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GEO-ENVIRONMENTAL IMPACT ASSESSMENT STUDIES OF GROUNDWATER IN THE MARU RIVER BASIN OF SALBARDI REGION, AMRAVATI DISTRICT, MAHARASHTRA

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Abstract

Ground water contains a wide variety of dissolved inorganic chemical constituents in various concentrations, resulting from chemical and biochemical interactions between water and the geological materials. Inorganic contaminants including salinity, chloride, fluoride, nitrate, iron and arsenic are important in determining the suitability of ground water for drinking purposes. The predominant types of the volcanic rocks are the basaltic lava flows of Deccan Plateau. Water bearing properties of different flow units control ground water occurrence and movement in Deccan Traps. The Deccan Traps have usually poor to moderate permeability depending on the presence of primary and secondary pore spaces including vesicles/fractures. A new method of Transverse River-valley Profile (TRP) study and interpretation was adopted. Several TRP parameters were identified which were quantifiable, and, therefore, useful in the inter-TRP and inter-drainage comparisons and correlations. The method was applied to the study of several TRPs of the Maru drainage basin. Several multi-disciplinary thematic maps on uniform scale were prepared. These themes included quantitative geomorphology, drainage network, geology, tectonics, soil types and properties, soil erosion, gully growth and land degradation, etc. When it was found that high erosion had taken place in the central segment of the basin caused by a high rate of incision by the Maru and its tributaries, this feature was related to neo-tectonically controlled river grade adjustments. The TRP study could also differentiate a four-tier terrace system (T_1-T_4) in the Maru drainage basin, and its differential dissection and displacement. Hypsometric analysis of the Maru drainage basin was carried out to decipher the stages of landform evolution, and to assess the influence of geologic and tectonic factors on topography and its modifications. It was concluded that the area of the sub-catchments controls the aspect ratios of the basin because of lateral drainage branching and network bifurcation. Two landform evolution models were generated on the basis of variations in the coordinates of the slope inflection points on the hypsometric curves in terms of relative height and plain area. The remote sensing techniques have been proved to be very efficient in identification geo-hydrological and geo-environmental aspects of the study area. Geology, geomorphology, hydro-geomorphology, geo-hydrology, structure, soils, erosion, and land use land cover helped in identification of the potential zones for development planning and forecasting limitations to their implementation with seasonal accuracy. Lineaments and their intersections appear to be potential sites for groundwater. The Maru drainage basin is suitable for surface reservoirs and check dams. The study shows that the integration of all attributes provide more accurate results to identify the geo-environmental and geo-hydrological characteristics.

Introduction:

Ground water is one of the most important components of the hydrologic cycle in nature. The occurance 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 and industries. For the estimation of aquifer parameters, understanding the geological frame work in which groundwater occurrences is necessary. The less important non-commercial minor occurrences of groundwater is also of great importance, as it provide a key to ground water exploration purposes. (Dhokarikar,1987). The hazardous growth and concentration of population and industries in urban areas in recent years has caused many serious problems. One of the major problem is the scarcity in groundwater occurance. Groundwater is the natural gift to the living beings which is most precious and widely distributed resource on the earth, Groundwater is the renewable resource but its renewability is not infinite. So the groundwater management and development has to be planned in scientific way. So that the adverse effect of over development could be avoided. Reliable estimation of groundwater resources applying suitable methodology is therefore a prime necessity. (Bagade, 1999; Vyas,1999). The Maharashtra state is mostly covered by the Deccan trap basalt showing irregular levels in groundwater occurance. This diversity of Deccan Trap basalt with reference to groundwater occurance varies with change in topography, geomorphologic and local environmental conditions. Hence to locate a suitable site for groundwater exploration is very difficult task in this region. The flows of Deccan trap basalt vary in thickness from few meters to hundreds of meters. These flows or litho units behave differently in ground water occurance due to change in their chemistry, compactness, presence of amygdales, vesicles, fractures etc. In Deccan trap, groundwater occurs mostly due to its secondary porosity and the presence of joints, fractures, vesicles, amygdales etc.

