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Application of Geo-Electrical Surveys to Study the Groundwater Potential Zones in the Deccan Basalt Region of Jalgaon District, Maharashtra

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ABSTRACT

The availability of groundwater is limited both todomestic and irrigation purposes in the Deccan Trap region predominantly occupied by the basaltic flows of Sahyadri group of cretaceous to Eocene age. The Dharangaon Taluka, Jalgaon District, Maharashtra State is a watershed region where the availability of groundwater in shallow aquifers have depleted drastically due overexploitation and increasing population. The shallow formations in this area are the black cotton soil with a thickness of about 1 m followed by calcareous soil that has less than 1 m thickness. The weathered vesicular basalt below the calcareous soil to a depth 5 to 8m and the moderately weathered basalts below the vesicular basalt form the groundwater potential zones in this area. Geo-electrical resistivity methods were used as a fast and economical tool to detect the groundwater potential zones. The 112Vertical Electrical Resistivity Sounding(VES) carried out in the area yielded a resistivity of about 18 ohm m for poor fractured zones to about 65 ohm m for moderately fractured zones and 75 ohm m for highly fractured zones. Most of the area has highly fractured basalts, except the southern region hence the region could act as a recharge area. The groundwater flow was observed to be from north to south due following the subsurface topographic pattern. The first order drainage through the River Anjani flowing in NW direction and merging in River Tapi is the main source of recharge for groundwater in the area. Thus, the highly fractured northern part of the area forms the recharge zone for the southern part where the basement depth was found to be about 40m and is recommended to serve as storage for groundwater in this area where minor irrigation tanks can be constructed for both domestic and irrigation purposes.

Keywords:— *Deccan Basalts, Jalgoan Maharashtra, Dharangaon Taluk, Vertical Electrical Sounding, River Anjani.*

I. INTRODUCTION

Human settlements have threatened the availability of groundwater due to increasing population and overexploitation. This has severely affected the quality and quantity of groundwater through mismanagement of available resources. The hydro-geological and geophysical studies both qualitatively and quantitatively of an area allow us to define the various parameters involved in assessing and exploiting the groundwater aquifers. The present study has chosen a watershed region in Maharashtra State where acute shortage of groundwater exists due to drought and overexploitation. The study area lies in the Dharangaon Taluka, Jalgaon District of Maharashtra State.

The Deccan Volcanic Basalts composed of various lava flows of Cretaceous-Eocene age comprise most of the formations in Maharashtra State. The Deccan Basalt rocks are of mostly five types viz., vesicular basalt, amygdaloidal basalt, fractured jointed basalt, massive compact basalt and weathered basalt (Deolankar, 1980). The individual lava flow varies greatly in thickness from a few metres to as much as 30-35 meters. Several Researchers (Adhyalkar and Mani, 1972; Adhyalkar, 1975) have discussed the hydrogeology of Maharashtra State. The characteristics of different lava flows have been identified (Krishnan, 1982) and their stratigraphic sequences were established.

Geophysical studies have proved to be effective in delineating prospective aquifer zones in the Deccan Basalt region (Deshpande and Sen Gupta, 1956; Bose and Ramakrishna, 1978; Shettigara and Adams, 1989; Ram Raj Mathur and Rao, 2018).Geo-electrical resistivity surveys are commonly used for groundwater exploration and have proved to be economical.

The area under investigation is the TE-41mini watershed No.4/4 of Tapi Basin, Dharangaon Taluka, Jalgaon District, Maharashtra. A total of 16 villages are located in this area. The hydrogeology of the area revealed that it was not suitable for groundwater and farmers were facing a drought situation with insufficient sources for groundwater in the form of dug wells.

To solve the groundwater availability problems in heterogeneous rock areas like the Deccan Basalts geo-electrical surveys were used to delineate and suggest promising and favourable zones for groundwater. These suggestions have helped the farmers to draw sufficient groundwater for drinking and irrigation. In the present paper an attempt has been made to map the fractures associated with shallow groundwater horizons and suggest zones of exploitation using geo-electrical sounding data.

II. Location Map of Study Area

The Dharangaon Taluka, Jalgaon District, Maharashtra State lies between latitudes 21000' to 21060'N and longitudes 75015' to 75022'E. The district occupies the northern part of the State and is bounded on the north by Barwani and Kargone Districts of Madhya Pradesh State. There are sixteen villages (Figure 1) which are agriculturally well developed and is in the Tapi Valley and designated as watershed No.TE-41(4/4) covered by Deccan Basalts.

