders etc. As per groundwater exploration data alluvium is occurs up to 100 m.

HYDROGEOLOGY OF STUDY AREA

Hydrogeology is primarily concerned with the formation, distribution, circulation, and chemistry of groundwater in the context of the geological environment. In Basaltic regions along with locations of study area, the occurrence and movement of ground water primarily depends on the degree of interconnection of secondary pores/voids developed by fracturing and weathering (Golekar, 2013). The Bazada acts as a recharge zone to the alluvium occurring southwards and at the same time forms a potential aquifer for ground water development due to its highly porous and permeable nature. The principal water bearing formations in the Alluvium are granular zones consisting mainly of sand, gravel and pebble which are encountered at various depths (Patil, 2005). The clay horizons occurring at various depths as alternate layers form aquiclude when these layers are significantly thick (Golekar, 2013).Basaltic and bazada part of study area are acts as recharge zone and alluvium part is acts as discharged zone or storage zone.

METHODOLOGY

Electrical resistance to groundwater exploration has been reported by many authors. The vertical electrical resistance method is widely used to estimate the thickness of high load, weather and broken zones (Karanth, 1987) (Tellford, 1990). Wenner and Schlumberger electrode configuration methods are widely used, Schlumberger electrode configuration method is widely used and less time consuming method, ensuring good resolution and better results (Gupta, 2012) (Erram, 2010) (Duraiswami, 2005) (Singh, 2002). The groundwater was examined using the vertical electric sounding method. The method of vertical electric sounding is based on measuring the potential difference between the electrode pair.while transmitting direct current between another electrode pair IGIS Hyderabad (India) made SSRMP-ATS model machine were used for the resistivity signal measurements. The Schlumberger configuration composed of four collinear electrodes (Andrade, 2011). Current and potential electrodes are placed in such a way to maintain one fifth of the spacing between the inner and outer electrode. The current electrodes are increased to a greater separation during survey while, potential electrodes remain in same position until it observes, voltage becomes too small to measure (Sharma, 1997 & Tellfort, 1990). The resistivity soundings were carried out using the Schlumberger electrode configuration with a maximum current electrode separation (AB/2) = 100m². Kearey and Brooks (Kearey, 1988) method was used for calculation of apparent resistivity as, $\rho a=\pi$ [(L/2)2 – (b/2)2]/b X V/I Where, L and b is the current and potential electrode spacing respectively. The interpretation of the VES was carried out by the IX1Dv3.1 software in terms of layered resistivity model $\rho 1$, $\rho 2$, $\rho 3$ matching measured curves with a set of theoretically calculated master curves interpreted using master curves techniques. The VES pseudo cross section and resistivity cross section maps were prepared by using IPI2WIN geoscientific software2. In present study one to five-layer model is generated over 15 locations of area.

RESULT AND DISCUSSION

There are five cross sections are drawn in different directions. The resistance data obtained in the present study is compared with that of deforestation of tube wells in the study area (Patil, 2009). The normal range of resistance values of various litho units in the present study area is considered to be 21 as suggested by previous researchers, which is referred to in Table 1.

Table 1: Litho units and Resistivity (Patil et al., 2009; 2015)

Litho-Units	**Resistivity (Ω m)**
Clayey/silty layer	1-3
Medium grained sandy layer	3-5
Loose sand and gravel bed	5-7
Clay with pocket of sand	7-15
Clay with lenses of sand	15-25
Compacted clay with pebbles, cobbles, gravels	25-45
Compacted clay bed	45-60
Hard and compact rock	Over 60

The VES data were studied using curve matching techniques for 15 VES locations, the resistance and thickness of the geoelectric components presented in Table 2. VES data was obtained using computer software IPI2WIN with multiple iteration reversals. 1 to 5 layer models are obtained in the study area. This is shown in Table 2.

