LAPS TIME FOR RISE AND FALL IN GROUNDWATER LEVEL AND GROUNDWATER FLUCTUATION STUDIES IN BASALTIC TERRAIN OF SOLAPUR DISTRICT, MAHARASHTRA, INDIA

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ABSTRACT

Hydrogeological investigations provide information for planning, delineation, evaluation, exploitation and management of groundwater resources. The main input, rainfall, plays an important role in fluctuation of water table. Depending upon the hydrogeological characters of the subsurface the rate of recharge after the rainfall event decides the groundwater levels and there is always a time gap, which is defined as laps time to attain the maximum water level and subsequently there is a time gap for attaining lowest water level which is also a function of Geology and differences in the heads provide the flow of water from higher potential to lower potential. This flow of water brings down the water levels increasing the gap between the surface and the water table which is designated as the vadose zone. The dynamic resource in the groundwater reservoir is governed by the vadose zone, through which water level fluctuates. Thicker the Vadose zone more is the space available for groundwater accumulation. Further the aquifer parameters transmissivity and storage coefficient are important parameters to decide the groundwater potential in an area and helpful in determining the capacity of aquifer to store water and the ease with which water can flow through permeable zones. Also this helps in delineating areas feasible and non-feasible for artificial recharge. Therefore these studies has been done in the Dhubdhubi basin, a sub basin of Bhima river, which covers part of South Solapur and Akkalkot Talukas of Solapur District Maharashtra, located on survey of India Toposheet no.47 0/14, 47 0/15, 56 C/2 and 56 C/3 on the scale of 1:50000, lies between latitude 17^0 21' to 17^0 41'N and longitude 76^0 00' to 76^0 11'E covering an area of 450 sq.km.

Keywords: Groundwater, Fluctuation ,Basaltic Terrain.

1. Introduction

Deccan basalt or trap rock consist of vast pile of bedded lava flows having two to three distinct horizons, the lower one are clinker followed by massive part which is hard and compact and the upper horizon is characterized by vesicles and cavities filled with secondary minerals. The massive traps are fractured and jointed at places and act as water conduits. Weathering of these rocks are favorable zones for subsurface storage. Nature and composition of the rock types, Geological structures, Geomorphological setup, hydro metrological conditions and hydrogeological properties of rocks influence the prospects of groundwater in Deccan volcanic formations.

Rainfall plays an important role in fluctuation of water table. For groundwater recharge apart from rainfall transmissivity and storage coefficient are important parameters which need to be estimated. Therefore, studies on groundwater level fluctuations are essential to develop suitable scheme for understanding groundwater resources of an area. Groundwater level also has major role in selecting the areas feasible for groundwater harvesting, for this purpose water level were recorded in 42 observation wells, on monthly basis for five years in the Dhubdhubi basin, a sub basin of Bhima river, which covers part of South Solapur and Akkalkot Talukas of Solapur District, Maharashtra. Located on Survey of India toposheet number 47 O/14, 47 O/15, 56 C/2 and 56 C/3, on the scale of 1:50,000 laying between latitude $17^0\ 21^1$ to $17^0\ 41^1$ N, and longitude $76^0\ 00^1$ to $76^0\ 11^1$ E. Covering of an area of 450 sq. Km as shown in fig 1. The wells where selected such that they represent weathered formations, jointed/ fractured basalts and vesicular/ zeolitic basalts.

