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ASSESSMENT OF AVAILABILITY OF GROUNDWATER USING VES & IT'S SUITABILITY FOR IRRIGATION PURPOSE, SAMBHAJINAGAR, MAHARASHTRA

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Abstract

The assessment of groundwater availability using Vertical Electrical Sounding (VES) is a widely used geophysical technique to understand subsurface hydrogeological conditions. The method provides critical information about groundwater availability, aquifer thickness, and the quality of water. Assessed groundwater availability in Chhatrapati Sambhajinagar (formerly Aurangabad), Maharashtra, involves analyzing recent data and studies to understand current conditions using georesistivity meter, electrodes, and cables. The sample were collected from suitable sampling points such as A (Barapulla Gate), site B (Makai Gate), site C (Income Tax Office), site D (Banewadi), site E (Waladgaon), and site F (Patoda) of Kham River at Sambhajinagar. VES was effective in identifying multiple aquifers in the region. High resistivity zones corresponded to fresh groundwater, while low resistivity zones indicated saline water. The water quality of the left bank and right bank of Kham river was observed as poor water but meet to utiliged for irrigation perpose or agriculture actvities.

Key words: Vertical Electrical Sounding techniques, ground water quality, water quality index.

Introduction

Agriculture is one of the significant sources of livelihood for the population resides in rural areas and their livelihoods depend upon it (Alwan et al. 2019). The challenge of implementing prosperous agriculture in the current time requires an integrated and systemic approach that should address sustainable use and management of natural resources, especially water, to ensure food security and agricultural livelihoods. However, many hindrances are facing this intention in Maharshtra, India including deteriorated infrastructure, poor operation and maintenance of the systems, weak governmental support and lack of regulatory national plans (FAO, 2012). Water is a crucial need for humans in many aspects of living including irrigation of agricultural crops; however, there is a gradual decrease in the water resources of the world, especially in the arid and semi-arid areas, with a confronting increase in requirement due to the rapid growth of the world’s population and industrial/agricultural advancement.

Groundwater is probably less contaminated from any hindrance created by climate change, droughts, and floods compared with surface water (Barbieri et al., 2021; Noor et. al., 2023; Zhang et. al., 2023. Generally, groundwater reservoir provides reliable, safe, and sustainable water for future generations if the source is judiciously managed. This requires considerable policies and laws, strategies and guidance, monitoring and management as well as investments and stakeholders (Saito et al., 2021).

Knowledge of groundwater potential vis-à-vis the hydro-geophysical and physiochemical investigation in the area is of fundamental importance since there have been cases of failed boreholes, to reduce well failure, thereby increasing precision and result oriented groundwater resources management programs in the area. It is anticipated that the result of the research will be useful material on the use of groundwater by both domestic and agricultural proposes. It can also serve as a background document for groundwater resources within and outside the research area.

Understanding the ground water potential in relation to hydro-geophysical and physiochemical studies in the study area is crucial as ther have been instances of unsuccessful boreholes.This knowledge aims to minimize well failure and enhance the effectiveness of groundwater resource management initiatives in the area. It is expected that the outcome of the study will provide valuable information on groundwater utilization for both domestic as well as agricultural purposes.

Study Area

Sambhajinagar serves as the headquarters for both the district and the division of Marathwada. It is located at Kham River with Latitude N: 19° 53' besides longitude E: 75° 20' of geographical position. The city of Sambhajinagar is crossed by the Kham River. The sample were collected monthly during December 2022 to May – 2024 from site A (Barapulla Gate), site B (Makai Gate), site C (Income Tax Office), site D (Banewadi), site E (Waladgaon), and site F (Patoda). The location of study area and selected sites detected in fig.01 to fig. 02.