Table 2: Location, Resistivity Layers, Thickness and Curve Type

Sub Watershed No.	VES No.	Resistivity (Ω m)					Thickness (m)					Curve Type
		Layer I	Layer II	Layer III	Layer IV	Layer V	Layer I	Layer II	Layer III	Layer IV	Layer V	
Wadgaon	1	5.75	16.4	1.63	49.2	3.35	0.5	0.646	1.76	7.12	6.24	KHK
Mangarul	2	1.69	2.5	4.04	0.137	0.627	0.5	2.17	3.06	0.209	11	AKH
Khedibhokari	3	3.4	16.6	2.55	18	2.46	1.02	1.91	2.08	12.2	20.3	KHK
Near Rukhankheda	4	8.59	151	15.8	38.7	92.3	0.5	0.737	1.72	7.37	25.4	KHA
Machale	5	7.77	3.53	209	153	3.51	1.08	1.2	0.369	4.45	12.2	HKQ
Malapur	6	19.9	128	56.2	355	73.4	0.5	1.3	2.2	6.4	40.8	KHK
Vishanapur	7	16.6	35.2	16.5	273	1563	1.5	1.3	5.3	29.3	11.7	KHA
Vardi (Own Farm)	8	4.1	3.8	16.7	6	1391	0.7	0.2	1.4	5.1	6.2	HKH
Vardi (Babukaka farm)	9	5.6	15.9	104	6.3	44.1	1.3	1.3	4.6	11	31.9	AKH
Vardi-Unapdev raod	10	23.4	89	17.7	38.8	14.2	0.5	0.9	1.9	8.1	80.1	KHK
Nandu aaba farm	11	15.8	22.4	42.8	17.8	13.8	0.5	3.1	7.9	3.2	41.3	AKQ
Adawad	12	10.3	25.1	18.6	16.8	7.5	0.8	0.9	13.9	1.9	66.7	KQQ
East side of Unapdev	13	20.6	222	29.5	102	24.4	0.5	0.7	1.1	19.7	28.5	KHK
West side of Unapdev	14	68.3	5.9	123	30	7.1	0.5	0.8	1.5	22.6	42.8	HKQ
Sojargoti mata mandir	15	14.2	41.4	14.7	26.2	29.4	0.6	1.1	2.3	14.2	6.2	KHA

The first layer model showing resistivity between 1.69 Ω m to 68.3 Ω m. VES No 14 may be consisting of Hard and compact rock formation and all remaining VES Nos first layer shows unconsolidated loose material from in thickness of 0.5m to 1.3m range.

The Second layer model showing resistivity between 2.5 Ω m to 222 Ω m. VES No 4,6,10 and 13 shows resistivity above than 60 Ω m therefore It may be consisting of Hard and compact rock formation. VES No 7, 12 and 15 may be consisting of compacted clay with pebbles, cobbles, gravels and all remaining VES Nos second layer shows unconsolidated loose material. The thickness of second layer is from 0.2 m to 3.1 m range.

The Third layer model showing resistivity between 1.63 Ω m to 209 Ω m. VES No 5,9 and 14 shows resistivity above than 60 Ω m therefore It may be consisting of Hard and compact rock formation. VES No 6 consists of compacted clay bed in thickness of 2.2m. VES No 7,12 and 15 may be consisting of Compacted clay with pebbles, cobbles, gravels and all remaining VES Nos third layer shows unconsolidated loose material. The thickness of third layer is from 0.36 m to 13.9 m range.

The Fourth layer model showing resistivity between 0.13 Ω m to 355 Ω m. VES No 4,6,7 and 13 shows resistivity above than 60 Ω m therefore It may be consisting of Hard and compact rock formation. VES No 1 consists of compacted clay bed in thickness of 7.12 m. VES No 5,10,14 and 15 may be consisting of Compacted clay with pebbles, cobbles, gravels and all remaining VES Nos fourth layer shows unconsolidated loose material. The thickness of fourth layer is from 0.20 m to 29.3 m range.

The Fifth layer model showing resistivity between 0.62 Ω m to 1563 Ω m. VES No 4,6,7and 8 shows resistivity above than 60 Ω m therefore It may be consisting of Hard and compact rock formation. VES No 9 and 15 consist of compacted clay with pebbles, cobbles, gravels and all remaining VES Nos fifth layer shows unconsolidated loose material. The thickness of fifth layer is from 6.2 m to 80.1 m range.