2. Geology

The Dhubdhubi basin consists of basaltic lava flows representing Indrayani stratigraphic unit of Sahyadri group of Deccan trap formation of Upper Cretaceous to lower Eocene age (GSI 2001). Sabale, 2008 described the lithounits in the basin, according to him, Weathered zeolitic/ fragmentary lithounit is exposed in the southern portion of the basin, at Kudal and Devkavate villages and is overlained by red boles of 1m thickness, around Andhewadi and near Kalhippargi, representing oldest flow (Ist flow) in the basin. The thickness of this flow is 21m. Flow IInd, also of 21m thickness, consisting of lower 8m thick weathered basal clinker, starts at an altitude of 431m between Shaval and Kalhippargi. This is overlained, by fractured/massive basalt of 12m thickness, around Kalhippargi, Handral, Karajgi, Shirval and Kadabgaon villages. One meter thick red bole graded into

zeolitic/vesicular basalt is exposed NE of Handral, Jeur, Ingalgi, Achegaon, Tillyal, Hipale, extending beyond Ratnapur (Borul). It is the marker bed between IInd and IIIrd flow. This is overlained by 4m thick unit of Basal Clinker around Hanjagi, South of Karjal and north of Hipale. Above these rocks, massive basalts of 19m thickness are resting and are outcropped around Akkalkot station, Dodyal, Konhalli, Karjal, Shingadgaon, Hanamgaon and Rampur. 22m thick vesicular zeolitic basalt unit is overlaying this around Bagehalli, NE Konhali, North of Dahitanewadi, Walsang, Gurdehalli and Kardehalli. This vesicular zeolitic lithounit is graded into 1m thick red bole and basal clinker of the younger flow, exposed near Wadgaon. The total thickness of the IIIrd flow is 46m. This is overlained by fractured / massive basalts of the younger flow (IVth flow) in the basin around the villages Halhalli, Dindur, West of Thirth, North of Wadgaon, Dhotri and North of Shirpanhalli. The basin boundary in the North and NE shows exposures of zeolitic basalt. The massive portion of Ist, the oldest flow in Dhubdhubi basin is not represented. The general gradient of lava flows in the basin is around 1:550 to 1:800 towards SE. However, Exposures of alluvium, having a thickness range of four to seven meters are the quaternary formations exposed in the basin around Andhewadi (K) and near Handral along the stream.

3.Groundwater fluctuation studies:

It is observed that unconfined, semi confined and confined aquifers are formed in basaltic terrain of Solapur District (CGWB 2005). The unconfined aquifers are developed due to the weathering of upper vesicular/ zeolitic flow unit of basalts and jointed/ fractured basalts. In the unconfined aquifers to understand the behavior of groundwater levels in the Dhubdhubi basin, 42 observation wells (locations shown in figure 1) have been monitored and water levels were recorded on monthly basis for five years starting from July 2002 to May 2007. The wells were selected such that they represent weathered formation, jointed/ fractured basalts and vesicular/zeolitic basalts. The rainfall and groundwater level fluctuations are shown in figs. 2 to 7, from which the following observations are made:

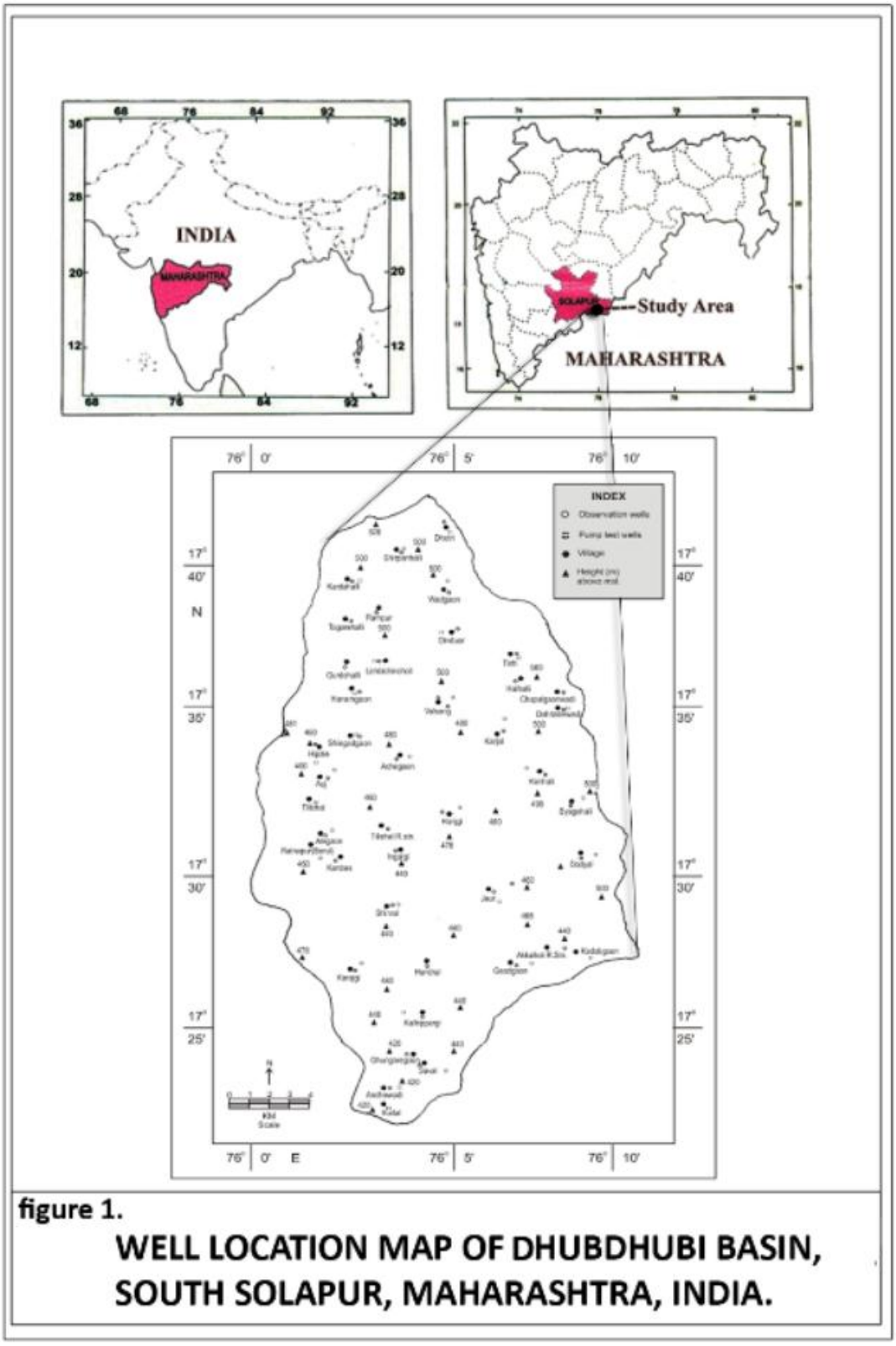


figure 1.

WELL LOCATION MAP OF DHUBDHUBI BASIN, SOUTH SOLAPUR, MAHARASHTRA, INDIA.

