SUMMARY
AND
CONSLUSION

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Water is the most important natural resource and is the key element of socio-economic development of the country. There is growing trend toward the increasing exploitation of groundwater to meet the needs of growing populations. Both in terms of water availability and the quality of groundwater depends upon physical environment, origin and movement of water. As the water moves through the hydrogeological cycle, various chemical, physical and biological processes change its original quality through reactions with soil, rock and organic matter. Natural processes and human activities cause changes in groundwater quality directly or indirectly. Groundwater is degraded when its quality parameters are changed beyond their natural variations by the introduction or removal of certain substances. The degradation may impair the usefulness of water, but is not necessarily harmful to health. The scarcity of clean potable water has emerged in recent year as one of the critical problems facing India today, even while the coverage of the people, with access to supply in India has reached levels of over 80%. Declining quality and quantity of water supply in India can be described as crises, which needs immediate intervention.

The work done so far in understanding the petrographic and hydrogeological investigations of the Uma river basin, which is a tributary of the Purna alluvial tract with special reference to watershed management, are very limited. In the present study, an attempt has been made to develop a decision support system to establish, compare and correlate the nature and aerial extent of individual lava flows and flow sequences, along with their detailed petrographic, geomorphic, hydrological and environmental analysis aspects. This study has also provided first hand information on systematic correlation of water resource management of a crucial part of the Purna River Basin with additional information on structural correlation.

The Uma River basin, which is a tributary of Purna River, lies between eastern part of Murtizapur, Akola District and northern part of Karanja, Vashim district forming about 200 m. thick lava flows covering an area of 615 sq. km. (Latitude: 20° 50' - 20° 25', Longitude: 70° 20' - 77° 30') and survey of India toposheet no 55 H/5,6,7, 9 and 10.

Extensive geological field mapping was carried out with the help of 8-field traverse and numerous spot checks. 50-rock sample and 15 chemical samples along with 6 red/green bole samples were collected. Whole rock major, trace and rare earth element analysis for 15 samples were carried out at the Royal Holloway and Bedford New college, University of London, U.K. using ICPS and AAS techniques. Detailed petrographic and mineralogical investigations and modal analysis were carried out for 23 representative thin section at the Center for Earth Science Studies (CESS), Thiruvananthapuram, Kerala to understand various mineral phases. In this study 200 meter lava pile is divide into formations and four chemical types.

Groundwater samples from 130 dug wells tapping unconfined aquifer of the study area were collected over a period of two years (1999 and 2000) during pre and post monsoon (June and December months) for respective years. The collected samples were analyzed for physical (Temperature, TDS and conductivity) and chemical parameters (major ions viz.: Ca, Mg, Na, K, HCO_3, CO_3, SO_4, and Cl).

The main objective of the study is to establish, compare and correlate the nature and aerial extent of individual lava flows and flow sequences, along with their detailed petrographic, geomorphic, hydrological and environmental analysis aspects in a systematic way by utilizing various computer aided programs and statistical techniques; as the position of the study area is very crucial as it can fill the existing gap of knowledge related to petrological and hydro-environmental aspects. This study will also provide first hand information on systematic correlation of water resource management of a crucial part of the Purna River Basin with additional information on structural correlation. The outcome of the study may provide a model to understand the regional evolution of the Deccan Basalt Province as a whole and groundwater resource management

Detailed morphometric analysis was carried out to understand morphometry of the Uma river basin. In general, the area is characterized by horizontal lava flow forming flat-topped plateau showing multiple escarpments. Analysis of remote sensing data through visual interpretation of IRS imagery was carried out to prepare the geomorphological and land sat map of the area. Extensive field mapping was carried out to trace the aerial extent of lava flows and flow sequences which are based to the establishment of flow stratigraphy of the Uma river basin.