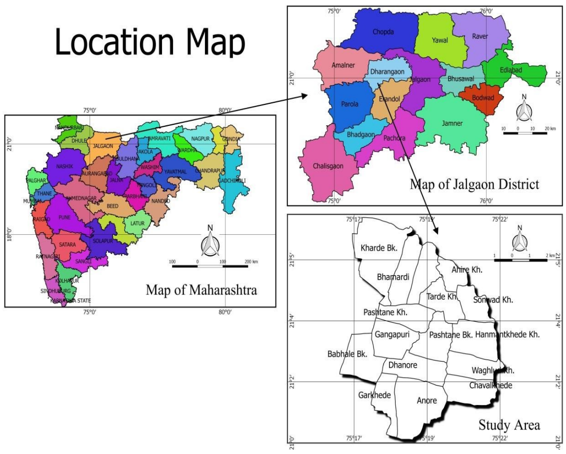


Figure 1: Location map of Dharangaon Taluka, Jalgaon District, Maharashtra State(GSDA,2015)

III. Geology and Geo-Hydrology of Study Area

The Jalgoan District is divided into three main physiographic divisions, Satpura hill ranges in the northern part with dense forest, Tapi valley consisting of alluvial plain in the central part of the district and

Ajanta hill ranges, flanking the hill ridges and small valleys in the southern part of the district (Figure 2). This area forms the most extensive lava eruption and formation in Peninsular India and called as Large Igneous Province (LIP). Tapi River is the main drainage flowing through the district and its major tributaries are Purna in the South and Bhokar, Suki, Morna, Harki, Manki and Gul in the north.

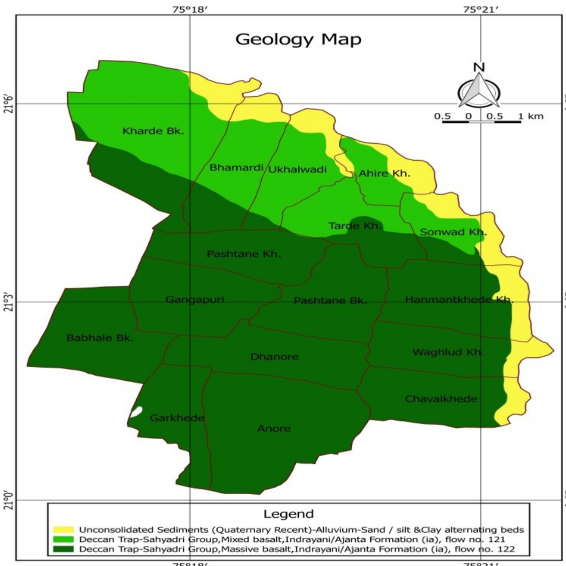


Figure 2: Geology of Dharangaon Taluka, Jalgaon District, Maharashtra State (GSDA,2015)

The soil in Jalgaon district are essentially derived from the basaltic lava flows and are classified as, a) Deep black soils, b) Medium black soils, c) Loamy and sandy soils and d) Forest soils. Deep black soils are observed in northern part of Amalner, Erandol, Jalgaon, Bhusaval and Edilabad Talukas. Medium black soils occur over large areas in the district in the central belt of the Tapi Valley and southern hills. In Tapi Basin soils are black alluvial clay occurring in the southern parts of Yaval, Raver, Chopda, Jalgaon, Bhusaval, Chalisgaon, Amalner, and Bhadgaon (Krishnan,1968). Loamy soils are observed in the southern-most part of Amalner, Erandol, Jalgaon and Bhusaval. Sandy soils are observed on the foothills of Satpura ranges and near southern hillocks. Forest soils are dark brown and occur on slopes mainly in the Satpura ranges.

Deccan Basalts of upper cretaceous to lower Eocene age is the major rock formation, covering about 8040 sq. km in central and southern parts of the district. These rocks formations are intruded by the dykes of the same period(Deshpande G. G,1998). Alluvium occurs over an area of 3600 sq. km in the northern part of the district below the Satpura Ranges.

Ground water in Deccan Trap Basalt occurs mostly in the upper weathered and fractured zones to a depth of 20-25 m(Rai, 2012).Due to the presence of deeper fractures and permeability of rocks infiltration to deeper depths could be a possibility at some places in this region (Babar, 2012). The upper weathered and fractured zones form phreatic aquifer and ground water occurs below the water table in unconfined conditions. At deeper levels, the ground water occurs under semi-confined conditions.Deccan basaltic lava flows formed between 60 and 68 million years occupy a large part of Jalgaon region. The entire pile of horizontal and multilayered lava flow show variation in their physical characteristics (Subbarao, 1988).