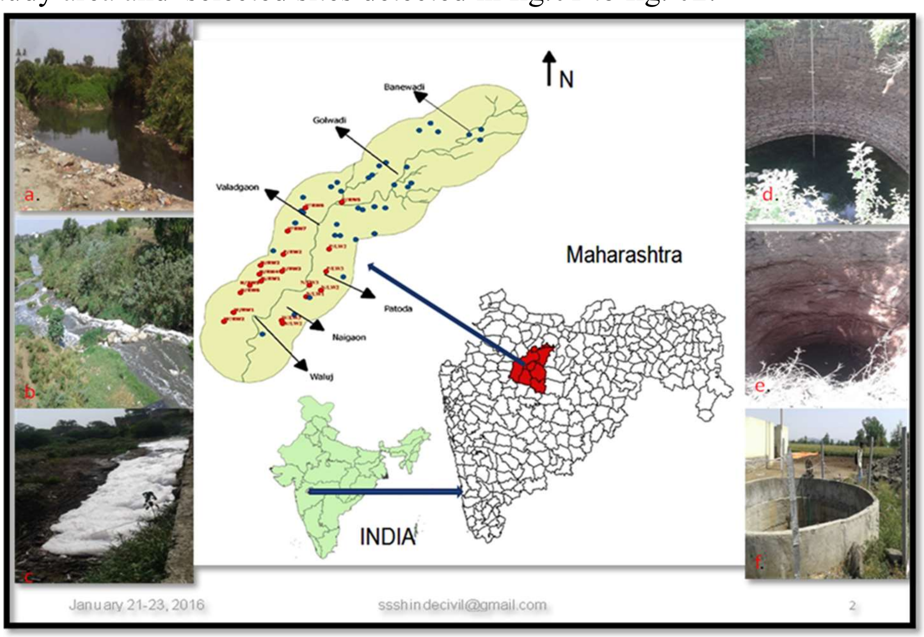

Fig.01: Study area of Kham River

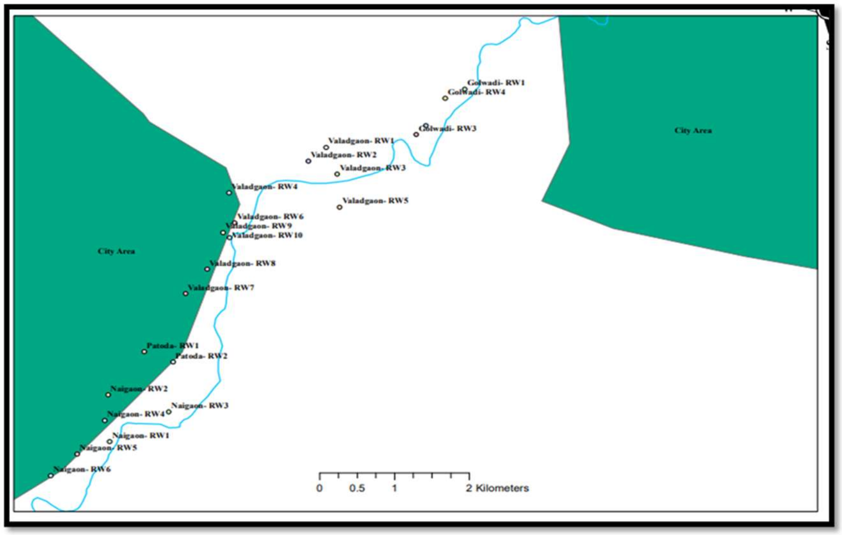

Fig.02: Study sites of Kham River study Area

Research Methodology

Vertical Electrical Sounding (VES) is a geophysical method used to investigate subsurface layers by measuring their electrical resistivity. It is particularly effective for assessing groundwater resources. The methodology can be broken down into several key steps: Identify suitable sites based on preliminary hydrogeological surveys, maps, or satellite data and ensure the area is free of significant surface obstacles that may interfere with measurements.

Vertical Electrical Sounding is a geophysical method used to investigate subsurface geological structures by measuring the electrical resistivity of the ground at various depths. For the determination of geological structure the locations selected based on geological maps, previous studies, and accessibility. The Common setups include the Schlumberger and Wenner configurations and placed the electrodes in the chosen configuration. In the Schlumberger method, for example, two current electrodes (A and B) and two electrodes are used and the distance between electrodes, which will determine the depth of investigation. Use Ohm's Law and the electrode configuration geometry to calculate apparent resistivity.

$$Pa = K\,\frac{\boldsymbol{V}}{\boldsymbol{I}}$$

Where K is geometric factor on the electrode configuration, V is the measured voltage, and I is the injected current. Conduct several soundings at different locations or depths for a comprehensive view. The depth of investigation generally increases with larger electrode spacing.