A pseudo and cross sections of the study area were generated by IPI2WIN software. There are 5 pseudo and cross sections drawn.

1. A pseudo and cross section of VES No 15, 13 and 14 which are shows different resistivity zones. VES No 15 shows that high resistivity zone between 25m to 100m depth and low resistivity zone between 0m to 25m. VES No 13 shows that high resistivity between 4m to 25m depths and low resistivity zone between 25m to 50m depths and resistivity increased between 50m to 100m depth. VES No 14 shows low resistivity between 0m to 100 depths. (Figure 2)
2. A pseudo and cross section of VES No 5, 9, 10, 11 and 13 which are shows different resistivity zones. VES No 5 shows that low resistivity zone between 0m to 20m depth and high resistivity zone between 20m to 100m. VES No 9 shows that low resistivity between 0m to 100 m depth, VES No 10 shows that low resistivity zone between 0m to 90m depth and high resistivity above from 90m depth. VES No 11 shows the low resistivity between 0m to 100m depth, it is shows different and low resistivity zone between 25m to 50m and resistivity increased between 50m to 100m depth. VES No 14 shows low resistivity between 0m to 100m depth, it is shows different resistivity average value 40.50ohm-meter between 50m to 100m depth. VES No 13 shows the low resistivity zone between 0m to 50m and high resistivity zone between 50m to 100m depth, it is shows 356ohm meter resistivity. (Figure 3)
3. A pseudo and cross section of VES No 7,9 and 2 which are shows different resistivity zones. VES No 7 shows the low resistivity between 0m to 7.5m depth and high resistivity zones occurred between 7.5m to 38m depth and very high resistivity zones were found between 38m to 90m depth and again low resistivity zone were encountered between 90m to 100m depth. VES No 9 were shows the low resistivity zone found between 0m to 100m depth. VES No 2 shows the low resistivity between 0m to 20m depth and high resistivity zone found between 20m to 100m, the average resistivity value was 767 ohm-meter. (Figure 4)
4. A pseudo and cross section of VES No 6, 7, 15, 11 and 12 which are shows different resistivity zones. VES No 6, at this location the high resistivity zone shows between 6.5m to10m depth and also found between 50m to 100m depth. It is shows very high average resistivity value 5307ohm meter. VES No 07 shows high resistivity between 10m to 50m depth and low resistivity zone occurred between 50m to 100m depth. VES No 15 shows low resistivity zone between 0m to 30m and high resistivity zone found between 30m to 70m depth. VES No 11 shows low resistivity zone between 0m to 100m depth. VES No 12 also shows low resistivity zones between 0m to 100m depth. (Figure 5)
5. A pseudo and cross section of VES No 6, 7, 15, 11 and12 which are shows different resistivity zones. VES No 4 shows the high resistivity zone between 2.5m to 100m depth, only regolith zone shows low resistivity zone up to the 15m depth and above 15m, it was showing very high resistivity zone. The average resistivity value was 1757ohm meter. VES No 12- show low resistivity zone between 0m to 100m. (Figure 6)