The Deccan trap basaltic terrain of Pohra area, Amravati district, [lat. 20°.55' - 20°.58' and Long.77°45'-77°55'] falling in survey of India toposheet No. 55H/13 is studied with reference to resistivity survey, pumping test, hydrogeomorphological condition, geophysical, remote sensing and lineament aspects. Remote sensing technique, hydrogeomorphological maps, resistivity survey results are also helpful in identifying different basaltic layers present underground and their possible correlation (Fig.1).

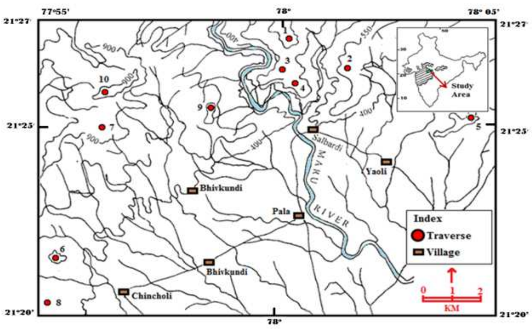

Fig. 2: Physiographic map of Salbardi area showing field traverses 1 to 10.

Resistivity Survey:

In 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). Attempt has been made by Thigale (1979) to establish relationship of plants with the occurance of groundwater. The various methods and techniques have certain limitations in groundwater exploration. The resistivity survey is found to be useful to detect the aquifers in Deccan traps. Balkrishna and Ramanujachary (1978) have analyzed the results of the resistivity survey in the Malwa plateau, Deccan plateau and the flanks of the Sahyadri ranges. Sathyamurthy et.al. (1979) studied the result of electrical resistivity surveys for ground water in Deccan traps of Maharashtra.

Geophysical method 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 Traps, where various layers of the lava flows are present, this method is proved to be useful. There is a difference in geochemical, petrographic, jointing pattern and vesicles etc. of the

Deccan trap which ultimately reflect in the difference in resistivity values of these flows. The true resistivity values and thickness of the layers are obtained by interpretation of the sounding curves. (Parikh, 1989).

In this study, an attempt has been made to explore the ground water bearing formations by Schlumberger vertical electrical resistivity sounding method at 12 important locations at Pohra area with AB/2 = 120 meters and Mn/2 = 10 meters. The curves obtained by plotting resistivity Vs AB/2 interpreted by using the curve matching technique (Fig. 1) of Orellana and Mooney (1966). This study has laid to the identification of groundwater regime of the region by indicating the general slope of the groundwater movement toward the west. The first and uppermost layer represents moderately to highly fractured basalt covered by thin top soil. Whereas the second layer is characterized by hard, compact, massive basalt (Fig. 2). The permeability of this second layer is very less, which is reflected in the low values of storativity, transmissivity and storage coefficient of this area, as compare to the standard values of these parameters for Deccan traps.

The Pohra area is characterized by three main lithological units which include weathered basalt with top soil, hard, compact, massive basalt and vesicular basalt. In this study, an attempt has been made to understand the ground water potential and watershed management of the region. (Table 1) This survey also proved to be useful for identifying various basaltic layers present underground and their possible correlation (Fig. 3).

Pumping Tests:

The total eleven wells selected for pumping text are located in 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 form the 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 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 rocks. (Ballukaraya, 1989). The basic purpose of carrying out the pumping test is to determine the safe yield of the wells and specific capacity or discharge draw down ratio of the wells. These two parameters define production capacity of wells which help in the 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 behavior, which will be useful to study the ground water flow studies. The pumping test is generally used to study the parameters like storativity, transmissivity and yield characters. These values define the yield characteristics. In Deccan Traps, the result of the pumping test varies widely because of the difference in lithological conditions. According to Rao (1974) porosity of fractured basalt may be as high as 50 percent. Adyalkar (1984) believes that vesicular basalt constitutes the best which shows a porosity of 25-30 percent, permeability ranges between 5-15 m/d, specific capacity of 100-200 Pm/m and specific yield of 3-10 percent corresponding to storativity of 0.03 to 0.10.

In this study, topographic maps have been utilized as base maps and all the hydrogeological information such as lithology, water table contours, topographic contours, thickness, performance and nature of the aquifer, variation in the yield was plotted and interpreted. This study has demonstrated the occurance of mini basins showing specific groundwater flows in the area of investigation which is separated with others 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. This study has given rise to the areal extent and depth of penetration which is 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 (Table 2).