Results and Discussion

Station A

The Distance between electrodes is increased at regular intervals as per the Schlumberger method from 1.5m to 60m. The Apparent Resistivity calculated between spacing factor and resistivity values obtained from the equipment for Station A is between the range of 23 and 36 Ohm/m. The Lowest apparent resistivity values are observed at depth between 3 to 3.5m, 6 to 9m and 35 to

40m. The Lower apparent resistivity values indicate a more porous and permeable strata which is indicative of aquifer formation. The Apparent resistivity at depth at 1 to 3m, 4 to 4.5m, 9 to 10m and 40 to 53m is indicative of weathered or permeable strata with moderate porosity. The Highest apparent resistivity is at depth of 1.3m, 20 to 26m and below 45m. At these depths the rock is hard or compact with no permeability/porosity whatsoever. No water content will be found at these depths. Variations in apparent resistivity at different depths can be attributed to changes in subsurface lithology, moisture content, and other geological factors. For instance, higher resistivity values may correspond to dry, compact materials, while lower values could indicate saturated or clay-rich layers.The variation in resistivity depicted at Fig. no.3 and Table 1.

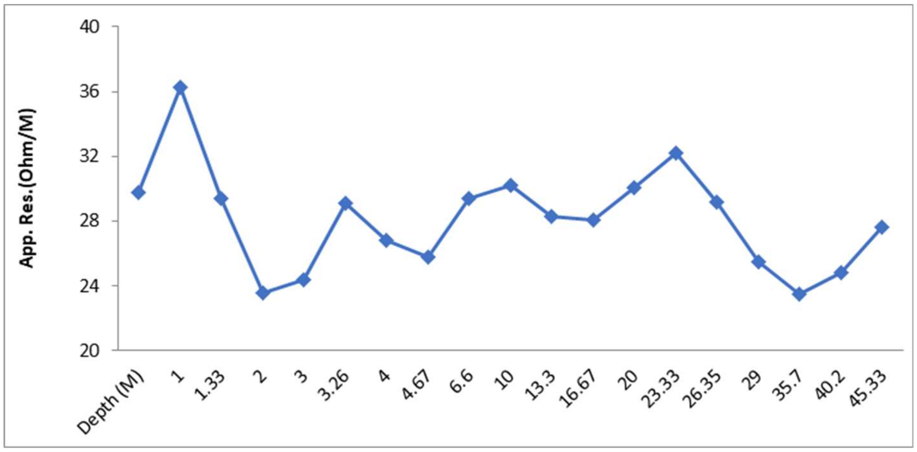

Fig.3: Apparent Resistivity at different depth at Station A

Table 1: Variation in Apparent Resistivity (Ohm/m) at Station A.

Sr. No	AB/2(m)	MN/2(m)	R(Ohms)	App. Rest. (Ohm/m)	Depth (m)
1	1.5	0.5	0.21074	29.8	1
2	2	0.5	0.173	36.3	1.33
3	3	0.5	0.21361	29.4	2
4	4.5	0.5	0.2661	23.6	3
5	6	0.5	0.25738	24.4	3.26
6	7	0.5	0.21581	29.1	4
7	7	2	0.23433	26.8	4.67
8	8	2	0.24341	25.8	6.6
9	10	2	0.21361	29.4	10
10	15	2	0.20795	30.2	13.3
11	20	2	0.22191	28.3	16.67
12	25	2	0.22349	28.1	20
13	30	2	0.20864	30.1	23.33

14	35	2	0.19503	32.2	26.35
15	40	2	0.21507	29.2	29
16	40	10	0.24628	25.5	35.7
17	45	10	0.26723	23.5	40.2
18	50	10	0.25323	24.8	45.33
19	60	10	0.22754	27.6	52.65

Station B

The Distance between electrodes is increased at regular intervals as per the Schlumberger method from 1.5m to 60m. The Apparent Resistivity calculated between spacing factor and resistivity values obtained from the equipment for Station B is between the range of 10 and 20 Ohm/m. The Lowest apparent resistivity values are observed at depth between 1 to 1.5m, 4m and 35 to 40m. Apparent resistivity values between 0.5 and 2 Ω·m were observed in aquifers with high salinity levels and contamination (Mazac, et. *al.* 1985). The Lower apparent resistivity values indicate a more porous and permeable strata which is indicative of aquifer formation. The Apparent resistivity at depth at 2 to 4m, 4.5 to 10m, 40 to 45m and 50 to 52m is indicative of weathered or permeable strata with moderate porosity. The Highest apparent resistivity is at depth of 4.5 to 10m, 16 to 30m and below 52m. At these depths the rock is hard or compact with no permeability/porosity whatsoever. No water content will be found at these depths. According to Sundararajan al. et (2012) indicated high resistivity values in the upper layers, which they attributed to unsaturated and compacted dry soils. The variation in resistivity shown Fig. no.4 and Table 2.

