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Aquifer demarcation using Geophysical methods in Lakhmapur village, Dindori taluka, Nashik, Maharashtra, India

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Abstract

Aquifer demarcation is essential thing for socioeconomic activities like irrigation, domestic and industrial uses. Farmers and rural people who are dependent on agricultural land, causing externalities and implications on labour scarcity, ground water depletion, welfare loss and inefficiency. Hydrogeological and Geophysical studies are carried out in Lakhmapur village, to know the groundwater availability which is based on analysis and assessment for convenience of groundwater, where resistivity anomalies are validated with groundwater available in weathered zones at the interface between the overburden and bedrock. Due to heterogeneity in lithological units, the electrical resistivity also varies locally. In the present study, the three-layer sounding curves are found to be of two types, depending on the resistivity values, these are AA and HA types. Depth to basement in Lakhmapur village, varies from 8.616 m. to 12.13 m, at the confluence of village, the depth of the basement is maximum at about 12.13 m, it seems good groundwater zones. Depths are 7.712 m to 8.616 m in west side and depths are 10.17 m to 12.13 m in east side of study area, which are also seems good groundwater zones.

Keywords: Geophysical methods, Ohms law, AA and HA curves, aquifer depth

Introduction

The study area Lakhmapur village is located in between 18.33 degree and 20.53 degree North latitude and between 73.16 degree and 75.16 degree East Longitude at Northwest part of the Maharashtra state, at 565 meters above mean sea level. It is left bank of Kadawa river basin, which is situated between Palkhed and Karanjavan dams, it is rocky both in bed and bank, but the bed is wide, and the average volume of water is small compared with the area through which it flows. Irrigation works of considerable importance have been established on it. At its confluence with Godavari, a pick-up weir has been constructed, raising the upstream water levels and resulting in the formation of the Nandur Madhyameshwar reservoir.

Geoelectrical resistivity survey technique was used to study the availability of groundwater water. The resistivity meter (McOHM) was used to collect the vertical electrical sounding (VES) resistivity data at different locations, followed by Schlumberger electrode configuration, the collected data were interpreted in terms of resistivity and the outputs were observed by dug well groundwater. The combination of VES data and dug well groundwater data gives useful information on subsurface hydrogeologic conditions by observed that geoelectrical resistivity of the layers containing groundwater resistivity range between 25 to 30 Ωm and VES criteria of fit groundwater quality for aquifer resistivity values of 10 to 15 Ωm was valid for the locations. The results indicate that VES survey has the potential to identify the layer containing water and groundwater depth.

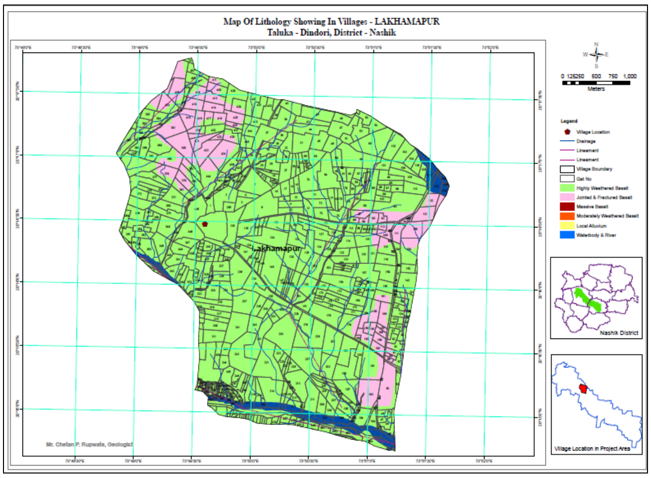

Fig 1: Lakhmapur village lithology map

Geologically of the study area covers the Deccan volcanic basalts (Cretaceous to lower Eocene age). showing vesicular and mixed Basalt structures. Figure 1 showing administrative location and lithology of Lakhmapur village.

Methodology

Hydrogeological field sampling was carried out in Lakhmapur village on left bank of Kadwa river. Sampling locations W1, W2, W3, - - -, W20 are located in the adjacent of river left bank and is characterized by the shallow depth. The Kadwa River passing through the Lakhmapur village receives rainwater sewage.