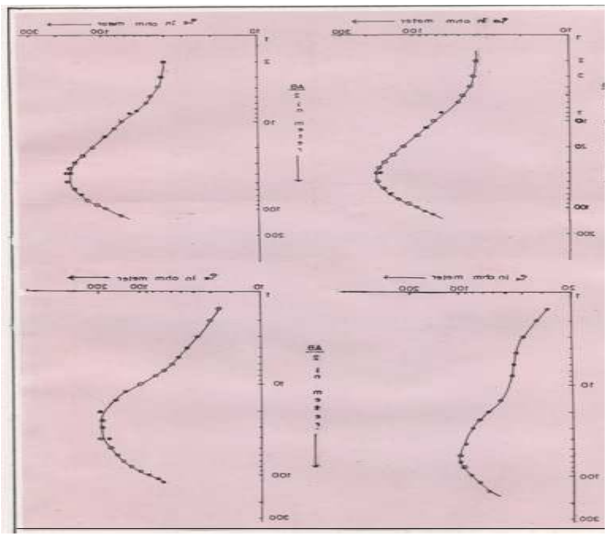

Fig.2 Logarithmic plots of AB/2 Vs Resistivity in the study Area

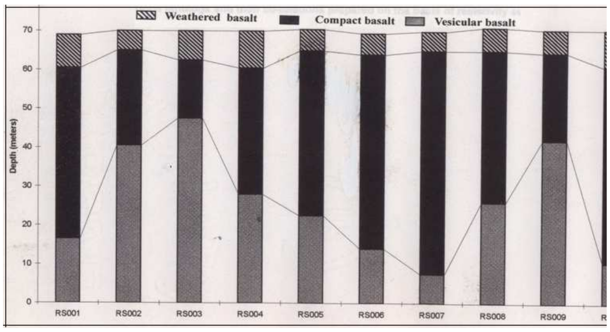

Fig.3 Litho logs and their correlation computed on the basis of Resistivity data

Table 1 Results of Resistivity survey and suggested recommendations for the Study area.

Location	0—5-—10—-15-—20—25---30---35—-40—-45-—50—55— 60— 65— 70m
RS001	|w.b ||c.b ||v.b
RS002	|W C.B. V.B.
RS003	|WB ||CB VB ||CB
RS004	iwb cb hvb
RS005	WB|| CB ||VB
RS006	|WB|| CB ||VB
RS007	iwbii cb
RS008	|WB|| CB ||VB
RS009	|WB|1 CB VB || CB
RS010	|WB CB[HFr] || VB
RS011	|CB || VB || CB
RS012	|WB|| CB || VB

Recommendations:

Location	Recommendations
RS001	Fractured and Weathered zone encountered up to the depth of 15 m bgl.
RS002	Fractured and Weathered zone encountered up to the

	depth of 15 m bgl..
RS003	Fractured and Weathered zone encountered up to the depth of 15 m bgl.
RS004	Fractured and Weathered zone encountered up to the depth of 15 m bgl.
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 250 ft. Saturated zone struck below 45 mts. bgl.
RS009	Not Feasible
RS010	Feasible for Open well of depth 15 m bgl. and also for Bore 200 m bgl.
RS011	Not feasible
RS012	Not feasible.

- WB - Weathered Basalt
- CB - Compact, Massive Basalt|
- HFr - Highly fractured Basalt
- VB - Vesicular Basalt [beginning with red tuffaceous layer]

The transmissivity values for well No. 1, 2 and 4 are found to be 48.82 sq.mt./day; 69 sq.mt./day and 59.15 sq.mt/day respectively. The standard values for transmissivity [T] for Deccan Trap is 30-100 sq.mt./day. The calculated value of 'T' is according to the standards. The specific capacity values calculated for well No. 1, 2 and 4 are 47.59 lt/min./m, 59.04 lt/min./m respectively. The storage coefficient values for well No. 1, 2 and 4 are 0.527, 0.032 and 0.89 respectively, which are relatively less comparable to the standard value for Deccan trap aquifers. This might be due to the fact that the consistently compact, massive, hard trap [> 300 /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 2).