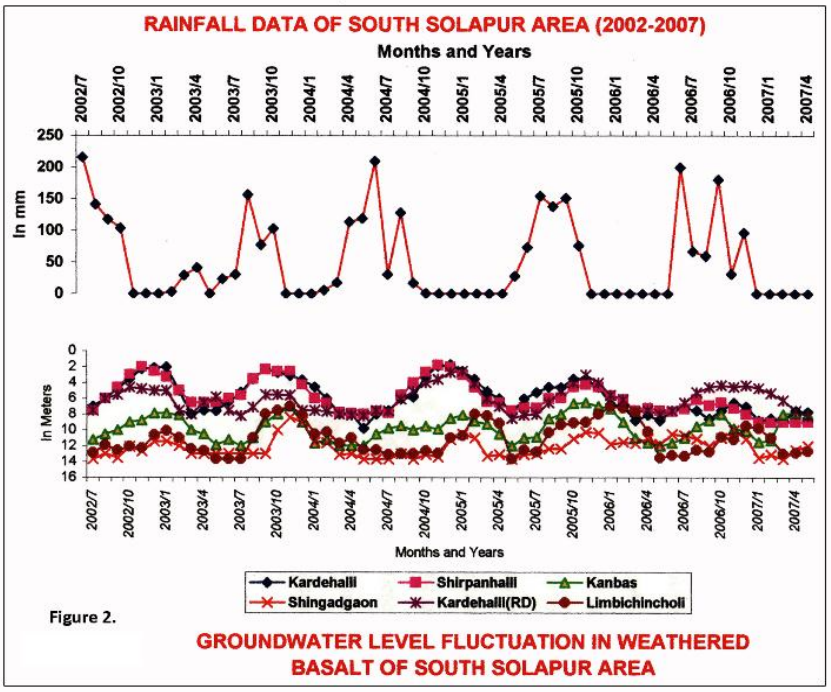
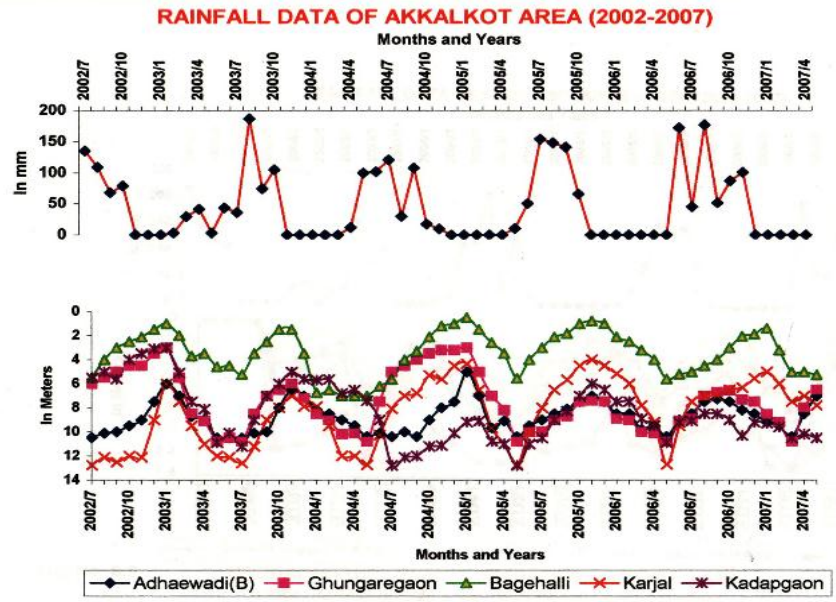


Figure 2.

GROUNDWATER LEVEL FLUCTUATION IN WEATHERED BASALT OF SOUTH SOLAPUR AREA



GROUNDWATER LEVEL FLUCTUATION IN WEATHERED BASALT OF AKKALKOT AREA

Figure 3.

The pre-monsoon water levels in weathered formations (fig. 2 and 3) range between 7.60 m below ground level (mbgl) at Kardehalli and 14.50 m at Limbichincholi. This indicates that pre- monsoon water levels of the basin are always below 7.6m in the weathered formations.

The post-monsoon water levels in the weathered formation (fig. 2 and 3) range between 2.25 m bgl at Kardehalli and 8 m bgl at Limbichincholi.

Water levels in wells from jointed /fractured basalts (fig. 4 and 5) range between 5 m bgl at Dahitanewadi and 14 m bgl at Karajgi during pre-monsoon season and between 2 m bgl at Dhotri to 8 m bgl at Dodyal, during post-monsoon season.