Physiographically, the study area can be classified into low lying plains towards the bank of Uma river and abrupt vertical cliffs made up of horizontal basalt flows with multiple scarps towards the southern side. The results of geomorphic analysis indicate the predominance of erosional landform over the depositional landforms. The study area can be interpreted as a moderate morphogenetic region. As per the physiographic classification, the study area falls in the central high land region with moderate concentration of lava flows traversed by Uma River, which is one of the tributaries of the Purna saline tract showing mature stage of development. The major geomorphic process that predominates in the region includes spheroidal weathering and fluvial erosion. Slope analysis indicates the presence of flat crest, an interim slope with a fairly constant angle off from the plain

The detailed morphometric analysis of the study area reveals the predominance of dendritic drainage pattern with the presence of sixth order stream. At places, local radial pattern of drainage is also seen. The Uma River at places displays perpendicular course to the Purna River indicating some structural control on the lithology of the basaltic landforms having uniform resistance to erosion. The result of morphometric analysis indicates negative correlation of stream order with the total number of streams present in the drainage basin. The average drainage frequency and drainage density computed for the study area indicating, lower value in the plateau and plains and higher values in the hilly terrain showing steep scarps and undulating features. The lower value for the circularity ratio confirms the uniform lithology and some structural control in the study area.

Results of remote sensing analysis reveals that study area can be grouped into three major geomorphic units viz. Fluvial origin showing excellent ground water prospectus mainly consisting of sand and gravel; Denudational origin mainly consisting of weathered basalt which shows moderate to poor ground water prospectus and Structural origin shows good to poor groundwater prospectus. With the help of IRS LISS III imagery land system map was prepared which shows that the study area is characterized by the presence of alluvial deposits in the northern part of the basin and Deccan trap in southern side

Extensive field mapping was carried out to trace and correlate the aerial extent of individual lava flows and flow sequences which lead to the establishment of field stratigraphy of Uma river basin. Two well-defined formations exposing 9 flows have been identified they are A formation and B formation. A detailed geological map of the area was prepared.

The lava flows exposed in the study area can be distinguished with one another due to their stratigraphic position, textural parameters like aphyric, microphyric and porphyritic nature. Phenocrystic assemblage such as plagioclase, clinopyroxene, olivine mostly altered to iddingsitie, opaque minerals and primary glass. The common textures include porphyritic to subophitic. However, certain aphyric flows show the presence of microphyric and flow textures. Plagioclase usually occurs as labradorite, clinopyroxene as augite to subcalcic augite with minor occurrence of pigionite in the groundmass. Olivine occurs as iddingsite or serpentine along the borders and iron oxide as a solid solution series of titanomagnetite and ilemanite with the occasional presence of primary glass. Carlsbad, albite and crossed twins are quite common in plagioclase with the occasional presence of Beveno twins. Clinopyroxene occurs as prismatic grains showing subhedral form whereas magnetite occurs as octahedral to anhedral grains, ilemanite occurs as irregular lath shaped and skeletal forms. In general, the cavities of amygdals are filled with various zeolite minerals associated with quartz, calcite and other associate minerals like chlorite etc. The present stratigraphic divisions are mainly based on distinct field characteristics, phenocryst assemblages, major physiographic breaks and significant shifts in elemental abundance, and ratios particularly, K_2O, MgO, TiO_2, P_2O_5, Ba, Sr, Ni, Cr, Zr, Mg*, Ba/Ti, Ba/Sr, Ba/Zr, Sr/Ti, Zr/Ti and TiO_2/P_2O_5. Based on above characteristic the above formations are further subdivided into various chemical types (CT) each of which consists of one or more flows showing similar chemical characteristics without a stratigraphic bias.

The 'A' Formation is characterized by the presence of fine-grained, Pl mafic microphyric flow with red bole at the top. Based on geochemical parameters, four flows are identified in the study area giving three chemical types (CT1, CT2, CT3 and CT4). Petrographically this formation is characterized by porphyritic to subophitic texture. This formation shows higher concentration of TiO2, P_2O_5, Ni , Zr and lower concentration of MgO and CaO than B Formation. The compositional distinction along with wide aerial extent makes it possible to separate this chemical type from other chemical types. This formation is overlained by fine-grained plagioclase phyric, highly vesicular basalt flows of 80-m thickness belonging to 'B' Formation. Five chemical types based on physiographic and chemical breaks characterize this formation. Petrographically, this formation is characterized by aphyric to Pl mafic phyric flows showing porphyritic texture. Chemically, the flows of B Formation show a compositional range of MgO (6.01- 6.44), TiO_2 (1.85 – 2.48), P_2O_2 (0.12 – 0.19), Sr (217 – 235) and Ba/Y (2.27 – 8.27) indicating the presence of highly evolved sequence at the top.