The result 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 shows excellent potential for the groundwater exploration with higher safe yields, whereas, well No. 2, 10, 14 and 18 showed moderate productivity with medium safe yield. Well No. 8 and 12 shows low potential with very low safe yield and recuperation and hence not suitable for further ground water development. It is important to mention that well No. 19 has good potential for further development which can provide the safe yield up to l,25oo Its/day. The results also demonstrate the occurance 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 wells 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. These values will also be useful in further defining the boundaries of the basin which differ with the other basins 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 shape of the contours.

Table. 2 Results of the Pumping test and suggested recommendations for the Study area.

Well	Safe Yield [Qs]	Specific Capacity [C]	Transmissivity (t)	Storage Coefficient[S]
01	1,12,370 Us/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	71,400Lts/day	1 8.46Lts./min/mt.ofD/D	59 sq.mt./day	0.89
06	4, 17,000 Lts/day	104Lts./min/mtofD/D	51 sq.mt./day	0.059
08	18,720 Lts/day	15Lts./min/mt.of D/D	210 sq.mt./day	1.31
09	1,1 3,4 14 Lts/day	39Lts./min/mt.of D/D	274 sq.mt./day	0.239
10	63,360 Lts/day	44Lts./min/mt.of D/D	105 sq.mt./day	0.196

12	13,3 15 Lts/day	18Lts./min/mt.of D/D	330 sq.mt./day	0.134
14	57,960 Lts/day	25Lts./min/mt.of D/D	62 sq.mt./day	0.112
18	29,952 Lts/day	16Lts./min/mt.of D/D	181 sq.mt./day	0.66
19	79,200 Lts/day	44 Lts./min/mt.of D/D	459 sq.mt./day	2.42*

* Fracture zone encountered in a well attributes high transmissivity value.

Recommendations

Well No.	Recommendations
01	Deepening of well by 2 m bgl.. Can increase the well yield by 25 - 30 Percent
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 m bgl. 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 m which may give the Safe Yield 1,00,000 - 1,25,000 Lts./day.

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 exploitation limit to which the development can be extended 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 provide a rational solution to problems faced hither to in watershed approach of ground water development. The results of the pumping test data indicate that these are limited groundwater prospectus in the region which certainly needs careful planning and management of the available water resource.

Hydro geomorphic Condition of the Study Area:

The occurance and distribution of groundwater is mainly controlled by lithological, structural, geomorphologic and climatic conditions. In Salbardi area, structural ridges over Gondwana and Deccan Traps, denudational hills over basalts and Achaean rock formation and highly dissected basaltic plateau are often endowed with hard and compact rock on the surface which indicate network of dissection. The thickness of weathering is also less and is limited to few centimeters and as such often there is not storage space left resulting in poor availability of ground water. This zone by and large represents non cultivable areas with only forest as major land cover. The overall ground water potential of these units are poor. This is predominantly the run off zone. The moderately dissected plateau occurs along the fringes of the highly dissected plateau and forms mainly the midlands. Here the thickness of weathering is moderate and the degree of terrain dissection is also moderate. In general, this unit support, thin vegetation as observed in the field. The characteristics of this unit render this as a recharge zone. The groundwater prospectuses of this unit are moderate to poor (Table. 3).

The lower dissected plateau unit is the major geomorphic unit amongst the dissected basaltic plateau area. This landform is observed to have adequate thickness of soil with weathered mantle (Fig..4). Lineaments, fractures if present, tend to identify this is a potential recharge cum storage zone. The semi confined aquifer in this area have been developed both for irrigation and water supply. The famous orange gardens in Warud and Morshi area are located in this land form. The overall groundwater potential of this zone can be grouped as moderate productive. Withdrawal of groundwater for orange cultivation has resulted in de-watering of aquifers in large areas of this belt and it requires water conservation as well as artificial recharge treatment to make up the loss of already depleted ground water table. The Purna alluvial plain present at the foothill region of the Satpuda hill ranges is one of the most potential pockets in Maharashtra (Fig. 3). The thickness of alluvial deposit ranges from 10-350 meters comprising of clay, silt, sand lenses and gravels as per central ground water board results. This alluvial belt can be classed as productive except chemical quality in the saline zone.