The yield of dug wells tapping the upper phreatic aquifer is between 21 and 337 m3/ day at depths of 5-15 m bgl. Bore wells drilled to 60-150 m depths tap groundwater from the weathered and vesicular basalt and found to yield 1.8 to 52 m3/day.

Northern part of the district is underlain by Tapi Alluvium that is subdivided into two sub-groups, i.e., upper younger alluvium to a depth of 70-80 m and the deeper older alluvium to a maximum depth of 450 m. The upper 70-80 m of younger alluvium has 2 to 5 layers of granular zones of sand

and gravel ranging in thickness from 2 to 20 m and forms the potential groundwater zones. At deeper levels the alluvium is mostly clayey and forms and aquiclude.

Ground water in alluvium occurs below the water table in semi-confined and confined conditions. The depth of the dug wells in these formations range from 25 to 50 m bgl with yield from 120 to 200 m3/day in winter and from 100 to 150 m3/day in summer. In Bazada aquifers the yield of dug wells vary from 160 to 200 m3/day in winter and 100 to 180 m3/day in summer.

The climate of the district is hot and dry except during the south-west monsoon season during June to September. The minimum temperature is 10.1°C and maximum temperature is 44.6°C in the region (CGWB 2016).

Jalgaon District receives an average rainfall of about 690 mm. The average annual rainfall for the last ten years, i.e., 2007-2016 is shown in Table 1. Average annual rainfall in the district during the year of 2016 was 636.05 mm.

IV. Geo-Electrical Surveys

Geo electrical resistivity sounding were carried out to decipher both lateral and depth variations of resistivity covered by different geological formations (Telford, et al., 1976; Yadav and Singh, 2007). The Anvic CRM-500 Resistivity Meter and SAS-300 of ABEM were used for the purpose of acquiring Vertical Electrical Sounding (VES) data (Dahlin, 2000). The Schlumberger array with a maximum current electrode separation, AB/2 = 160m was chosen(Matias, 2002). A Total of 112VES(Figure 3) wasconducted in the Dharangaon Taluka, Jalgaon District,

Table 1: Average rainfall in Dharangaon Taluka, Jalgaon District, MaharashtraState (Source: www.gsda.mah.nic.in)

Sl. No.	Taluka	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
1	Jalgaon	674.23	417.90	514.40	606.20	729.50	315.80	951.20	706.12	375.00	719.40	6009.75
2	Bhusawal	565.02	333.80	397.20	766.00	540.50	353.40	860.60	576.18	495.71	738.90	5627.31
3	Yaval	777.50	450.00	456.00	981.40	626.60	495.60	906.10	752.50	533.86	610.10	6589.66
4	Raver	747.30	429.00	495.00	822.40	510.00	433.40	683.70	547.58	455.96	609.30	5733.64
5	Muktainagar	569.70	429.40	509.60	938.80	571.00	385.20	704.70	393.37	428.95	468.50	5399.22
6	Amalner	679.40	506.40	534.30	576.20	477.60	401.20	727.80	577.16	393.77	412.40	5286.23
7	Chopda	747.00	573.40	719.00	867.20	692.70	475.90	1112.60	799.95	374.15	670.40	7032.30
8	Erandol	637.00	634.00	660.00	752.50	675.00	477.00	878.50	787.80	397.02	722.90	6621.72
9	Parola	627.30	538.20	455.20	693.20	561.50	532.00	832.80	553.40	451.00	601.20	5845.80
10	Chalisgaon	531.60	657.70	534.50	618.50	653.20	351.00	738.60	592.30	437.73	699.30	5814.43
11	Jamner	834.20	579.50	413.30	504.30	512.10	331.40	695.90	454.00	337.71	592.40	5254.81
12	Pachora	536.36	542.50	509.00	698.30	636.40	341.50	819.80	624.00	395.50	679.10	5782.46
13	Bhadgaon	481.60	660.00	465.00	684.80	608.00	321.80	865.40	606.85	408.97	723.90	5826.32
14	Dharangaon	695.00	535.00	543.00	553.00	586.00	345.00	980.00	718.00	397.00	714.00	6066.00
15	Bodwad	553.00	527.00	511.00	823.00	684.00	350.00	884.00	518.00	456.00	579.00	5885.00

Maharashtra. The VES data was interpreted using IPI2WIN software(Bobachev, 2003). Iso-resistivity maps for different current electrode separations (AB/2) for estimating the type of formations at various depths within the watershed area were plotted. Geo-electric sections were prepared to estimate(Kelly, 1976) the depth of the different formations.