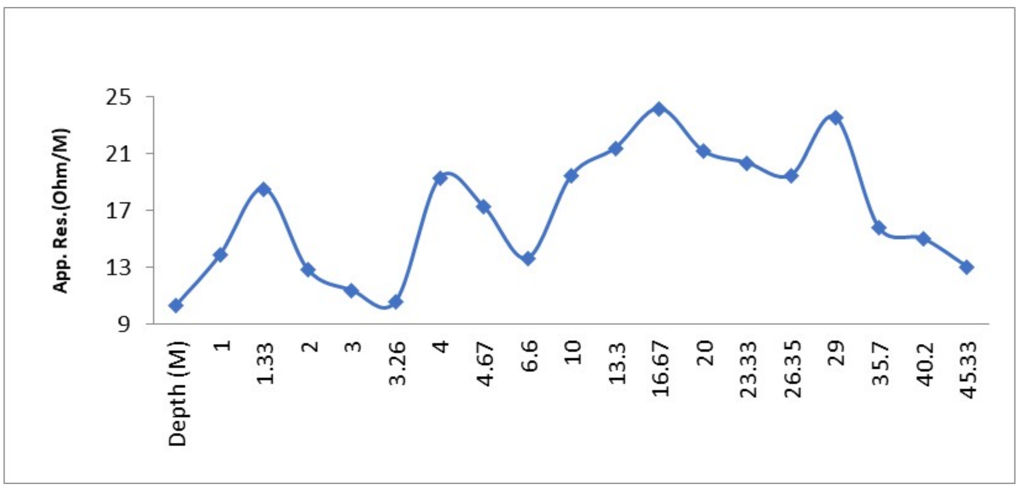

Fig. 4: Apparent Resistivity at different depth at Station B

Table 2: Variation in Apparent Resistivity (Ohm/m) at Station B.

Sr.No	AB/2(m)	MN/2(m)	R(Ohms)	App. Rest. (Ohm/m)	Depth (m)
1	1.5	0.5	0.609709	10.3	1
2	2	0.5	0.453102	13.86	1.33

3	3	0.5	0.33891	18.53	2
4	4.5	0.5	0.489097	12.84	3
5	6	0.5	0.551845	11.38	3.26
6	7	0.5	0.593012	10.59	4
7	7	2	0.325726	19.28	4.67
8	8	2	0.363636	17.27	6.6
9	10	2	0.460748	13.63	10
10	15	2	0.322879	19.45	13.3
11	20	2	0.293595	21.39	16.67
12	25	2	0.259934	24.16	20
13	30	2	0.296506	21.18	23.33
14	35	2	0.308751	20.34	26.35
15	40	2	0.322382	19.48	29
16	40	10	0.26644	23.57	35.7
17	45	10	0.397972	15.78	40.2
18	50	10	0.418109	15.02	45.33
19	60	10	0.481226	13.05	52.65

Station C

The Distance between electrodes is increased at regular intervals as per the Schlumberger method from 1.5m to 60m. The Apparent Resistivity calculated between spacing factor and resistivity values obtained from the equipment for Station C is between the range of 29 and 46 Ohm/m. The Lowest apparent resistivity values are observed at depth between 16 to 20m, 23 to 25m, to 40m. The Lower apparent resistivity values indicate a more porous and permeable strata which is indicative of aquifer formation. The Highest apparent resistivity is at shallow depth of 1.3 to 2.5m, 4.5 to 5.5m and near 35m. At these depths the rock is hard or compact with no permeability/porosity whatsoever. No water content will be found at these depths. The Rocks found at the above depths will be hard compact basalt and with poor recharge conditions.

