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Characterization of groundwater resource and estimation of aquifer parameters in Basaltic terrain, eastern part of Amravati district, Maharashtra

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ABSTRACT

This study encompasses the detailed hydro geological investigation carriedout in the Basaltic terrain of eastern part of Amravati region which represents lower dissected plateau of Deccan trap formation. The characteristic features of shallow groundwater regime is depicted by utilising field, hydro geomorphological, hydro geochemical, geophysical and remote sensing techniques. The upper parts of the lava sequence is dominated by highly fractured vesicular lava flows containing zeolite bearing horizons.The results indicate the presence of four geomorphological units in the area of investigation which includes flood plain, undissected plateau, moderatly dissected plateau and highly dissected plateau which serve as a guide to demarcate potential zones of groundwater occurrence and recharge in the study area.

This study demonstrates the characterisation of groundwater resource and estimation of aquifer parameters by utilising pumping test at eleven representative well sites. The results have been computed to decipher storativity, transmissivity, storage coefficient and specific yield which are crucial in understanding water level fluctuations and groundwater potential of the region. The results indicate slightly lower values for most of the parameters when compared with the standard values for Deccan Basalt aquifers due to consistently compact, massive and hard trap (>300 m/m resistivity) at lower elevations below the highly fractured, jointed and vesicular basalt which acts as suitable sites for groundwater exploration. The integrated approach in the present study clearly demonstrate that aquifer parameters including groundwater flow and distribution which are mainly controlled by drainage pattern, slope elements lineament pattern, structural parameters, rainfall and hydro geomorphology.

INTRODUCTION

Groundwater is one of the most important component of the hydrologic cycle in nature. The occurrence of groundwater is wide spread but uneven. In some rocks it occurs in small quantity, whereas some other rocks contain enormous groundwater that can be used for major purposes of agriculture, drinking water and industries. For estimation of aquifer parameters, understanding of the geological frame work in which groundwater occures is necessary. The less important non commercial minor occurrence of groundwater is also of great importance, as it provide a key to groundwater exploration purposes (Dhokarikar 1991).

The parameters like transmissivity, storativity, specific capacity and safe yield provides valuable guidance for groundwater estimation and management in multilayred hard-compact formation like Deccan Basalts. In this study an attempt has been made to understand the characterization of groundwater resource and estimation of aquifer parameters in basaltic terrain in the eastern part of Amravati district, Maharashtra (fig. 1).

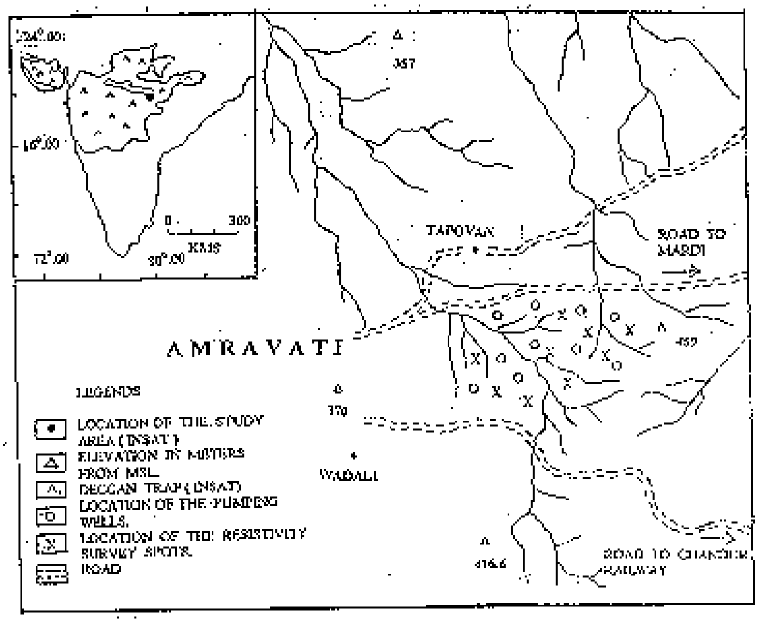

Figure 1. Location map of the study area.