The presence of repeated occurrence of various chemical types at the stratigraphic levels highlights with cyclic nature (Beane et., al., 1986; Khadri et. al., 1988).

The main water bearing formation of the region is basaltic lava flows (Deccan trap). Recharge of ground water is controlled by topography, thickness of weathered zone, and infiltration capacity of soil and subsoil strata within the zone of aeration. The study area is dominated by nine different flows, which are separated by the horizons of red / green boles. The vesicular part of the flow possesses primary porosity but permeability has developed by processes of weathering. These and the fractured zones are the major water-bearing horizons in the area.

The hydrogeology of the area is studied on the basis of pre and post monsoon field survey conducted for the years 1999 and 2000 during June and December months. 130 wells for each season were analyzed to check the water level fluctuation and water bearing formation of the area. Deccan trap is the main water bearing formation of the area followed by alluvium. Nearly all the wells were tapped in basalt and few were tapped in alluvium. However, in most of the area, the wells in alluvium also encountered the Deccan trap at the bottom. Even though the occurrence of groundwater in hard rocks is very rare due to the absence of primary porosity, it is interesting to note that basaltic lava flows develop peculiar characteristics, especially on the top layer which makes the basaltic rock capable of holding and transmitting groundwater. Secondary features like spheroidal weathering, jointing, fissuring and fracturing develops the storage space for groundwater. The sand and gravel beds have high degree of porosity and permeability. In the study area the sand and gravel beds are, the major water bearing formation as they are found in patches along nalla course. Wells located in these formations have good yield because of higher porosity and permeability of this formation.

Groundwater level fluctuation is mainly dependent on the difference in water levels of pre monsoon and post monsoon periods, which can be directly linked, to recharge and discharge of groundwater. The area shows low water level fluctuation zone (< 1.5 m.), moderate water level fluctuation (1.5 – 3 m.), moderately high water level fluctuation zone (3 – 6 m.) and high water level fluctuation zone (>6). The seasonal fluctuation of groundwater level between the pre-monsoon and post-monsoon period for both the years varies between 0.50 to 9-m. bgl. Most of the study area follows in moderate to moderately high water level fluctuation. The low water level fluctuation is more prominent in the region, which is controlled by recharge of groundwater by surface irrigation. Whereas, high level mining of groundwater during non-monsoon seasons for irrigation purpose causes fluctuation. In order to estimate the yield of wells in the shallow aquifers in the area, 15 pumping tests were conducted at selected location

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 aquifer characters and 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.

All pumping test were carried out on large diameter dug wells. Papadopulous and Cooper (1967) method is the right procedure to arrive at aquifer parameters (Karanth 1987, Kruseman and Rider 1990). In the present study, Papadopulous and Cooper (1967) method was studied to determine aquifer parameters by analysing pumping test data. In this method plot of time draw down data on double logarithmic paper are prepared for all the pumped wells. These plots are matched with the Papadopulous and Cooper (1967) type curves. This study has demonstrated the occurrence of mini basins showing specific groundwater flows in the area of investigation, which are separated from each other by a permeability barrier or a high. Recharge experiments have also indicated the benefit areas of irregular shape and eccentric outline with respect to recharge location. This study has given rise to the aerial 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.

The results demonstrate the transmissivity values for well no.1, 4, 9 and 10 which are found to be 22.91, sq.mt/day, 58.12 sq.mt/day, 22.88 sq.mt/day, and 24.68 sq.mt/day respectively. The value of transmissivity for Deccan Traps is 30-100 sq.mt/day. The calculated value of "T" are comparable according to the standards. The specific capacity values calculated for well no.1, 4, 9 and 10 are 22.22 lt/min/mt, 67,445 lt/min/mt, 22,939 lt/min/mt and 60,247 lt/min/mt respectively. The storage coefficient values for well No. 1,4,9 and 10 are 0.118, 0.220, and 0.020respectively, which are 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 is present at the lower elevation in the study area. Secondly the values of safe yield (QS) for well no. 1,4, 9 and 10 are 35,560 lt/day, 67,445 lt/day, 22,939 lt/day and 60,247 lt/day respectively.

