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ELECTRICAL RESISTIVITY STUDIES FOR GROUNDWATER EXPLORATION IN THE TILGANGA RIVER BASIN OF WALAWA, SHIRALA BLOCK OF SANGLI DISTRICT, MAHARASHTRA, INDIA

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ABSTRACT

A geophysical survey was carried out in the Tilganga River basin located in the northwestern region of the Sangli district, Maharashtra, utilizing the electrical resistivity method. Eighteen vertical electrical soundings (VES) were conducted to identify potential groundwater zones and to assess the thickness of the weathered formations that influence the groundwater dynamics of aquifers within alluvial deposits and trap rock. The interpretation of the VES data was performed using the IP2IWIN software, which facilitated the creation of layered models for each sounding through curve matching techniques. The study identified four distinct strata. The first layer exhibited resistivity values ranging from 2.6 ohm-m to 140 ohm-m, with thickness measurements between 0.2 m and 0.9 m. The second layer displayed resistivity values from 2.1 ohm-m to 29.33 ohm-m. For the third layer, resistivity varied from 2.75 ohm-m to 33.9 ohm-m, with thicknesses ranging from 5.2 m to 52.2 m. The fourth layer showed significantly high resistivity, reaching up to 949 ohm-m from the village of Mahadevwadi to Karmale and Rethare Dharan. The KH curve type was observed in 30% of the VES locations, while KQ and HK types were noted in 20% of the sites. Results from VES 2 and 8 indicated high resistivity values in the cross-section analysis. Pseudo cross-sections and resistivity maps were generated using IPI2WIN software. The resistivity data from VES 9 and VES 10 revealed the presence of hard compact basalts at depths of 13 m and 20 m, respectively. Additionally, VES 2 and 8 indicated high resistivity zones at depths ranging from 4 m to 20 m. The findings from the VES were compared with existing borehole and tube well logging data for validation.
Keywords: Groundwater exploration, IP2IWIN software, pseudo section, cross-section, Tilganga River.

INTRODUCTION

Sangli is a district located in the Western Maharashtra region of India. This area is experiencing a decline in water levels due to the rapid expansion of agricultural and industrial activities. Groundwater serves as a crucial resource for agriculture in the region. Areas that face excessive water extraction are experiencing groundwater scarcity, underscoring the necessity for accurate assessment of available subsurface water resources and the implementation of effective measures to ensure the sustainable availability of water. The study area, characterized by its unique geohydrological conditions and climatic factors, exhibits varied aquifer behavior, particularly influenced by the Deccan trap rock found along the banks of the Tilganga River basin. The Schlumberger array method (Dr. Jaydeep Nikam, 2023) (Jaydeep Nikam, 2023) is employed to identify subsurface lithology, offering ease of operation and electrode configuration that enhances the signal-to-noise ratio, provides good resolution of horizontal layers, and improves depth sensitivity. (Patil.S.N., Kachate.N.R, Marathe.N.P., Ingle.S.T. and Golekar.R.B., 2015) (Zambre & Thigale , 1980). (Dr. Jaydeep Nikam, 2023)

Study area

The current research area, as illustrated in Figure 1, encompasses the upper Krishna watersheds designated as Kr/42, covering approximately 147.36 square kilometers. It is situated between the coordinates of Latitude 17°05'24"N to 17°01'48"N and Longitude 74°05'24"E to 74°19'48"E, as per GSI Toposheet numbers 47K/4 and 47K/8 at a scale of 1:50,000. The region experiences a semi-arid climate, with average annual rainfall ranging from 889.30 mm to 1005.90 mm in the Walawa taluka. The Krishna River flows along the eastern boundary of the study area, which is characterized by hilly terrain on the western side and a gentle slope to the east. The soil composition in this area varies from brown-black to dark-black soils.