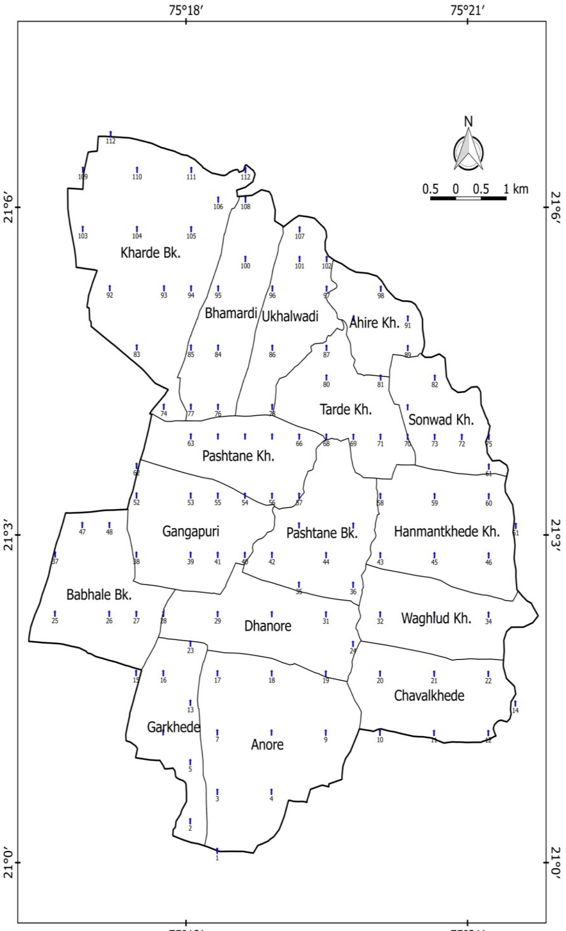
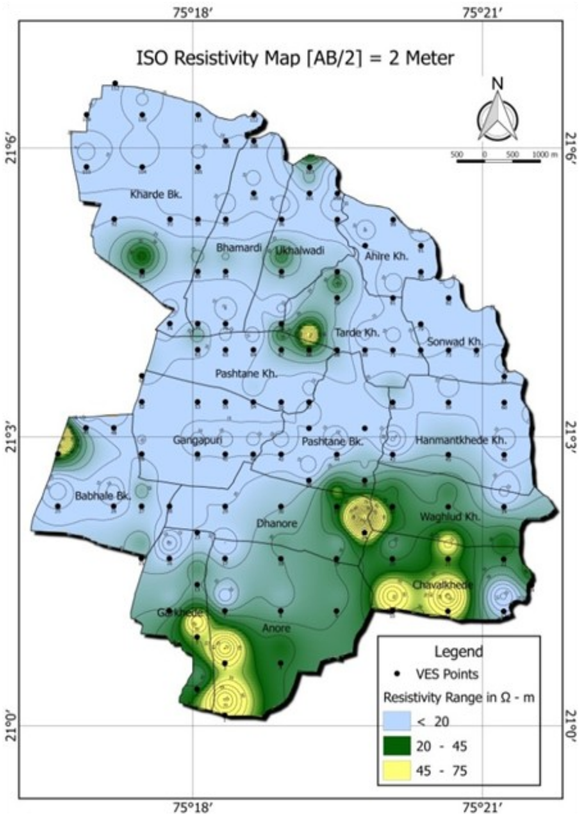
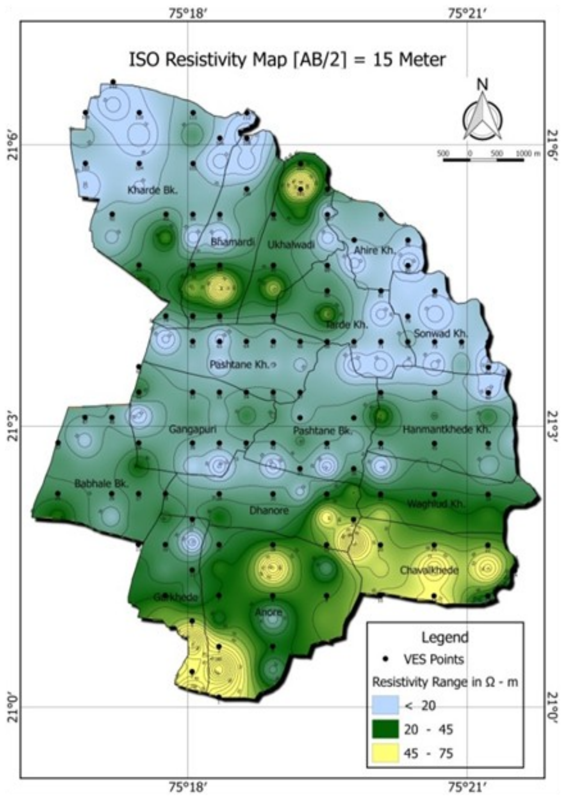