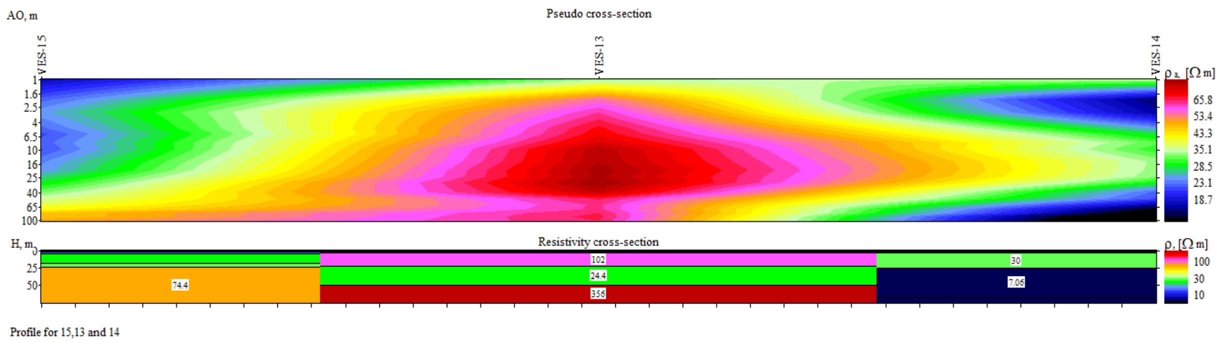

Figure 2: Pseudo Cross section for VES-15, VES -13 and VES-14

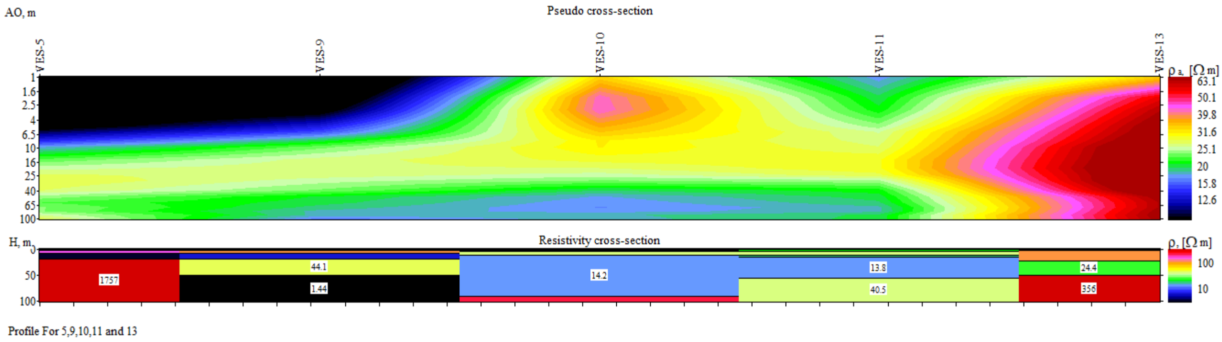

Figure 3: Pseudo Cross section for VES-5, VES-9, VES-10, VES -11 and VES-13

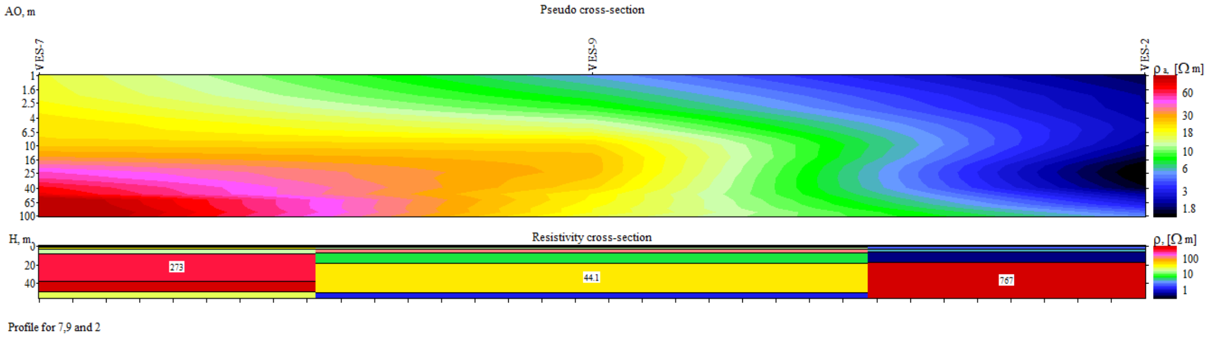

Figure 4: Pseudo Cross section for VES-7, VES-9 and VES-2

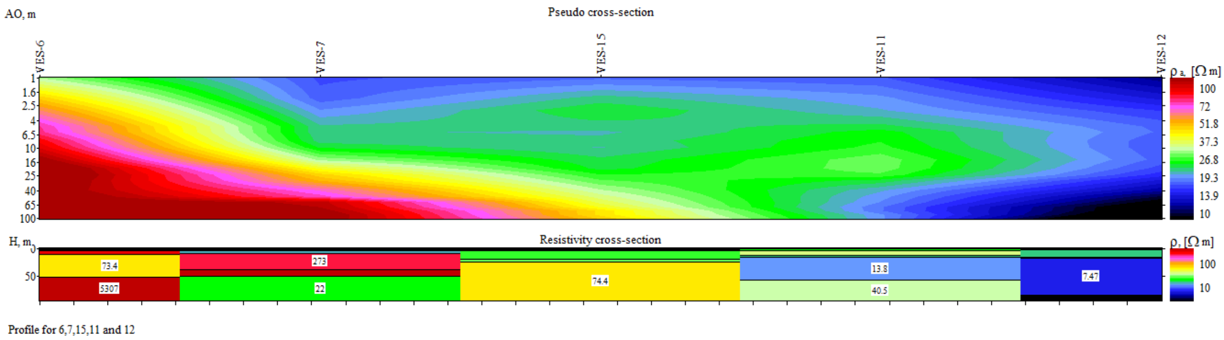

Figure 5: Pseudo Cross section for VES-6, VES-7, VES-15, VES -11 and VES-12

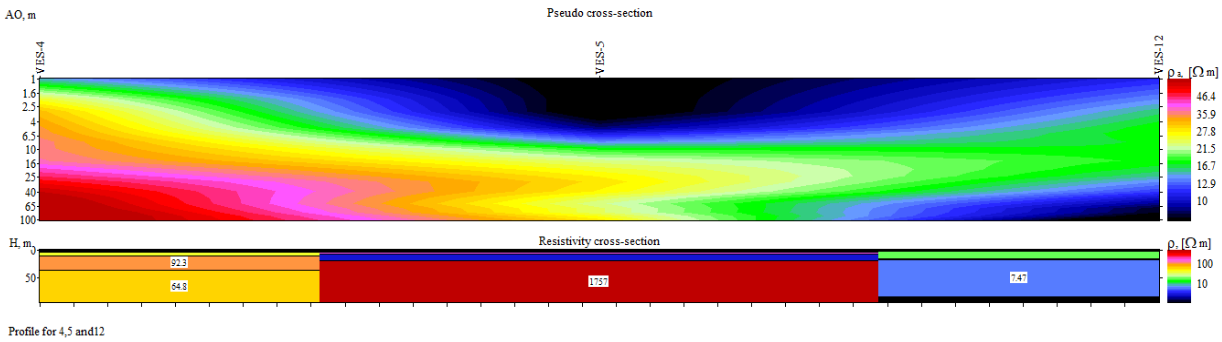

Figure 6: Pseudo Cross section for VES-4, VES -5 and VES-12

CONCLUSION

The vertical electrical resistivity is useful to notice and marka excellent potential zone of groundwater. During the study various characteristics indicated the variations in the geo-physical parameters such as resistivity zone of Deccan Trap and Alluvium formation of different locations at area under study. The high resistivity zone at shallow to deep depth in study area has been observed in VES No 6,7,8,13 and 14. It shows a presence of hard rocks layer at some depth. VES No 4 and 5 have high resistivity zone at middle layer and low resistivity zone at upper and lower layers; it may be good potential zone of ground water. These two points are taken in chahardi in lier formation. The low resistivity zone has been noticed in VES No 1,2,3 and 12, which indicates the presence of clay with some part of sand to compacted clay bed, it may be a good groundwater potential zone. These points are taken in Tapi alluvial formation. VES No 9,10,11 and 15 have low resistivity zone, there may be a presence of clay with pocket of sand to compacted clay bed. Loose Sand pockets are goods zone of ground water. These points are taken in bazada formation. VES 9 (Near Vardi) have shown variation resistivity, it because o fmodifications cum changes in layer of hard rock and loose or portions of sands noticed in area under study. This point is taken at contact zone of Tapi alluvium and trap. Vertical Electrical Sounding Method has played the important role to prove and support that the variation in resistivity zone indicates the shortage or may be delineating potential groundwater zones present in study area.

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