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Geology of the study area

The geological framework of the study area encompasses the Deccan volcanic basalts (Cretaceous to the lower Eocene period), specifically within the Purandergarth formation of the Deccan volcanic Province. (DVP) (GSI, 1999)

DeccanTraps

Deccan traps occupies all of study area, The study area is covered by Deccan volcanic rocks of Cretaceous to Eocene age showing vesicular and mixed Basalt structures (Nayak, 2006). (GSI, 1999)

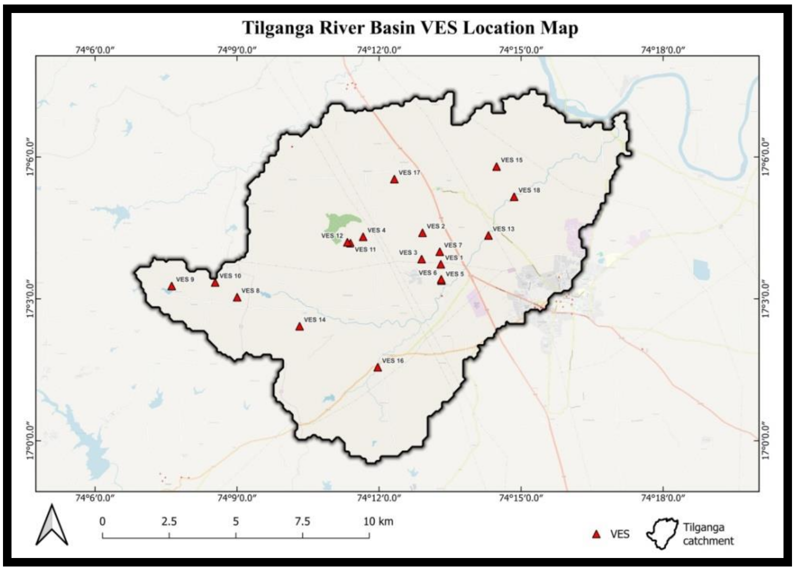

Figure: 1 Location map of study area.

Hydrogeology of the study area

The presence of groundwater across various terrains is significantly influenced by factors such as topography, climate, and geological conditions. Typically, the groundwater gradient trends eastward. Within the study area, groundwater wells indicate a water level at a depth of 12.60 meters during the pre-monsoon season, which subsequently rises to depths ranging from 2.60 meter to 3.00 meters in the post-monsoon period. Additionally, a weathered or fractured basalt zone contributes to a substantial yield of water.

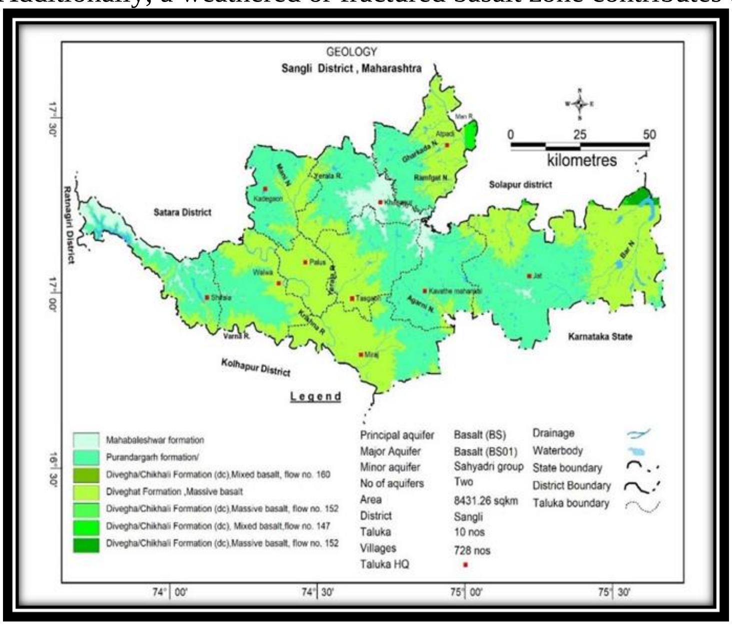

Figure-2 Geological map of the study area (GSI, 1999)

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METHODOLOGY

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$\rho a = \pi\ [(L/2)^2 - (b/2)^2]/b \ X\ V/I$

Where, L and b is the current and potential electrode spacing respectively.