Figure 3: Location of Vertical Electrical Sounding (VES) in Dharangaon Taluka, Jalgaon District, Maharashtra State



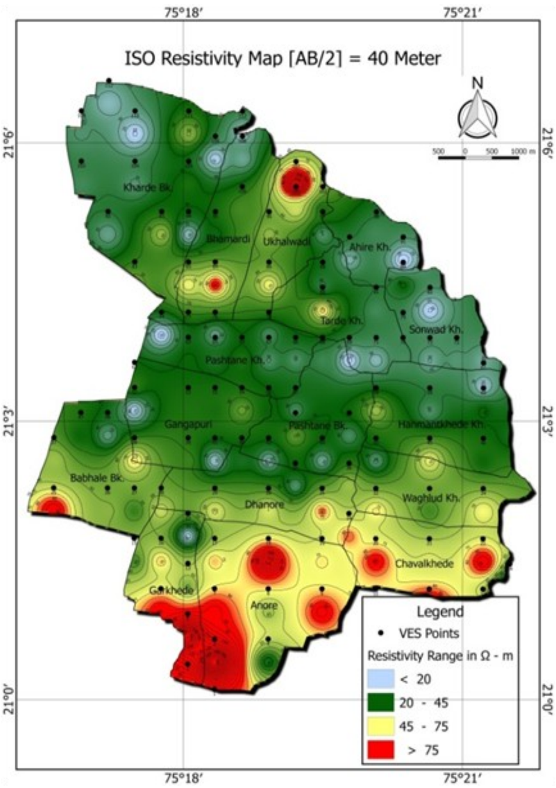
(a)



(b)

V. RESULTS AND ANALYSIS

Based on the Iso-resistivity maps(Figure 4) of different current electrode separations (AB/2) and also well section observations the following resistivity ranges (Table 2) are assumed for different formations in the area.



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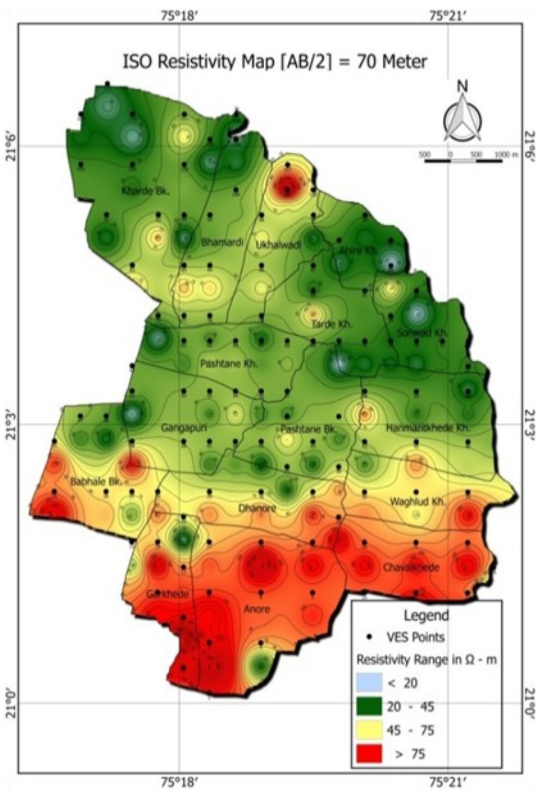

Figure 4: Iso-resistivity Maps of Dharangaon Taluka, Jalgaon District, Maharashtra for (a) AB/2 = 2 m (b) AB/2 = 15 m (c) AB/2 = 40 m (d) AB/2 = 70 m