The results of the pumping test carried out at fifteen representative wells in the study area indicate the presence of three categories of wells showing excellent, moderate and low productivity of wells. Well no. 2, 3, 5, 6, 7, 8, 11, 12, 13, 14 and 15 show excellent potential for the groundwater exploration with higher safe yields. Where as, well no. 4 and 10 showed moderate productivity with medium safe yield.

Well no. 1 and 9 showed low potential with very low safe yield and poor recuperation and hence are not suitable for further groundwater development. The significant recommendations include the further development of well no. 2, 10 and 14, which can increase the groundwater potential with upward rise in the safe yields. Whereas, well no. 3,5,6,7,8,11,13 and 15 does not require further development as these well have already reached their optimum level of production.

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. 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. The adoption of mini-basin as a unit for assessment of groundwater provides a rational solution to problems faced hitherto 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.

The quality of water in a river system varies greatly. This is the consequence of variable precipitation, physical conditions, waste inputs, and biological activity within the river.

The range of Electrical Conductivity (EC) in the area is 312 to 1500 and 321 to 1790 for pre and post monsoon 1999 and 311 to 1587 and 348 to 1724 for pre and post monsoon 2000 respectively.

The lower EC is along central and southern part of the area due to the presence of a good basaltic aquifer, which are recharged quite regularly by rainfall as compared to alluvium.

The pH of analyzed sample varies from 6.1- 7.9 and 6.2 - 8 for pre and post monsoon 1999 and 6.1 to 7.9 and 6 to 7.9 for pre and post monsoon 2000 respectively. Low values of 6.1 for sample obtained for Bidgaon and to a higher value of 8 recorded near Gunjawada indicae slightly acidic to alkaline nature of the area.

The anion chemistry shows that bicarbonate is the dominant ion in the study area. The concentration of bicarbonate varies from minimum 58 mg/l in Belmandal to maximum value of 785 mg/l at Bramhi (B). The bicarbonates are derived mainly from the soil zone CO_2 and at the time of weathering of parent minerals.

The high concentration of bicarbonate indicates the intense chemical weathering process taking place in the area. The chloride concentration in the analyzed samples varies between 12 mg/l at Kinkhed to 987 mg/l at Valai. The chloride present in the samples shows excess limit.

The concentration of sulphate varies from 22 mg/l to 258 mg/l . The sulphate is derived from the oxidative bearing of sulphide minerals, but the average concentration of sulphate in the present study area has ruled out any lithogenic input of this ion into the water.

The major cations include Ca, Mg, Na and K. The cationic chemistry is dominated by sodium and calcium. The concentration of sodium in the wells ranges from 12 mg/l at Matod, Mirpur, Kurum and 248 mg/l at Drugwada. In cationic abundance calcium, magnesium and potassium follow sodium (Na> Ca> Mg> K) in the study area.

The evolution of water and relationship between rock types and water composition can be evaluated by Trilinear Piper Diagram (1953). The piper's trilinear plots of the groundwater samples of the study area revels that the water samples fall in the area of 1, 4 and 6 field suggesting that alkaline earths exceeded alkalies and strong acid exceeds week acid respectively. The ion representing non-carbonate hardness i. e. alkaline earths and strong acids dominate the total hydrochemistry.

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To ascertain the suitability of groundwater of the area for municipal, agricultural or industrial uses it is very much essential to classify the groundwater depending upon their hydro-chemical properties. The groundwater of the study area has been classified genetically as " high chloride", " high Sulphate" and "super carbonat" water and is very hard (234 mg/l to 822 mg/l).

To assess the suitability of groundwater for drinking and public health purposes, hydrogeochemical parameter of groundwater of the study area are compared with guideline values recommended by World Health Organisation (WHO) and Indian Standard for drinking water (ISI). It shows that the groundwater has partial suitability for drinking purpose and public health because the hardness of groundwater sometimes exceeds the admissible limit. The values of TDS and EC exceed permissible limit some times indicating higher ionic concentration. The values of total hardness of analyzed water samples indicating the water is moderate to hard type. Concentration of bicarbonate exceeds the Indian standard permissible limits (785 mg/l) for drinking water at some sites.