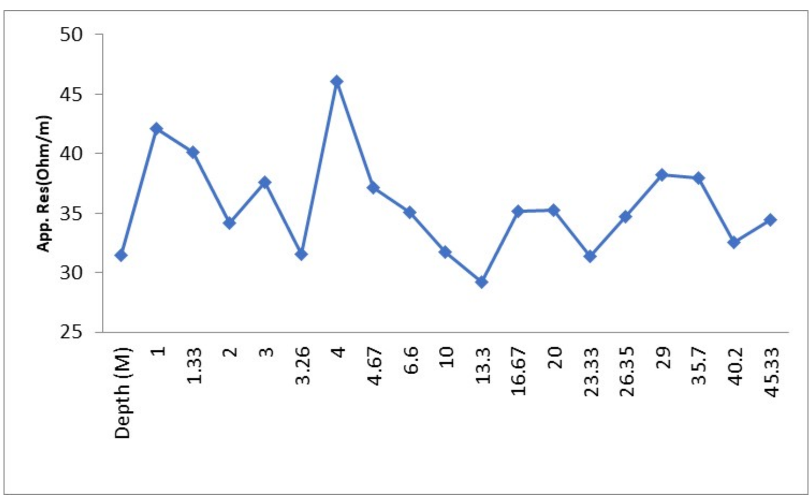

Fig. 5: Apparent Resistivity at different depth at Station C

Table 3: Variation in Apparent Resistivity (Ohm/m) at Station C.

Sr. No	AB/2(m)	MN/2(m)	R(Ohms)	App. Rest. (Ohm/m)	Depth (m)
1	1.5	0.5	0.199365	31.5	1
2	2	0.5	0.149169	42.1	1.33
3	3	0.5	0.156413	40.15	2
4	4.5	0.5	0.183733	34.18	3
5	6	0.5	0.166844	37.64	3.26
6	7	0.5	0.19886	31.58	4
7	7	2	0.136167	46.12	4.67
8	8	2	0.168908	37.18	6.6
9	10	2	0.178815	35.12	10
10	15	2	0.197795	31.75	13.3
11	20	2	0.214995	29.21	16.67
12	25	2	0.178612	35.16	20
13	30	2	0.178055	35.27	23.33
14	35	2	0.200255	31.36	26.35
15	40	2	0.181084	34.68	29
16	40	10	0.164183	38.25	35.7
17	45	10	0.165437	37.96	40.2
18	50	10	0.192875	32.56	45.33
19	60	10	0.182293	34.45	52.65

Station D

The Distance between electrodes is increased at regular intervals as per the Schlumberger method from 1.5m to 60m. The Apparent Resistivity calculated between spacing factor and resistivity values obtained from the equipment for Station D is between the range of 40 and 80 Ohm/m. The Apparent resistivity values are extremely high and indicate no aquifer formation, shallow or deep. The Loose soil or weathered rock can be found at extremely shallow depth till about 2.5m. The Strata below 3m is most probably fractured Basalt with very little permeability. The Sub surface geology consists of Amygdaloidal and Compact Basalt which allows no movement or water content. No Groundwater extraction is possible at the location.

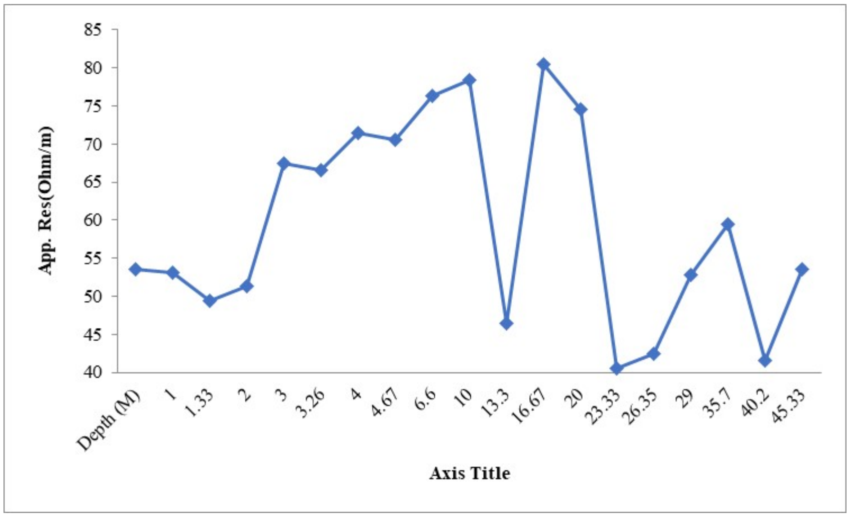

Fig. 6: Apparent Resistivity at different depth at Station D

Table 4: Variation in Apparent Resistivity (Ohm/m) at Station D.