Basic Principles and Electrode configuration

Ohms law is the basic principle of electrical resistivity methods. In this method, a known amount of electrical current (I) is sent into the ground by pair of electrodes and the potentials (ΔV) developed due to current between electrodes, are measured by placing another pair of potential electrodes between them. The ratio of (ΔV/I) gives resistance (R) and by multiplying R with a geometric factor (k) of the electrode separation, the resistivity (ρa), which is inverse of conductivity of the ground, can be determined. It is obvious that the depth of penetration increases with increase in electrode spacing. There are number of electrode arrangements for the geophysical investigations (George and Frank, 1966).

Schlumberger electrode configuration

McOHM Resistivity meter manufactured by OYO Corporation, Tokyo, Japan was used to conduct the resistivity survey in the study area. The procedure involves the measurement of potential difference between other two electrodes in the vicinity of the current flow. The arrangement of the current electrodes and potential electrodes, voltmeter and ammeter and the battery, are shown in the

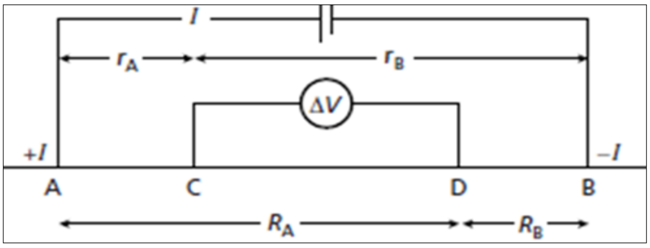

Fig 2: The apparent resistivity is obtained in the field.

Figure 2. Field Arrangement during the resistivity survey (Orellana and Mooney, 1966, 1972) [10]

In Schlumberger configuration, four electrodes are placed along a straight line in which the distance between the two inner potential electrodes is kept very close to each other compared to the distance between the current electrodes. The electrodes by which current is introduced into the ground, are called current electrodes and electrodes between which the potential difference is measured, are called potential electrodes. The apparent resistivity 'ρ_a' measured with this array is given by the formula.

$\rho_a = \Pi*((AB/2)^2 - (MN/2)^2)/MN)\ R$

Where R = V/I

$\rho_{a} =$ Apparent Resistivity

A, B=Current electrodes

M, N = potential electrodes.

V= Potential difference

I= Applied current

Vertical electrical sounding and Depth probing

Vertical electrical sounding stations were selected within the study area with respect to their topographic features. In practice, the distance between the potential electrodes is usually kept less than 1/5th of the distance between the current electrodes. the changes in ρ_a values measured (depth-wise), indicate variations like lithology, structure, etc. in the subsurface at the investigation point. Hence, this technique of VES is useful in horizontal and gently inclined structures. VES techniques are considered useful to determine the depth of the overburden, bed rock and aquifer.

Results and discussions

Analysis and Interpretation of the Resistivity data

The data obtained from VES, were analysed and interpreted using curve matching technique for 12 locations of Orellna and Mooney (1966, 1972), which is most common in the interpretation of the resistivity data. VES data is plotted on a double logarithmic transparent sheet with spacing (AB)/2 on the X axis and the apparent resistivity 'ρ_a' on the Y axis. The double logarithmic transparent sheet chosen has the same modulus as that of the theoretical curves available. The apparent resistivity values calculated from each measurement are plotted against their corresponding AB/2 values in a double logarithmic scale. The three layer master curves chosen for the match are from the album of curves prepared by Narayan and Ramanujachary (1967). The three layer sounding curves are of two types depending on the resistivity value; these are AA type (p1<p2<p3) and HA type (p1>p2<p3). The geoelectrical sections along a number of lines in different directions have been prepared, as interpreted form resistivity values, to study variations in lithology, and to demarcate and ascertain the nature of subsurface formations.

Geophysical Investigations

To know the vertical variation of the aquifer and also to locate high potential ground water zones in the basin, a total of 12 Vertical Electrical Soundings were carried. The locations of the sounding points are same of above Hydrogeological samples. The maximum length of electrode separation is kept between 80 and 100 m from place to place, depending upon the requirement and accessibility of the area. The interpreted results of each sounding are given in Table 1. Observations of curves show that the ten VES locations belong to A type, two to H- type and one to Q type curves.