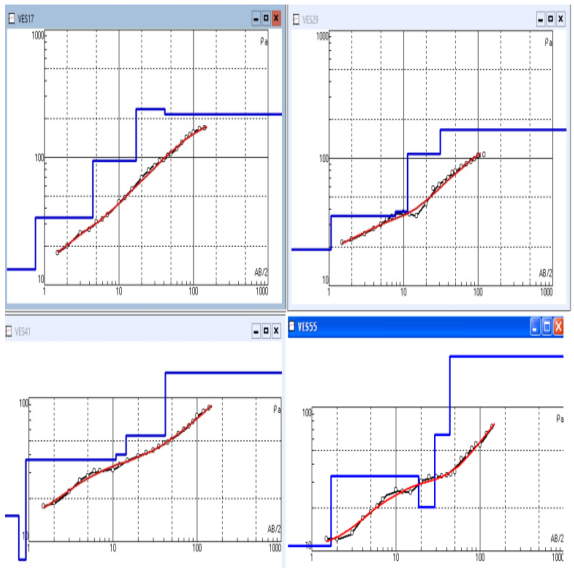

Figure 5: Vertical Electrical Sounding conducted in the Study Area

VI. Analysis of VES Data

The VES curves were interpreted in terms of layer parameters i.e., thickness and resistivity of individual layers. The layer parameters were initially obtained using curve matching technique with the help of standard master curves. These parameters were used as initial model for computer interpretation using IPI2WIN (Bobachev, 2003). The VES data is interpreted up to five layers.

Table 2: Resistivity Ranges for Different Formations based on Well Sections and ISO-Resistivity Maps

Type of Formation	Range of Resistivity
Weathered Basalt	10-20 ohm m
Weathered / Vesicular Basalts	20-50 ohm m
Fractured Basalt	50-70 ohm m
Compact massive Basalt	> 100 ohm m

The variation of resistivity observed in the Iso-resistivity maps clearly demonstrate that the southern part of the area has a shallow basement and the depth of the compact basalt rocks is about 20 m corresponding to AB/2 = 40 m or more. The north and the central part of the area the compact basalt depths are greater than 40 m corresponding to AB/2 = 75 m. Hence, the northern and central regions were found to be more suitable for recharge and storage of groundwater. In order to quantify the depths of the formations geo-electric sections were plotted along three profilesAA1(E-W), BB1(E-W) and CC1(N-S) (Figure 3).

The geo-electric section of profile AA1 (Figure 6) plotted in EW Direction with the data interpreted for the VES numbers 25,26,27,28,29,30, 31, 32 and 33 passing through the villages Bhabale (Bk), Dhanore, and Waghlude(Kh) indicates a resistivity of about 50-75 ohm m for the layer below the soil cover, which corresponds to the fractured basalt formations with a thickness ranging from 1.5 to 9m. These formations were found to have good seepage and retention of groundwater.

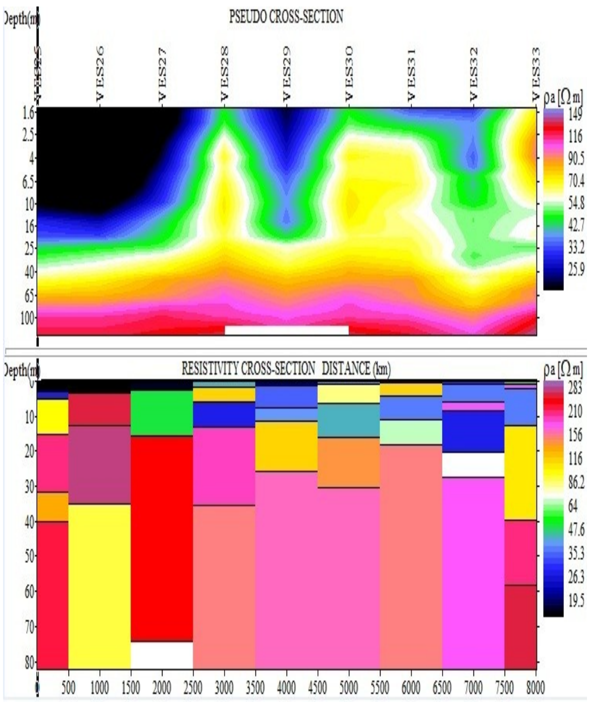

Figure 6: Pseudo depth section and Resistivity cross-section(AA1)

The geo-electric section BB1 (Figure 7) plottedin the EW Direction comprising of the VES numbers 92, 93, 94, 95, 96, 97 and 98 passing through the villages Kharde (Kh), Bhamardi, Ukhalwadi and Ahire(Kh) indicates a resistivity of about 60-90 ohm m for the layer below the soil cover, which corresponds to the fractured basalt formations with a thickness ranging from 1 to 10 m. These formations were found to have good seepage and retention of groundwater.