TERRAIN EVALUATION

Remote sensing data interpretation indicate the presence of seven distinct geomorphic landforms in the study area which include plateau top, denudational slope, denudational hill, moderately dissected plateau, highly dissected plateau , lower dissected plateau and alluvial plain.(Fig. 2) The cross section of landscape in the study area reveals the presence of marked flat terraces at 320 m. and 410m which indicate the sequence of events that might have resulted due to the evolution of the landscape. The lithological variations represented in the morphology of the lava flows particularly the compactness and vesicularity have caused undulations in the topography. The result demonstrates that the various topographic landforms developed by intrusive phase of the igneous activity offer more resistance to weathering and erosion which are represented by the presence of linear ridges breaking the monotony of the plains.

PUMPING TEST AND AQUIFER PARAMETERS

The wells selected for pumping test are located in a jointed, fractured and weathered Basalt. This is a lower dissected plateau of the Deccan Trap province which is situated at the western foot hill zone of the Pohra hill ranges. On the eastern side of the study area, the hills from plateau region which act as a recharge site and the area under study can be considered as a discharge site. The common practice is that the well selected for pumping test should be below the water level, up to the deepest water bearing horizons as a single homogenous aquifer. This assumption is valid to the extent that this zone is made up of an interconnected system of fractures, joints, surrounding blocks of impervious rock. (Ballukaraya. 1989). Figure 3 shows the yearly rainfall data of the study area.

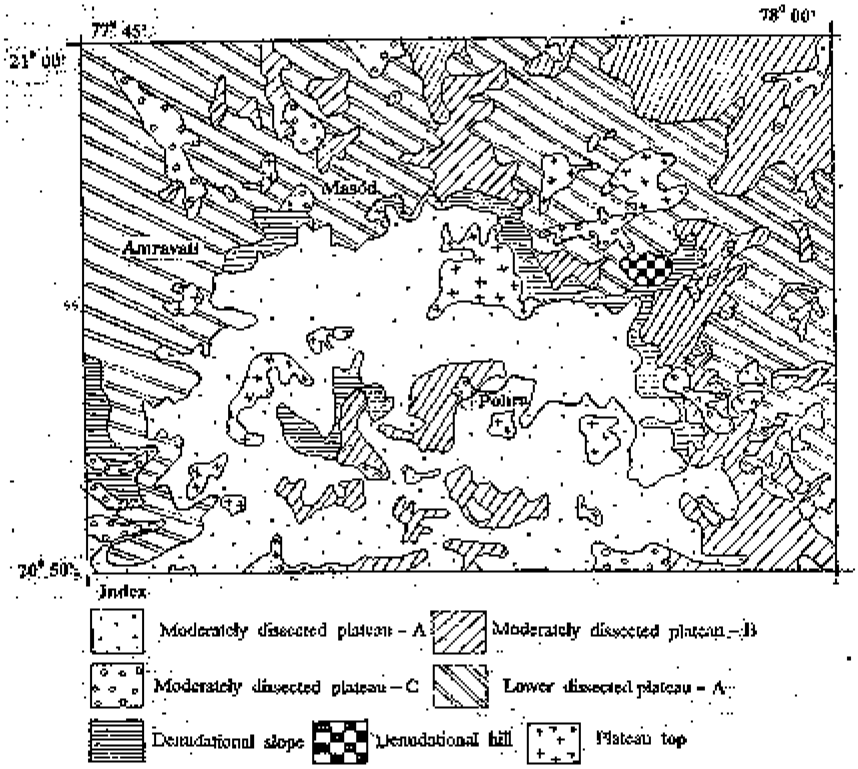

Figure 2. Geomorphological map of the study area.