The interpretation of the VES were carried out by the IPI2WIN software in terms of layered resistivity model ρ1, ρ2, ρ3 and ρ4 matching measured curves with a set of theoretically calculated master curves interpreted using master curves techniques. (Andrader.R., (2011)) (Zambre & Thigale , 1980) (Dr. Jaydeep Nikam, 2023)The preparation of the VES pseudo cross section and resistivity cross section maps was accomplished through the utilization of the IP2IWIN geo-scientific software. (Bobachve.A., 2003).

Vertical Electrical Sounding

The Schlumberger configuration is characterized by a linear arrangement of four electrodes. (Andrader.R., (2011)) This specific setup of current and potential electrodes is intentionally structured to maintain a ratio where the distance between the inner and outer electrodes is one-fifth of the overall electrode spacing. Throughout the survey process, the distance between the current electrodes is progressively increased, while the positions of the potential electrodes are kept constant until the measured voltage decreases to a point that is insufficient for precise measurement. (Debabrata Nandi, 2015). (Dr. Jaydeep Nikam, 2023)

The electrical resistivity prospecting for groundwater exploration is reported by many authors The vertical electrical resistivity method is widely used to estimate the thickness of over burden, weathered and fractured zones (Debabrata Nandi, 2015) (Patil.S.N., Kachate.N.R, Marathe.N.P., Ingle.S.T. and Golekar.R.B., 2015) . Wenner and Schlumberger electrode configuration methods are commonly utilized in geophysical studies, with the Schlumberger method being particularly favored due to its efficiency and ability to produce high-resolution results. In the current investigation, a model comprising three to four layers has been developed across 18 locations within the study area. Two cross sections, labeled AB and CD, extend from East to West. The resistivity data collected in this study has been compared with the logging data from existing borewells and dug wells in the region. (Zambre & Thigale , 1980)The generalized resistivity value ranges for various lithological units in the study area have been established based on recommendations from previous researchers, as detailed in Table 1.

Table.1Litho unit Resistivity

Sr. No.	Range of the Resistivity	Litho Unit
1	4-6 Ω m	Black Cotton soil /Regilith
2	6-10 Ω m	Black cotton soil with calcified soil/Murum
3	10-12 Ω m	Black cotton soil with Murum
4	12-26 Ω m	Highly weathered and fractured Basalt
5	26-60Ω m	Highly fractured Basalt
6	60-100 Ω m	Highly Fractured Basalt
7	100-250Ω m	Weakly Fractured Basalt
8	>250 Ω m	Hard compact Basalt.

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RESULTS AND DISCUSSION

The analysis of the data was conducted through curve matching methodologies across 18 Vertical Electrical Sounding (VES) sites, with the resistivity and thickness of the geo-electrical layers detailed in Table 2. The VES data were derived from various interpretations facilitated by the computer software IP2IWIN (Bobachve.A., 2003). Within the study area, models comprising three to four layers were successfully developed.

The initial layer of the model exhibits a resistivity range from 4 Ω m to 140 Ω m, with a thickness varying between 0.29 m and 0.9 m. It is possible that VES 1 and 3 are composed of a substantial layer of black cotton soil interspersed with kankars. The second layer of the model is characterized by a compacted clay bed observed at VES 5, 6, 7, 13, 15, 17, and 18, extending to depths between 1 m and 8.53 m, which also displays a specific resistivity.

The resistivity values range from 2.1 Ω m to 42.6 Ω m, with VES points 2, 4, 11, 12, 6, and 7 indicating low resistivity, which implies the presence of clay with pockets. The maximum resistivity observed in the third layer model reaches 889 Ω m and 1165 Ω m, occurring at depths between 5 m and 29 m, where compact basalt is identified at VES 17 and 9. In contrast, VES 2 and 3 exhibit resistivity values of 87.7 Ω m and 949 Ω m, respectively, at a depth of 90 m in the fourth layer model, suggesting the presence of hard and compact rock. Additionally, VES 5 shows a resistivity of 53.8 Ω m at a depth of 60 m, indicating weathered fractured basalt. A pseudo-section and cross-section were created using IPI2WIN software, revealing that the western part of the study area (VES 2) has high resistivity values extending to a depth of 8 m, followed by a low resistivity zone between 8 m and 20 m, and a continued low resistivity zone from 20 m to 100 m. Furthermore, VES 18, located in the eastern part of the study area, distinctly indicates a low resistivity zone at a depth of 30 m.