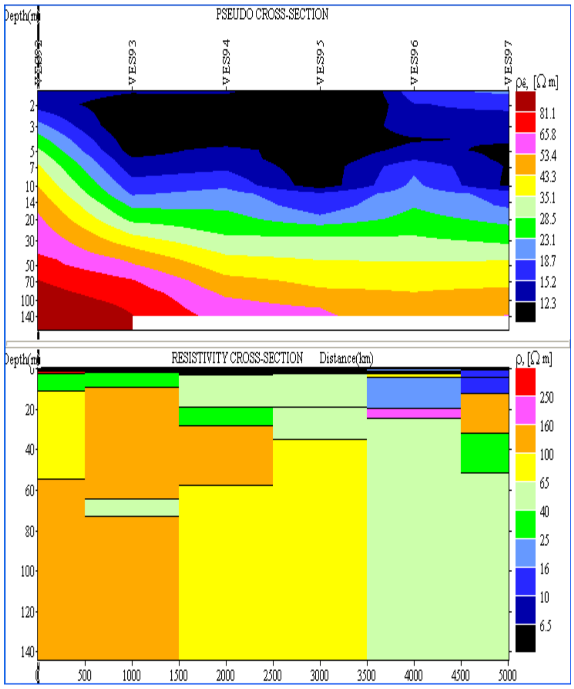

Figure 7: Pseudodepth section and Resistivity cross-section(BB1)

Along the geo-electric section CC1 (Figure 8) along NS direction of VES numbers 106,95,84,76,55,41,29,17,7and3 passing through the villages Kharde(Kh), Bhamardi and Pasthane (Kh), Gangapur, Dhanore and Anoredepicts the top layer resistivity range 5 to 20 ohm m with a thickness ranging from 0.5 to 10 m that correspond to highly weathered basalts. It was also observed that the thickness is relatively more than 10 m at Kharde (Kh), Bhamardi and Ukhalwadialong the geo-electrical section CC1.

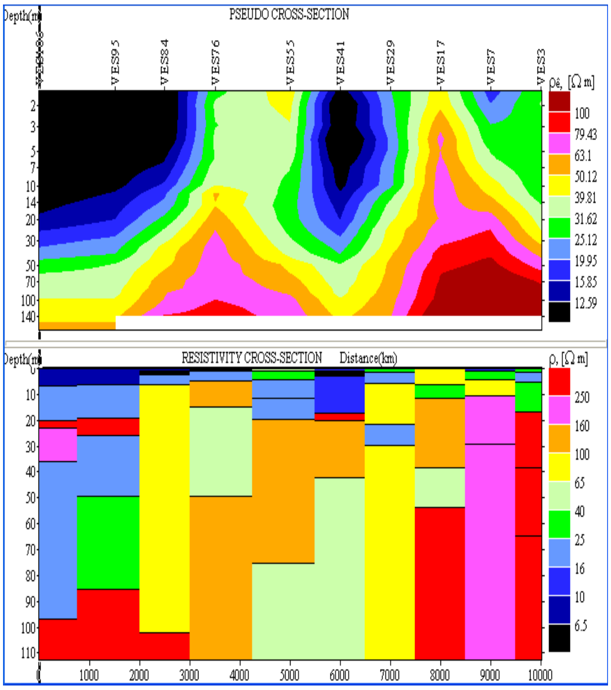

Figure 8: Pseudo depth section and Resistivity cross-section (CC1)

The second layer resistivity along BB1 ranges between 20 to 30 ohm m with a thickness of 5 to 15 m corresponding to weathered/fractured basalts. The thickness at Ahire(Kh) Village is more than 15 m along this section.

The third layer resistivity ranges between 30 to 50 ohm m with a thickness of 5 to 20 m, corresponding to vesicular basalt formations. The thickness of this formation is more at Bamardi, Ukkalwadi, Pasthane (Kh), Tarde(Kh), Sonwad, and Ahire(Kh) Villages.

Below the vesicular basalt formations the fourth layer resistivity ranges between 50 to 100 ohm m with a thickness of 5 to 50m corresponding to fractured basalt formations. The thickness of these formation is more at Kharde(Kh), Bamardi, Ukkalwadi, Pasthane(Kh), Tarde(Kh), Sonwad(Kh) and Ahire(Kh) Villages. The basement resistivity corresponding to compact massive basalts is more than 200 ohm m.

VII. CONCLUSION

Based on the Iso-Resistivity maps first layer show top soil in the litho type because present the grained of black soil and calcrete nodules which is compact in nature. In alluvium higher resistivity values ranges from 19.5 to 83.25 ohm m in villages Bhabale(Bk), Dhanore and Waghlude(Kh) which shows the compacted clay litho type while lower resistivity values ranges from 6.31 to 16.7 ohm m in villages Kharde (Bk), Ukkalwadi, Bamardi and Ahire (Kh) which shows the medium grained sand layer to pockets of sand which is favourable for ground water potential zones.