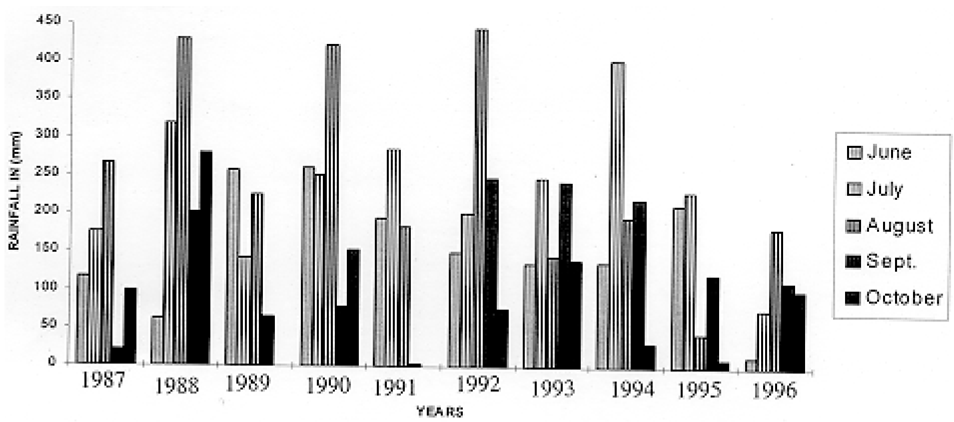

Figure 3. Plots showing yearly rainfall data of the study area.

The basic purpose of carrying out the pumping tests is to determine the safe yield of the wells and specific capacity or discharge draw down ratio of the well. These two parameters define production capacity of a well which helps in selection of pump capacity etc. Secondly the other two important parameters namely transmissivity (T) and storativity (S) can be more accurately calculated with the help of pumping test. This gives the information about the aquifer behaviour, which will be useful to study the groundwater flow studies.

The pumping test is generally used to study the parameters like storativity, transmissivity, yield character. These values define the aquifer characteristics. In Deccan Traps, the results of the pumping test vary widely because of the difference in lithological conditions. According to Rao (1947) porosity of fractured basalt may be as high as 50%. Adyalkar (1984) believes that vesicular basalt constitutes the best which show a porosity of 25-30%, permeability ranges between 5-15 m/d, specific capacity of 100-200/pm/m and specific yield of 3-10% corresponding to storativity of 0.03 to 0.10.

In this study topographic maps have been utilised as base maps and all the hydrogeological information such as lithology, water table contours, topographic contours, thickness and performance and nature of the aquifer, variation in the yield of wells were plotted and interpreted. This study has demonstrated the occurrence of mini basins showing specific groundwater flows in the area of investigation which are separated with other by a permeability barrier or a high. This is confirmed by the geoelectrical profiling data in the region which brings out the presence of these barriers reflected by the changes in the resistivity pattern. Recharge experiments have also indicated the benefit areas of irregular shape and eccentric with respect to recharge location. In this study has given rise to the areal extent and depth of penetration which in turn is helpful in determining the volume. The storativity (S), transmissivity (T) and specific yield values have been computed by judiciously planning the location of pumping tests from which the overall groundwater potential of the basin, present draft, net balance of water available and the stage of development of the basin have been determined.Figure 4 shows the static water level and pH, and status of some of the chemicals in blocks.

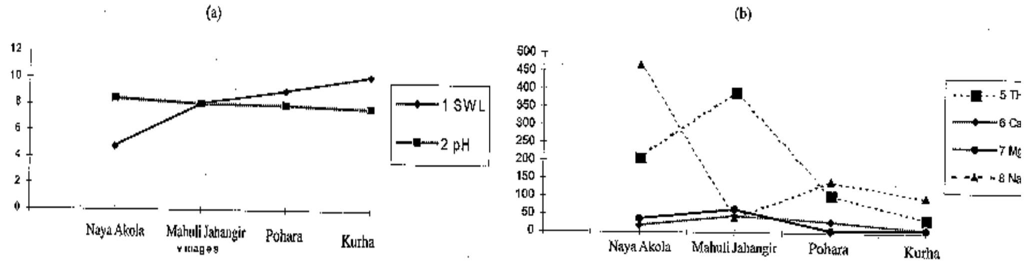

Figure 4. Chemical plots (a) static water level and pH (b) Thorium, Calcium, Magnesium and Sodium.