The parameters such as Electrical conductivity (EC), Sodium adsorption ratio (SAR), Percent sodium (Na%), Residual sodium carbonate (RSC) and Permeability Index (PI) were estimated to asses the suitability of water for irrigation. The EC and sodium concentration is very important to classify irrigation water. Classification of groundwater for irrigation depends upon EC value as suggested by Wilcox (1955) The groundwater of the study area can be described as good to permissible.

The sodium or alkali harzard in the use of irrigation is determined by the absolute and relative concentration of cations which is expressed in terms of sodium absorption ratio (SAR). SAR is an important parameter for the determination of suitability of irrigation water because it is responsible for sodium hazards. The calculated SAR value in groundwater of the study area ranges from 0.25 to 5.01 which implies that no alkali hazard is anticipated in the study area

The US salinity diagram shows that most of the water samples fall in the field of C2S1 and C3S1 for both the seasons except few samples fall in the field of C1S1 (December 1999and two samples falls in C3S2 (January 2000)). The samples fall in C2S1 and C3S1 field indicating medium to high salinity and low alkalinity water, which can be used for irrigation for almost all soils, with little level of development of harmful level of exchangeable sodium. The samples fall in C3S2 field, indicating high salinity and medium alkali hazard which restrict its suitability for irrigation, especially in soils with restricted drainage (Karanth, 1989).

The high value in RSC in water leads to an increase in the adsorption of sodium on soil (Eaton, 1950). Irrigation water having RSC values greater than 5 meq/l have been considered as harmful for growth of plants, while waters with RSC value above 2.5 meq/l are generally considered unsuitable for irrigation purpose. The RSC value in groundwater in the study area for pre monsoon ranges from –12.96 to 3.36 meq/l and for post monsoon from -13.41 to 4.87 meq/l. Based on RSC the groundwater of the study area can be grouped as excellent to poor.

The sodium percentage (Na%) in the study area ranges between 7 to 40%. Except well No. 53 to 56 which shows slightly high concentration of Sodium percentage. According to quality classification of irrigation water depending upon the Na% as proposed by Wilcox (1955) the groundwater of study area is good to permissible quality

The soil permeability is affected by long term use of water. It is influenced by sodium, calcium, magnesium and bicarbonate content of soil. Doneen (1964) has evolved a criteria for assessing the suitability of water for irrigation based on permeability Index (PI). The groundwater samples of the study area fall in class – I in Donne's chart (Domenoco and Schwartz, 1990), which implies that the groundwater is of good quality for irrigation purpose as far the permeability index is concerned.

Hydrogeochemical analysis data have been collected from the several tens of locations. It becomes quite difficult to visualize and study the geochemical relationship that may exist in aquifer water by using conventional graphical methods such as Schoeller's (1962) diagram, Piper Trilinear diagram (Piper, 1944) or Durov diagram (Zaporozec, 1972), though they are very useful tools in classifying the groundwater types. However, they suffer from certain limitations such as lack of clarity when the data are either large or for several time periods. Delineating relationship between geochemical water types is very difficult, while it is almost impossible to visualize the impact of both physical and chemical variation on the water chemistry (Melloul and Collin, 1992). Statistical methods particularly principal component analysis (PCA) and factor analysis, are often used to achieve the above objectives (Matalas and Reicher, 1967; Lawrence and Upchurch, 1976, 1982; Balsubramanian, 1986; Razak and Dazy, 1990; Melloul and Collin, 1992).

The factor analysis model assumed to represent adequately the overall variance of the data set and the structure expressed in the pattern of variance and covariance between the variable and the similarities between the observations (Davis, 1986).

Major ion chemistry, EC pH and static water level data of the groundwater in the study area were determined with the help of samples collected from 130 wells for two seasons.

This data matrix having variables (Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3) and 130 observations for each periods (n=130) have been used in the present factor analysis. The correlation coefficient of these variables (major ions) as also those of EC, pH and water level (bgl) are calculated. It is observed from the correlation coefficient matrix that Mg, Cl, CO_3 and Na have strong correlation with each other. A less pronounced correlation exists between EC and K as well as with pH and SO_3 In general no correlation between water level and any other variables is noticed. This indicates that the concentration of the variables may increase during both pre-monsoon as well as post-monsoon periods.