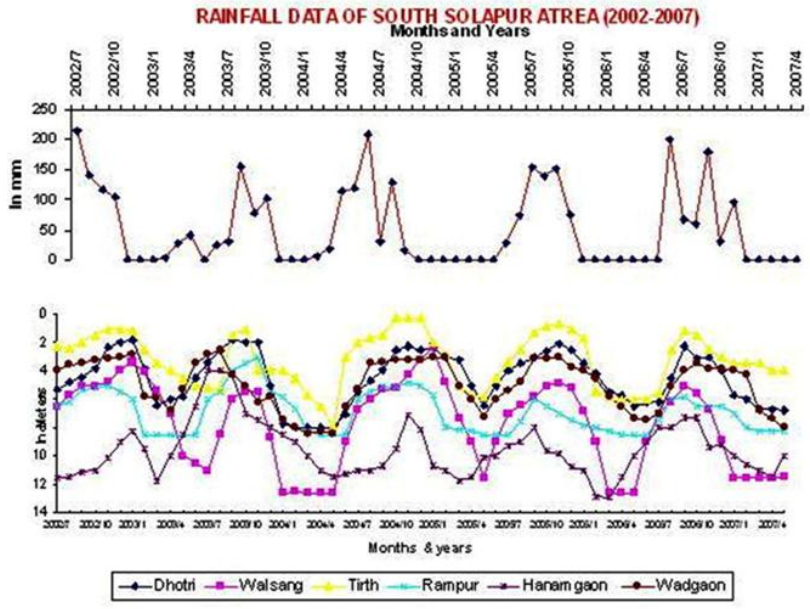


Figure 4.

GROUNDWATER LEVEL FLUCTUATION IN JOINTED AND FRACTURED BASALT OF SOUTH SOLAPUR AREA

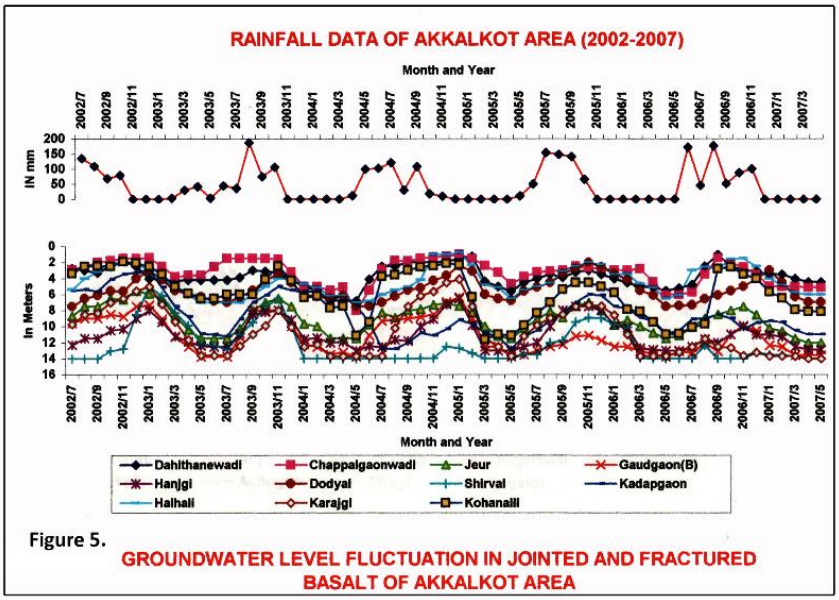


Figure 5.

GROUNDWATER LEVEL FLUCTUATION IN JOINTED AND FRACTURED BASALT OF AKKALKOT AREA

The vesicular / zeolitic formations (fig. 6 and 7) have water levels between 7.20 m bgl at Hipale and 13.80 m bgl at Gaudgaon (B) during pre- monsoon and that for the post-monsoon are 2 m bgl at Hiple and 7 m bgl at Auj.