In section CD, the results from VES 8 indicate the presence of a high resistivity zone at shallow depths within the village. The resistivity cross sections from VES 7, 8, and 9 reveal a low resistivity zone located between depths of 40 meters and 100 meters, which is associated with compact basalt. This finding is corroborated by the lithological data obtained from the village's Borewell, as illustrated in figure 4.

CONCLUSION

The evaluation of vertical electrical resistivity plays a crucial role in pinpointing areas that exhibit considerable potential for groundwater resources. Analyzing the geophysical properties of the Deccan Trap and black cotton soils reveals varying resistivity levels across different sections of the study area. Specifically, VES 2 (Peth) and VES 10 and VES 09 (Karmale) exhibit high resistivity at shallow depths, indicating the presence of hard rock formations. Conversely, the villages of Kapuskhed-Bahe, Peth, and Nerale display low resistivity zones within the depth range of 3 to 15 meters, suggesting these areas may possess favorable conditions for groundwater accumulation. Furthermore, the cross-sectional profile CD, which encompasses the villages of Kedarwadi, Peth, and Rethare Dharan, highlights a high resistivity zone that signifies the presence of Compact Basalt The observed variations in resistivity could be attributed to the presence of alternating layers of extensively weathered rock or fractured basalt, as well as the compact basalt layer located at the surface in the study area. Both fractured basalt and interflow zones serve as significant sources of groundwater. The resistivity cross-section analysis reveals distinct zones of low and high resistivity. The Vertical Electrical Sounding (VES) technique proves to be effective in identifying areas of groundwater potential.

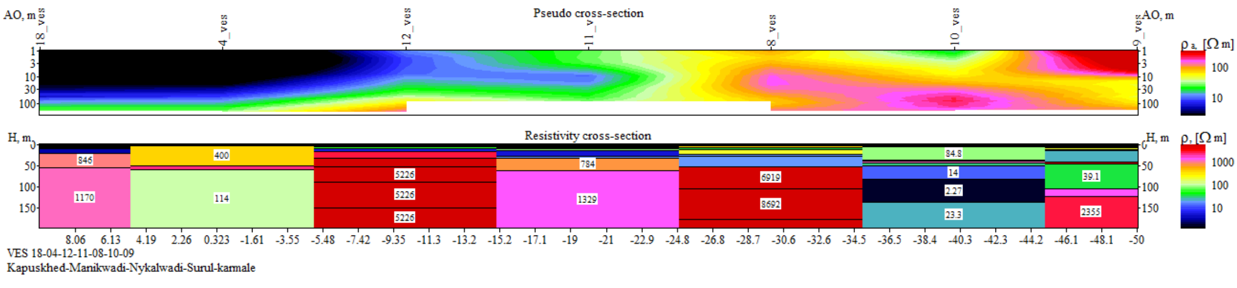

Figure-3 Profile AB resistivity cross section and pseudo cross section.

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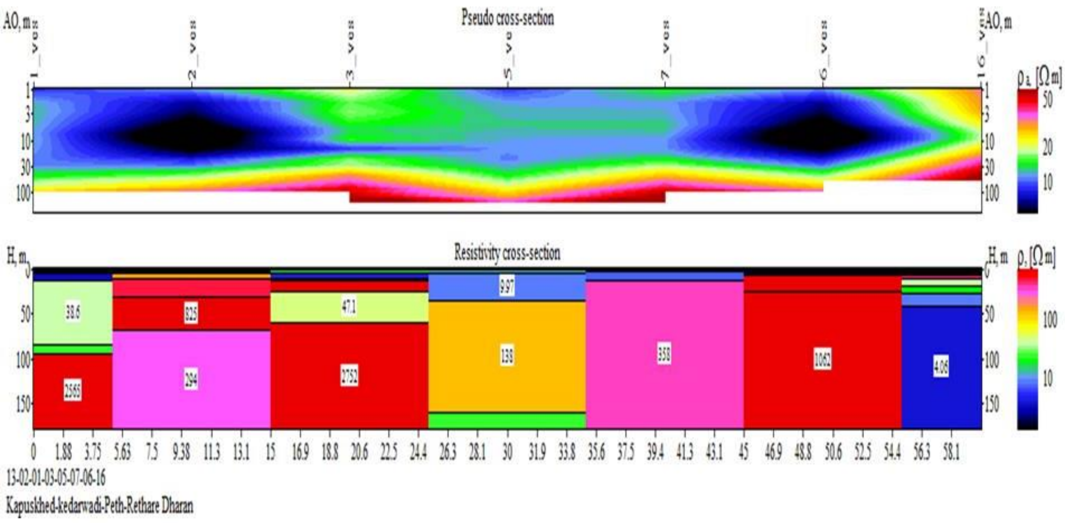