The transmissivity values for well no.1,2 & 4 are found to be 48.82 sq.mt/day, 69 sq.mt/day and 59.15 sq.mt/day respectively. The standard value of transmissivity for Deccan Traps is 30-100 sq.mt/day. The calculated value of “T” are according to the standards. The specific capacity values calculated for well no.1,2 & 4 are 47.59 lt/min/mt, 59.04 lt/min/mt and 18.46 lt/min/mt respectively. The storage coefficient values for well No. 1,2 and 4 are 0.527, 0.032 and 0.89 respectively, whereas relatively comparable to the standard value for Deccan Trap aquifers. This might be due to the fact that the consistently compact, hard and massive trap (>300m/m resistivity) is present at the lower elevation in the study area. Secondly the values of safe yield (QS) for well no. 1,2 and 4 are 1,12,370 lt/day, 34,240 lt/day and 71,400 lt/day respectively (Table 1&2).

Table 1. Results of the Pumping test and suggested recommendations for the study area.

(I) Pumping Test Results

Well No	Safe Yield (Qs)	Specific Capacity (C)	Transmissivity (T)	Storage Coef-fecient (S)
01	1,12,370 Lts/day	47.59Lts/min/mt.of D/D	48.82 sq.mt./day	0.527
02	34,240 Lts./day	59.04Lts./min/mt.of D/D	69.49 Sq.mt./day	0.032
04	71,400 Lts./day	18.46 Lts./min/mt.of D/D	59 Sq.mt./day	0.89
06	4,47,000Lts./day	104 Lts./min/mt.of D/D	51 Sq.mt./day	0.059
08	18,720 Lts./day	15 Lts./min/mt.of D/D	210 Sq.mt./day	1.31
09	1,31,414 Lts./day	39 Lts./min/mt.ofD/D	274 Sq.mt./day	0.239
10	63,360 Lts./day	44 Lts./min/mt.ofD/D	105 Sq.mt./day	0.196
12	13,351 Lts./day	18 Lts./min/mt.of D/D	330 Sq.mt./day	0.134
14	57,960 Lts./day	25Lts./min.mt.ofD/D	62 Sq.mt./day	0.112
18	29,952 Lts./day	16 Lts./min/mt.ofD/D	181 Sq.mt./day	0.66
19	79,200 Lts./day	44Lts./min/mt.ofD/D	459 Sq.mt./day*	2.42*

* Fracture zone encountered in a well attributes high transmissivity value
Please see location map for the actual location of the wells

Recommendations

Well No.	Recommendations
01	Deepening of well by 2mts.can increase the well yield by 25%-30%
02	Further development not required
04	Further development not required
06	Further development not required
08	Not potential
09	Further development not required
10	Potential well for further development(Recommended Diameter 6mts.x Depth 10 mts which may give the Safe Yield 80,000 - 1,00,000 Lts./day intermittently.
12	Poor recuperation, Not potential
14	Further development not required
18	Not potential as the rate of recuperation is slow.
19	Highly potential well for further development (Recommended Diameter 6mts.x Depth 10 mts which may give the Safe Yield 1,00,000 - 1,25,000 Lts./day.

The results of the pumping test carried out at eleven representative wells in the study area indicate the presence of three categories of wells showing excellent, moderate and low productivity of wells. Well no. 1,4,6,9 and 19 show excellent potential for the groundwater exploration with higher safe yields. Whereas, well no. 2,10,14 and 18 showing moderate productivity with medium safe yield. Well no. 8 and 12 show low potential with very low safe yield and poor recuperation and hence not suitable for further groundwater development. It is important to mention that well no. 19 has good potential for further development which can provide the safe yield unto 1,2500 lts/day. The results also demonstrate the occurrence of fracture zone in the well which is reflected by high transmissivity values. The significant recommendations include the further development of well no. 1, 10 and 19 which can increase the groundwater potential with upward rise in the safe yields. Whereas, well no. 2,4,6,9 and 14 does not require further development as these well have already reached their optimum level of production (table 1 &2).

Table 2. Results of Resistivity survey and suggested recommendations for the study area.