Table 1: Result of Interpreted Vertical Electrical Soundings carried out in Lakhmapur village of the Nashik district

Well no./ VESno.	Latitude=(°N)	Longitude (°E)	ρ1/h1	ρ2/h2	ρ3/h3	ρ4/h4	H (in m)	CurveType
1	20.10	74.27	19/0.322	4.01/7.39	3.8/0.904	5171/-	8.62	AA
2	20.12	74.24	19/0.322	4.01/7.52	3.81/0.781	5171/-	8.624	AA
3	20.16	74.18	21.6/0.359	3.83/3.18	5.6/7.06	8102/-	10.599	AA
4	20.14	74.12	4.69/6.02	48.9/3.76	1.7/2.61	8102/-	10.50	AA
5	20.18	74.14	4.69/6.04	48.7/3.82	1.38/2.13	8102/-	11.99	AA
6	20.24	74.22	4.631/5.2	35.09/2.703	2.648/3.369	202.6/-	11.27	AA
7	20.21	74.23	4.637/5.301	37.96/2.704	2.558/3.325	208.5/-	11.33	AA
8	20.25	74.25	5.02/6.09	1.68/2.68	13.3/1.33	2117/-	10.1	HA
9	20.27	74.19	5.28/5.64	1.26/2.24	32.8/2.14	2117/-	10.0	HA
10	20.13	74.11	5.26/5.84	1.3/2.24	42.9/2.79	2117/-	10.9	HA
11	20.42	74.08	5.24/6.39	1.4/2.3	42.9/2.28	2117/-	11.0	HA
12	20.68	74.48	5.35/5.41	2.61/4.76	42.9/1.96	1065/-	12.1	HA

Profile AB resistivity cross section and pseudo cross section

Interpreted results show that the top layer thickness ranges between 0.322 m and 6.04 m with resistivity 4.631 ohm m to 21.6 ohm m respectively. VES 1, 2 and 3 may be consisting of thin weathered basalt whereas VES 4, 5 and 6 may be consisting of thick soil mixed with highly weathered basalt.

Thickness and resistivity values for the second layer ranges from 2.703 m to 7.52 m and 3.83 ohm m to 48.90 ohm m respectively. VES 1, 2 and 3 may be consisting of highly weathered basalt whereas VES 4, 5 and 6 may be consisting of thick weathered basalt. Thickness and resistivity values for the third layer range from 0.781 m to 7.06 m and 1.38 ohm m to 5.6 ohm. m respectively. VES 1, 2 and 3 may be consisting of thin weathered basalt whereas VES 4, 5 and 6 may be consisting of thick weathered basalt.

Similarly, resistivity values for the fourth layer range from 202.6 ohm m to 8102 ohm m respectively. VES 1, 2, 3, 4, 5 and 6 may be consisting of thick highly compact massive basalt.

A pseudo and cross section were generated by using IPI2WINsoftware. The cross section AB shows that the west part of study area VES 1, 2 and 3 showing very resistivity zone up to 0.359 m depth, at the depth of 3.539 m to 7.842 m showing a very low resistivity zone, at depth from of 3.539 m 10.599 m showing also a very resistivity zone, at the depth 8.616 m onwards shows compact massive basalt (Figure 3).

Profile CD resistivity cross section and pseudo cross section

Interpreted results show that the top layer thickness ranges between 5.30 m to 6.39 m with resistivity 4.637 ohm m to 5.35 ohm m respectively. VES 7, 8, 9, 10, 11 and 12 may be consisting of thick highly weathered basalt.

Thickness and resistivity values for the second layer ranges from 7.88 m to 10.17 m and 1.26 ohm m to 37.96 ohm m respectively. VES 1 may be hard weathered basalt where as VES 8, 9, 10, 11 and 12 may be consisting of thin highly weathered basalt.

Thickness and resistivity values for the third layer range from 10.1 m to 12.13 m and 2.558 ohm m to 42.9 ohm. VES 7 may be thick highly weathered basalt, VES 8 may be thin weathered basalt whereas VES 9, 10, 11 and 12 may be consisting of thin hard weathered basalt.

Similarly, resistivity values for the fourth layer range from 208.5 ohm m to 2117 ohm m respectively. VES 6, 7, 8, 9, 10, 11 and 12 may be consisting of thick highly compact massive basalt.

A pseudo and cross section were generated by using IPI2WIN software. The cross section CD shows that the west part of study area VES 7, 8 and 9 showing low resistivity zone up to 5.30 m depth, at the depth of 8.0 m to 10.17 m showing a very low resistivity zone except VES 7, at depth from of 10.1 m 12.13 m showing also a very low to medium resistivity zone, at the depth 10.1 m onwards shows compact massive basalt (Figure 4). Both profiles AB, CD pseudo and cross sections lithology is co related with litho log data of open and bore wells of village Lakhmapur.