The dominant variables of each factor are, for June 1999 Cl, HCO_3, K with variance 41.88 % and eigen value 3.14. For December 2000 dominant variables are Cl, Mg, and SO4 with variance 41.45 % and eigen value 3.31 is refereed as factor 1. This is followed by decreasing order of dominance along with percentage of variance and eigen value of each factor.

The proportions of the total variance explained by the extracted factors of the data set are 98.99% for June 1999 and 100% for December 1999. The communalities of the variables and the proportion of their variance explained by extracted common factors are generally around 0.5 to 0.8. There fore the factor analysis model is assumed to represent adequately the over all variance of data set.

The major ion evolution sequence of groundwater has been computed as followes:

Travel along the flow-path →

$HCO_3 \rightarrow HCO_3 \rightarrow SO_4 \rightarrow SO_4+HCO_3 \rightarrow SO_4+ CL \rightarrow CL+SO_4 \rightarrow CL$

These changes are expected when water moves from shallow zone to active flushing, through intermediate zones where the flow path is very sluggish and the water is old. It is very evident from the above table that the dominance of the chloride ions for both periods over the other variable of groundwater is due to prolonged stay of water in aquifer for a longer time. The study has thus helped to characterize the geochemical quality of groundwater and also determines the possible source of dissolved solids in them. It has also helped in grouping the groundwater types and establishing relationship between groundwater quality and hydrogeochemical parameters such as lithology of the area and surface topography.

The results of statistical analysis have thus highlighted the usefulness of the factor analysis in understanding the hydrogeochemical evolution of groundwater in the study area as well as characterizing groundwater into different hydrogeochemical facies.

Water resource management of a region involves a detailed study of the surface and sub surface water. To integrate the entire surface and subsurface data manually requires huge manpower and time. By adopting the GIS techniques the result obtained will be faster and more accurate. Till recently, groundwater resource management was based on laboratory investigation, but the advent of satellite technology and GIS has made it very easy to integrate various databases.

After detailed geographical analysis the thematic maps were prepared from remote sensing data and conventional field and integrated with Surfer 7 and ARC/INFO GIS software. Depending on relative importance on groundwater exploration, the themes are assigned specific weights. Geomorphology plays major role in groundwater prospectus and hence given the highest weight of 34 while surface water body with a value of 4 lies at the bottom. The rank of each thematic map is scaled by the weight of the theme. All the thematic maps are then registered through ground control points and integrated step by step using the normalized aggregation method in GIS for each feature and final map was prepared giving four groups Viz. Highly favorable, moderately favorable, less favorable and poor for recharge.

Highly favourable zone for recharge includes gravel sand and clay of varying lithology. The zone is moderate infiltration runoff zone with moderate slop of<1.5%. The suitable recharge structures suggested are percolation ponds and check dams.

A moderately favourable zone for recharge includes moderately dissected plateau area with moderately thick soil cover and weathered rock. The zone shows moderate infiltration rate with moderate runoff and comparatively moderate slop. The suitable recharge structure recommended are percolation pond and check dams.

Less favorable zone for recharge includes denudational slope with weathered basaltic plateau exposing very thin soil. The zone shows moderately high runoff with moderate slope. The suggested suitable recharge structures are recharge pits or recharge trenches.

These areas have poor possibilities for recharge; they include denudational hills and isolated outcrops with moderate dissection forming moderately high-up land. The zones have poor infiltration rate with high slope. Generally, no recharge structures are suggested.

The study has provided information to fill the existing gap in the stratigraphic studies of Deccan lava pile of Uma River Basin. New geological map has been prepared to understand the form and structure of the region alongwith comprehensive stratigraphy, which is very crucial in understanding the tectonic history of Deccan Basalt Province. An attempt has been made to understand the chemical variation of individual flows and flow group and their petrogenetic aspects.

Detailed hydrogeological setup, groundwater potential, water level fluctuation, quality of groundwater and environmental management of the region gives an idea about existing scenario of the groundwater regime. An attempt has been made to evaluate quantitatively hydrogeological models to understand recharge potential of the area. This will provide an additional information for Central Ground Water Board (CGWB), Ground Water Developing Agency (GSDA), Town planning Department and certain NGO's by way of helping them to achieve the goals of state departments.