Sr.No	AB/2(m)	MN/2(m)	R(Ohms)	App. Rest. (Ohm/m)	Depth (m)
1	1.5	0.5	0.11716	53.6	1
2	2	0.5	0.11827	53.1	1.33
3	3	0.5	0.12713	49.4	2
4	4.5	0.5	0.12242	51.3	3
5	6	0.5	0.09318	67.4	3.26
6	7	0.5	0.09444	66.5	4
7	7	2	0.08796	71.4	4.67
8	8	2	0.08908	70.5	6.6
9	10	2	0.08231	76.3	10
10	15	2	0.0801	78.4	13.3
11	20	2	0.13505	46.5	16.67
12	25	2	0.07801	80.5	20
13	30	2	0.08418	74.6	23.33
14	35	2	0.15506	40.5	26.35
15	40	2	0.14777	42.5	29
16	40	10	0.11894	52.8	35.7
17	45	10	0.10572	59.4	40.2
18	50	10	0.15133	41.5	45.33
19	60	10	0.11716	53.6	52.65

Station E

The Distance between electrodes is increased at regular intervals as per the Schlumberger method from 1.5m to 60m.The Apparent Resistivity calculated between spacing factor and resistivity values obtained from the equipment for Station D is between the range of 10 and 35 Ohm/m. The Apparent resistivity values are low at depth of 1.3 to 2m. Only at this depth the resistivity values are low which indicates free flowing strata. Due to the low depth of the above-mentioned resistivity, the strata is mostly loose soil with moderate water content. The Moderate apparent resistivity is found at depths 2 to 4m, 13 to 18m and 45 to 50m. These low resistivity's in between the high values of apparent resistivity's indicate confined aquifer formation. Confined Aquifers are water tables trapped between two layers of hard rock or confining bed. The High resistivity values found at depths 10m, 20 to 30m and below 52m are indicative of confining bed or hard impermeable compact Basalt.

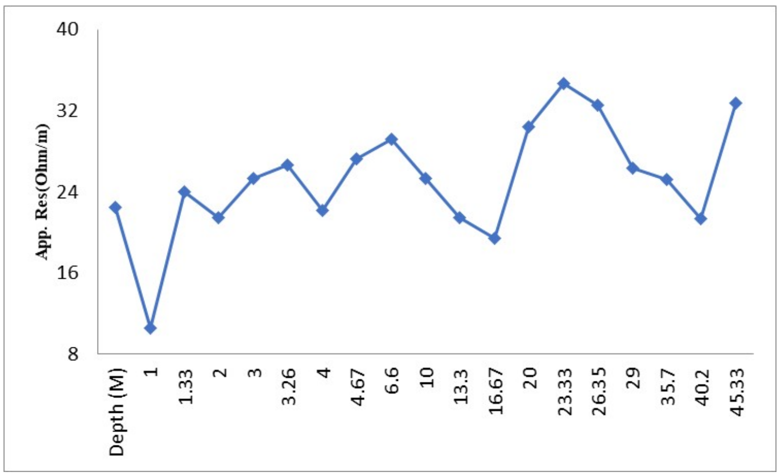

Fig. 7: Apparent Resistivity at different depth at Station E

Table 5: Variation in Apparent Resistivity (Ohm/m) at Station E.

Sr. No	AB/2(m)	MN/2(m)	R(Ohms)	App. Rest. (Ohm/m)	Depth (m)
1	1.5	0.5	0.279111	22.5	1
2	2	0.5	0.595261	10.55	1.33
3	3	0.5	0.261994	23.97	2
4	4.5	0.5	0.293047	21.43	3
5	6	0.5	0.248319	25.29	3.26
6	7	0.5	0.235824	26.63	4
7	7	2	0.283138	22.18	4.67
8	8	2	0.230459	27.25	6.6
9	10	2	0.214995	29.21	10
10	15	2	0.248516	25.27	13.3
11	20	2	0.293047	21.43	16.67

12	25	2	0.323711	19.4	20
13	30	2	0.206783	30.37	23.33
14	35	2	0.181241	34.65	26.35
15	40	2	0.19329	32.49	29
16	40	10	0.238149	26.37	35.7
17	45	10	0.249503	25.17	40.2
18	50	10	0.293595	21.39	45.33
19	60	10	0.191756	32.75	52.65