Depth to basement

Using the interpreted results of the soundings pseudo and cross sections (Figures 3 and 4) showing depth to basement, which varies from 8.616 m to 12.1 m. It is clear that depth to basement is nearly uniform in the basin, the depth being more in the western part of the basin and minimum in eastern part. The areas with greater depth of bed rock, are suitable for groundwater development. Based on the sounding data, the depth of the bed rock ranges from 8.616 m to above 40 m. At the confluence of the Lakhmapur village, the depth of the basement is found to be maximum of above 50 m.

Conclusions

Hydrogeological wells water levels and interpreted vertical electrical soundings helps to determine a good groundwater potential zone. By studying geophysical characteristics of Deccan Trap showing high and low resistivity zones in different parts of study area. VES 1 and 2 seen high resistivity zone at medium depth, it shows a presence of hard rock. VES 3, 4, 5, 6 and 7 seen medium resistivity zone at medium depth, it shows a water body in medium depth. VES 8, 9, 10, 11 and 12 seen very low resistivity zone at medium depth, it shows a water body in medium depth. In the profiles cross sections AB, CD are presents very low to low resistivity zones which are good water zone locations in Lakhmapur village.

References

1. Prasannakumar PS, Chinnappa Reddy BV, Ranjith Kumar PS, Roopa - Sand mining and its impact on agriculture and ground water depletion in Karnataka- A natural resource economic prospective - International Research Journal of Agricultural Economics and Statistics,2014:5(2):257-261.
2. Suresh U, Imran Basha U. Geophysical studies on the Shallow Groundwater Aquifer in drought prone Somavathi River basin, Ananthapuramu district (Andhra Pradesh), India: A case study - J.Ind.Geophys. Union,2020:24(5):36-44.
3. CGWB-Dynamic Ground Water Resources of Maharashtra, 2011-12. Wikipedia.
4. Hemalatha AC, Chandrakanth MG, Nagaraj N. – Effect of Sand Mining on Groundwater Depletion in Karnataka. submitted for Oral Presentation at the V International R & D Conference of the Central Board of Irrigation and Power, 2005, 15-18. Bangalore.
5. Ksenya Lvicheva, Nadezhda Makarenkova, Vera L. Zaytseva, Dmitriy A. Philippov – Influence of flow velocity, river size, a dam, and an urbanized area on biodiversity of lowland rivers. Article in Biosystems Diversity, 2019.
6. Patil SN, Kachate NR, Marathe NP, Ingle ST, Golekar RB. Electrical Resistivity studies for Groundwater exploration in the some parts Chopda blocks of Jalgaon District, Maharashtra, India.
7. Deshpande GG, Geology of Maharashtra, Geological Society of India, Bangalore,1998:129:160.
8. Patil SN. Studies of hydrology and watershed characters of Yawal taluka, Dist. Jalgaon (MS) India, Unpublished Ph.D thesis, North Maharashtra University, Jalgaon, 2005.

9. Kearey P, Brooks M. An introduction to geophysical exploration, ELBS Blackwell Scientific Publication, Oxford,1988, 296.
10. Orellana E, Mooney H.M. Master tables and curves of vertical electrical sounding over layered structures. Interciencia Madrid Spain, 1966, 150-166.
11. Bobachve A. Resistivity Sounding Interpretation IPI2WIN, Version 3.0.1, a 7.1.3. Mascow State University, 2003.
12. Sharma Prem V. Environmental and Engineering Geophysics, Environmental and Engineering Geophysics, 1997, 1.
13. Bhattacharya PKHP. Direct current geoelectric sounding principles and interpretation.
14. Karanth KR. Ground Water Assessment, Development and Management, Tata Mc Graw Hills Publications Company Limited, New Delhi,1987:(27):449-460.
15. Tellford WM, Geldart LP, Sheriff RE. Applied Geophysics, Cambride University Press, New York, 1990, 522-577.
16. Patil SN, Baride MV. Geophysical investigation for ground water in Yawal taluka district, Maharashtra, ISEG Jour Engg. Geol.,2009:36:1-4.
17. Logging of bore wells, Unpublished report, Groundwater Surveys and Development Agency, Nashik, 2002.