Figure-4 Profile CD resistivity cross section and pseudo-cross section

Table-2 Resistivity and thickness of geo-electrical sections.

Ves no.	Location	Latitude	Longitude	Elevation amsl	Resistivity(Ωm)				Thickness(m)				Curve Type
					Layer I	Layer II	Layer III	Layer IV	Layer I	Layer II	Layer III	Layer IV	
1	Peth	17° 0'25.01"N	74°13'15.24"E	501	5.74	91	3.54	30.2	0.5	1.2	3.02	12	KH
2	Peth	17° 4'23.83"N	74°12'55.03"E	502	20.4	20.7	1.04	18.7	1.15	2.53	6.99	19.2	KH
3	Mahadevwadi	17° 3'50.44"N	74°12'53.91"E	556	36.5	18.6	4.16	91	1.2	4.59	9.82	11.8	KH
4	Manikwadi	17° 4'18.78"N	74°11'39.78"E	540	0.757	0.185	0.4	400	0.6	0.88	0.87	20	HK
5	Peth	17° 3'23.30"N	74°13'19.03"E	500	6.67	50.1	9.97	138	0.5	5.22	29.8	126	HK
6	Peth	17° 3'43.89"N	74°13'18.23"E	512	22.33	10.3	1.74	255	0.83	1.27	4.49	18.9	KH
7	Nerale	17° 3'59.79"N	74°13'16.91"E	460	26.4	47.3	7.29	255	1.445	0.74	10.8	20	KH
8	Karamle	17° 3'2.14"N	74° 9'0.12"E	740	146	19.7	20.5	84	0.534	0.252	0.771	-	K
9	Karamle	17° 3'16.37"N	74° 7'37.18"E	745	372	102	889	374	0.5	0.167	1.26	0.508	KQ
10	Karamle	17° 3'20.91"N	74° 8'32.26"E	746	9.62	1650	9	173	0.552	0.138	1.1	-	KQ
11	Manikwadi	17° 4'10.73"N	74°11'23.74"E	540	25.35	16.6	3.81	28.5	2.05	0.95	3.9	80.8	KH
12	Nykalwadi	17° 4'11.83"N	74°11'19.79"E	560	18.2	9.02	55.3	55.3	1.05	5.9	6.63	8.94	KQ
13	Kapuskhed	17° 4'20.47"N	74°14'18.58"E	462	18.2	1.98	9.02	55.53	0.5	5.9	6.63	8.8	KQ
14	Surul	17° 2'25.28"N	74°10'19.26"E	640	102	54.4	14.4	37.05	0.67	1.14	2.2	4.08	KH
15	Nerala	17° 5'47.84"N	74°14'28.89"E	465	4.75	1.04	11.8	1.7	0.546	0.246	0.208	20	KH
16	Rethare Dharan	17° 1'33.31"N	74°11'58.32"E	520	31	89.9	3.67	5927	1.42	0.457	1.71	-	KH
17	Kedarwadi	17° 5'31.89"N	74°12'19.33"E	510	150	32	1165	13	0.6	0.62	1.17	5.36	KQ
18	Kapuskhed-Bahe	17° 5'9.57"N	74°14'51.15"E	460	3.25	1.02	7.01	0.419	5.09	0.325	0.989	-	HK

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