Station F

The Distance between electrodes is increased at regular intervals as per the Schlumberger method from 1.5m to 60m. The Apparent Resistivity calculated between spacing factor and resistivity values obtained from the equipment for Station D is between the range of 15 and 40 Ohm/m. The Apparent resistivity values are low at depth of 1.3 to 2m, 4 to 4.5m indicative of porous strata. The Increased apparent resistivity is observed at depth below 4m upto 13.5m. At these depths the sub surface strata is of hard rock with little to no permeability. The Resistivity values decrease after 13.5 to 20m which is indicative of confined aquifer and can be utilized for groundwater extraction. The Apparent resistivity values are maintained till 35.5m which states the presence of hard rock. Another deep confined aquifer is detected at depths between 35.5 to 40m, at which point resistivity drops substantially. The Resistivity values increase with increasing depth and the presence of hard rock is observed.

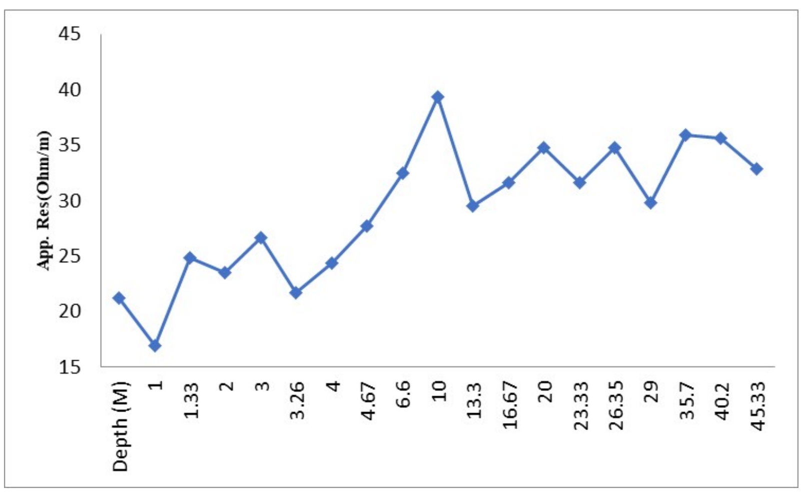

Fig. 8: Apparent Resistivity at different depth at Station F

Table 6: Variation in Apparent Resistivity (Ohm/m) at Station F.

Sr.No	AB/2(m)	MN/2(m)	R(Ohms)	App. Rest. (Ohm/m)	Depth (m)
1	1.5	0.5	0.29623	21.2	1

2	2	0.5	0.37028	16.96	1.33
3	3	0.5	0.25323	24.8	2
4	4.5	0.5	0.26678	23.54	3
5	6	0.5	0.23582	26.63	3.26
6	7	0.5	0.29007	21.65	4
7	7	2	0.25759	24.38	4.67
8	8	2	0.22696	27.67	6.6
9	10	2	0.19353	32.45	10
10	15	2	0.15972	39.32	13.3
11	20	2	0.21303	29.48	16.67
12	25	2	0.19886	31.58	20
13	30	2	0.18046	34.8	23.33
14	35	2	0.19873	31.6	26.35
15	40	2	0.18056	34.78	29
16	40	10	0.21074	29.8	35.7
17	45	10	0.17498	35.89	40.2
18	50	10	0.17616	35.65	45.33
19	60	10	0.19135	32.82	52.65

Conclusion:

- In conclusion, the resistivity survey carried out on Stations A to F indicates the sub surface geology and indicates the presence of groundwater.
- Station A and E shows the higher possibility of permeable sub surface strata as per the apparent resistivity data.
- Station D has the lowest amount of possibility of having any substantial amount of groundwater.
- Sub surface strata at Station D would be completely made up of hard compact basalt with no water movement between the rocks.
- Station B resistivity data indicates the presence of groundwater at shallow depth and indicates presence of fractured or vesicular basalt which are the perfect strata for aquifer formation.
- Station C study shows rock formations with very poor recharge conditions and very little groundwater presence can be detected.
- Station F study shows the presence of confined aquifers trapped between confined basaltic beds. Ample amount of groundwater can be detected at this station.

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