Summary and Conclusions

The geomorphic and morpho-tectonic evaluation of landscape in the study area has been mainly controlled by various parameters like hydro-geomorphologic, lithological, structural, climatic and environmental factors. The landforms have been resulted from various geomorphic processes like erosion, deposition, faulting, upliftment, tilting and pediplanation. The topographical profiles reveal the presence of marked flat terraces at 350 m, 600 m and 1150 m which indicate sequence of events which have resulted during the geomorphic and morpho-tectonic evolution of landscape. The lithological variations have caused undulations in the topography. The result indicate various topographic forms developed by intrusive phase of igneous activity which offer resistance to weathering and erosion represented by the presence of linear ridges breaking monotony of plains.

The result of the drainage analysis indicates hydro-geological conditions of the study area, which is more suitable for groundwater exploration with high drainage frequency. From drainage analysis, in given area the minor structure was inferred. The minor liniments which show the fracture the most of lineaments age in the North South direction. In remote sensing the lineament can be identified by the presence of straight drainages. The presence of dendritic drainage implies a lack of structural control. It was concluded that the area of the sub-catchments controls the aspect ratios of the basin because of lateral drainage branching and network bifurcation. Two landform evolution models were generated on the basis of variations in the coordinates of the slope inflection points on the hypsometric curves in terms of relative height and plain area.

Table 3 :- Various geomorphic units and their characteristic features

Map Symbol	Geomorphic unit	Description	Ground Water Prospectus	Yield Prospectus (Kl pi)
V.F.	Fluvial origin Valley Fill	Localized narrow valley with thick alluvial/colluvial material over the	Very good	60- 100

A. P.	Alluvial Plain	Weathered mantle. A narrow valley with thick alluvial material deposited along the river.	Very good	60- 100
HOP	Structural origin	High hills with high dissection, thin soil cover & rock out crops.	Poor	---
MDP	Highly dissected Plateau			---
	Moderately dissected plateau	Basaltic plateau with moderate dissection forming moderately high hills & up lands.	Moderate	---
LDP	A	Area of rock exposures with thin weathered mantle.	Poor	20-30
	B	Area of weathered rock with thin weathered mantle.	Moderate	30-60
	C	Area of weathered rock with thick weathered mantle	Good	---
	Lower dissected plateau	Area of weathered rock with thick weathered mantle and soil.	Good	---
DS DH	Denudational Origin	Moderately sloping area of hill with weathered basaltic rock and scree material.	Poor	—
	Denudational Slope			
	Denudational Hill	Basaltic hills formed due to differential erosion & weathering.	Poor	—

The remote sensing techniques have been proved to be very efficient in identification geo-hydrological and geo-environmental aspects of the study area. Geology, geomorphology, hydro-geomorphology, geo-hydrology, structure, soils, erosion, and land use land cover helped in identification of the potential zones for development planning and forecasting limitations to their implementation with seasonal accuracy. Lineaments and their intersections appear to be potential sites for groundwater. The Maru drainage basin is suitable for surface reservoirs and check dams. The study shows that the integration of all attributes provide more accurate results in identification of geo-environmental and geo-hydrological characteristics

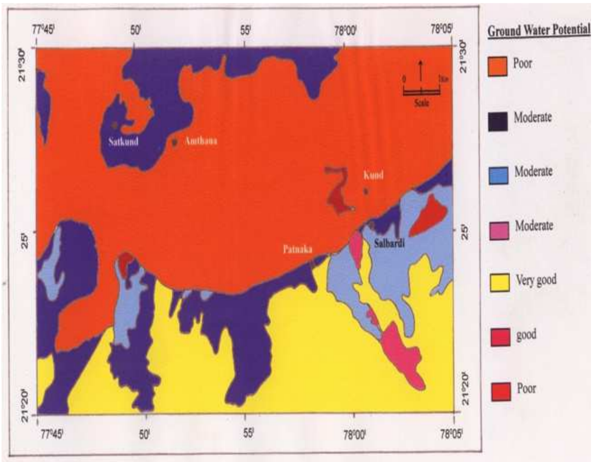

Fig.4 Hydrogeomorphological map of study area

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