The vertical electrical resistivity helps to determine a good ground water potential zone. From the geophysical characteristics of Deccan Trap and Alluvium shows high and low resistivity zone in different parts of study area. Villages Kharde(Bk), Ukkalwadi and Bhamardi shows a low resistivity zone between 2-10m it may be a good groundwater potential zone. Ahire (Kh) and Sonwad(Kh) have a low resistivity zones there may be a presence of clay or sand to compacted clay bed.VES 3 (Anore) have a presence of hard rock at 36.0m depth. In the cross section profile CC1 which represent the village Bhamardi, Pastane(Kh), Gangapuri, have a low resistivity zone and identifies the loose sand, silt layered present and high resistivity varies from Dhanore and Anore.

REFERENCES:

[1] Adyalkar P.G., Mani, V.V.S., 1971. Paleogeography, geomorphological setting and groundwater possibilities in the Deccan Traps of Western Maharashtra, Bull. Volcanology, Vol., 35, 696–708.

[2] Babar, M. and Shah, I.I., 2012.

Influence of geological and geomorphological characteristics on groundwater occurrence in Deccan basalt hard rock area of Tawarja river sub-basin, Latur, Maharashtra, India, Research Jour. of Environmental and earth science.

[3] Bobachev, A., 2003. IPI2Win 1D automatic and manual interpretation software for VES data, Available online: geophys.geol.msu.ru/ ipi2win.htm.

[4] Bose, R.N. and Ramkrishna, T.S., 1978. Electrical resistivity surveys for groundwater in the Deccan trap country of Sangli District, Maharashtra. J. Hydrol, v.38, pp: 209–221.

[5] C.G.W.B., (1998), Groundwater Resources of Maharashtra. Central Ground Water Board Ministry of Water Resources, Governament of India, Nagpur Maharashtra.

[6] Deolankar S.B., 1980. The Deccan basalts of Maharashtra state, India: their potential as aquifers. Ground Water, v.18, no.5, pp: 434–437.

[7] Deshpande B.G, Sen Gupta S.N., 1956. Geology and groundwater in the Deccan traps and the application of geophysical methods, Bull Series B GeolSurvInd, v.8, pp: 26.

[8] Dahlin, T.(2000), Electrode charge-up effects in DC resistivity data acquisition using multi electrode arrays. Geophys. Prospecting, v.48, no.1, pp: 181-187.

[9] Deshpande G. G., Geology of Maharashtra, Geological society of India, Bangalore. (1) 129-160 (1998).

[10] Kelly, E.W. (1976). Geoelectric sounding for delineating ground water contamination. Ground Water v. 14, pp.6-11.

[11] Krishnana M.S.(1982), Geology of India and Burma, Published by Higginbothams.

[12] Krishnana M.S. (1968),Geology of India and Burma, Published by Higginbothams.

[13] Kossinski, W.K. and Kelly, W.E. (1981). Geoelectric sounding for predicting Aquifer Properties, Groundwater, v.19, pp. 163-171.

[14] Matias, M.J.S. (2002). Squary array anisotropy measurements and resistivity sounding interpretation, Journal of Applied Geophysics v. 49, pp. 185-194.

[15] Rai,S.N. Thiagarajan, S., Ratnakumari, Y., Kumar, D., 2012.Exploring Deccan traps for groundwater in parts of Kalmeshwar taluk, Nagpur district, India, Journal of Applied Hydrolgy.

[16] Ram Raj Mathurand Rao, K. S., 2018, Efficacy of Integrated Geophysical Techniques in Delineating Groundwater Potential Zones in the Deccan Basalt Region of Maharashtra,J. Ind. Geophys. Union, v.22, no.3, pp: 257-264.

[17] Shettigara, V.K. and Adams, W.M., 1989. Detection of lateral variations in geological structures using electrical resistivity gradient profiling, Geophysical Prospecting, v.37, no.3, pp: 293-310.

[18] Subbarao, K.V., 1988, Deccan Flood Basalts, Geol. Soc. India Mem.No.10,

393 p. 21. Song, S.H., Lee, J.Y.

[19] Telford, W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., 1976; Yadav and Singh, 2007 Applied Geophysics, Oxford & IBH, pp: 860.

[20] Zohdy, A. A. R., (1989). A New Method for the Automatic Interpretation of Schlumberger and Wenner Sounding Curves, Geophysics, v. 54 (2), 245p.

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