(II) Resistivity Survey Results

Location*	0-----5-----10-----15-----20-----25-----30-----35-----40-----45-----50-----55-----60-----65-----70m
RS 001	|W.B ||C.B ||V.B
RS002	|WB|| C.B. || V.B.
RS003	|WB ||CB || VB || CB
RS004	|WB || CB || VB
RS005	|WB|| CB || VB
RS006	|WB|| CB || VB
RS007	|WB|| CB
RS008	|WB|| CB || VB
RS009	|WB|| CB || VB || CB
RS010	|WB || CB(HFr) || VB
RS011	|CB || VB || CB
RS012	|WB|| CB || VB

* Please see location map for details

Key words:-

WB=Weathered Basalt
CB=Compact, Massive Basalt|
HFr=Highly fractured Basalt
VB=Vesicular Basalt (beginning with red tuffaceous layer)

Recommendations

Location	Recommendations
RS001	Fractured and Weathered zone encountered upto the depth of 15 mts.b.g.l.
RS002	Fractured and Weathered zone encountered upto the depth of 15 mts.b.g.l.
RS003	Fractured and Weathered zone encountered upto the depth of 15 mts.b.g.l.
RS004	Fractured and Weathered zone encountered upto the depth of 15 mts.b.g.l.
Rs005	Weathered zone not extending below 5mts.
RS006	Weathered zone not extending below 5mts
RS007	Weathered zone not extending below 5mts
RS008	Feasible for Bore well of depth 250ft. Saturated zone may struck below 45 mts.b.g.l.
RS009	Not feasible
RS010	Feasible for Open well of depth 15mts.and also for Bore well of depth of 200 mts.
RS011	Not feasible
RS012	Not feasible

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The results of the pumping test data demonstrates that in each basin, the transmissivity and permeability values are very similar to one another indicating free movement of groundwater within the basin limits with the presence of permeability barrier towards the "high" where the values reduce drastically. These values will also be useful in further defining the boundaries of the basin which differs with the other basin in these parameters. Considering the free movement of groundwater within the limits of a basin, well location can be more accurately identified based on the shapes of the contours. The permeability data is very much useful in determining the optimum dimensions of the wells, safe distance between two wells and their probable yield. This will certainly help in determining the exploitation limit to which the development can be extended beyond 80% stage which will further lead to locate positive percolating areas where artificial recharge activities can be planned and distinct positive areas for water resource development can be suggested. Jagtap (1984) has indicated that the adoption of minibasin as a unit for assessment of groundwater provides a rational solution to problems faced hither to in watershed approach of groundwater development. The results of the pumping test data indicate that there are limited groundwater prospects in the region which certainly needs careful planning and management of the available water resource.

Geophysical Studies for Ground water exploration and Management

In the Deccan volcanic Province prospecting for groundwater is a challenging task. Remote sensing study is important for locating the potential zones of groundwater by demarcating the lineaments, various geomorphic units and lithology of the Deccan Traps (Adyalkar 1984). Attempts has been made by Thigale (1979) to establish relationship of plants with the occurrence of groundwater. The various methods and techniques have certain limitations in groundwater exploration. The resistivity survey is found to be useful to detect the aquifer in Deccan traps. Balkrishna and Ramanujachary (1978) have analysed the results of resistivily survey in the Malwa Plateau, Deccan Plateau and the flanks of Sahyadri ranges.

Geophysical methods provide indirect but most reliable picture of sub-surface formations by measuring various physical parameters like density, magnetic susceptibility, electrical conductivity etc. Electrical resistivity survey is the most suitable method for groundwater exploration. The vertical electrical sounding (VES) gives most accurate information about the strata present below. In hard rock terrain like Deccan Trap, where various layers of the lava flows are present, this method is proved to be useful. There is a difference in geochemical, petrographic, lineament pattern and jointing pattern of the Deccan Traps which ultimately reflect in the difference in resitivity values of these flows. The true resistivity values and thickness of layers are obtained by interpretation of the sounding curves Parikh (1989).

In this study, an attempt has been made to explore the groundwater bearing formations by schlumberger vertical electrical resistivity sounding method at 12 important locations with AB/2 = 120m and Mn/2 = 10m. The curves obtained by plotting resistivity Vs AB/2 interpreted by using the curve matching technique of Orlena and Mooney (1966). This study has led to the identification of groundwater regime of the region indicating the general slope of the ground water movement towards the west. The first and upper most layer represents moderately to highly fractured basalt covered by thin top soil. Whereas, the second layer is characterised by hard, compact, massive basalt. The permeability of this 2^{nd} layer is very less, which is reflected in the low values of storativity, transmissivity and storage coefficient of this area as compared to the standards for Deccan Traps.

WATER RESOURCE MANAGEMENT OF THE STUDY AREA

The groundwater extraction in Deccan Trap terrain mainly comes from the open dug wells by extracting water from the deeper layers of the aquifers. The open dugwells generally have low rate of inflow coming from the weathered mantle through fissures and fractures. Due to the poor hydraulic characters of the Deccan Trap aquifers, the open dug wells need appreciable storage capacity through collector wells. The overnight recuperation quantity which is stored in the wells during the nonpumping hours, therefore, assumes greater significance. The results indicate that the effective depth of the well is reckoned below the static water level upto the impervious bottom which is indicated by the full thickness of the aquifers.

The results of the characterization of groundwater resource and estimation of aquifer parameters in the basaltic terrain of the study area indicates that a majority of the wells have been excavated less than 3 meters depth indicating partially penetrated aquifer depths and a short period have shown a limited comparable low yields and became dry within a short period. Limited number of wells are found to perform better in average per day yields during winter and summer seasons where the groundwater was available for extraction from these wells even during summer months. The yields of hard rock aquifers which are mostly unconfined are of low rate where the fissures and fractures act as planes or conduits for circulation of groundwater. The results indicate that there is significant cone of depression formed around these structures during pumping hours. Hence it is suggested that modern designed structures need to be adopted for optimum utilisation of groundwater potential of the region.

The position of groundwater levels and the characteristics of well yields normally determine the choice of design of suitable dimensions of the dugwells and tube wells for optimum utilisation of groundwater potential of the study area which is mainly controlled by the prevailing hydrogeologic situation of the watershed. It is suggested that further depending of the existing shallow wells in the region for creating storage capacity with the optimum rate of recuperation of the aquifer in the area which would certainly increase additional irrigation potential of the study area. On the basis of various observations carried out under the systematic hydrogeological and geophysical surveys and well inventory date for a large number of irrigation wells in the study area it is noticed that there is a good scope of increasing the irrigation potential by improving yields of the existing well by adopting suitable artificial recharge methods.

SUMMARY AND CONCLUSION

The characterisation of groundwater resource and estimation of aquifer parameter in basaltic terrain of the study area have been highlighted by utilising pumping test and resistivity survey data analysis. The results of pumping test carried out at eleven representative well sites have been computed to decipher storativity, transmissivity, storage coefficient and safe yield which are crucial in understanding the groundwater potential and water level fluctuations of the region. The pumping test results have demonstrated the nature of groundwater regime in the area of investigation. The values of specific capacity, transmissivity, storage coefficient and safe yield for all the wells indicate the nature of aquifer and their characterisation in the study area. The results of the resistivity surveys carried out at 12 representative sites have demonstrated the geological and geophysical characters of the aquifers. In addition, it has indicated the potential water bearing zones in the study area suitable for groundwater exploration. The results demonstrate slightly lower values for most of the parameters when compared to the standard values for Deccan Basalt aquifers which might be due to the fact that consistently compact, massive and hard trap (>300 n/m resislicity) is present in the study area at lower elevations below the highly fractured, jointed and vesicular basalt which acts as a suitable zone for groundwater exploration. The integrated multidisciplinary approach in the study area demonstrates that the characterisation of groundwater resource and estimation of aquifer parameter in the basaltic terrain including groundwater flow and distribution are mainly controlled by topography of land forms, drainage pattern, slope elements, lineament pattern, structural parameters, rainfall and hydro geomorphological arrangement.

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