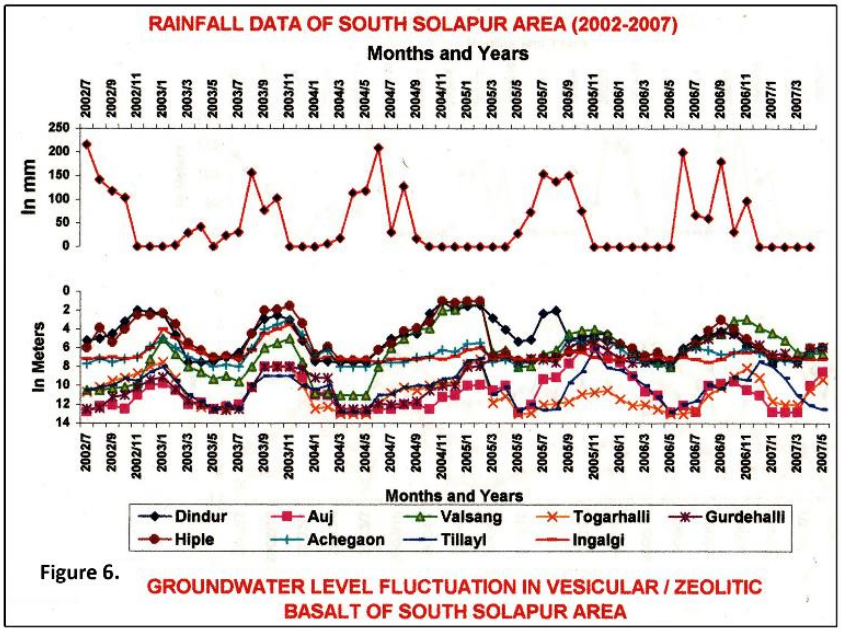


Figure 6. GROUNDWATER LEVEL FLUCTUATION IN VESICULAR / ZEOLITIC BASALT OF SOUTH SOLAPUR AREA

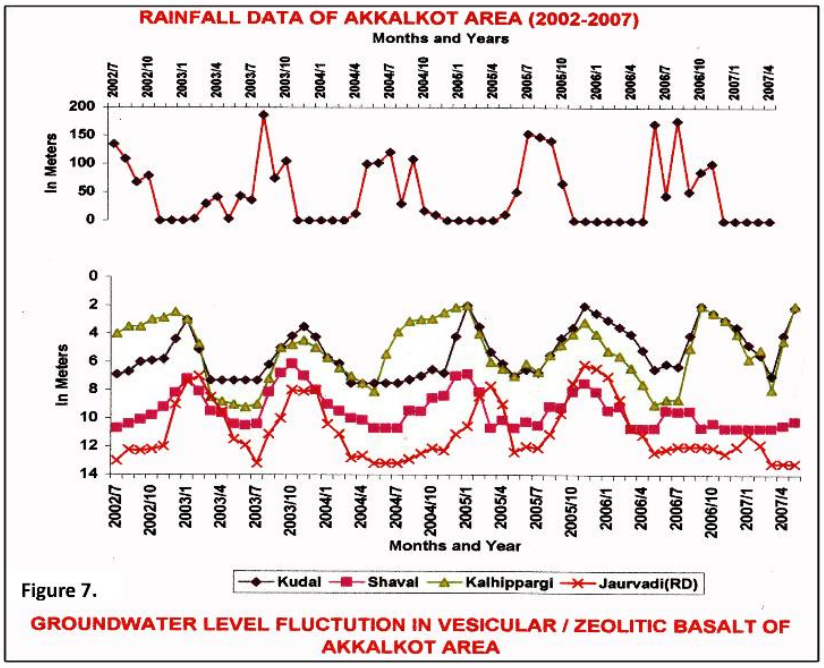


Figure 7. GROUNDWATER LEVEL FLUCTUTION IN VESICULAR / ZEOLITIC BASALT OF AKKALKOT AREA

4. Laps time studies for maximum fall and rise in groundwater level:

In the groundwater recharge system, rainfall is the main feeding source, water precipitated on the surface of the earth, enters in the groundwater system through infiltration from the Geological formations. There is a lag between the peaks of rainfall and water level rise in the wells, this lag we define as ‘laps time for rise’. Similarly, this rise in water level in absence of rainfall begin to fall, the maximum fall of water level also has a lag, this we define

as 'laps time for fall', these laps times for rise and fall are illustrated in figure 8, the time required for water level to get maximum and minimum saturated thicknesses helps in understanding the rate of rise and fall in water levels.

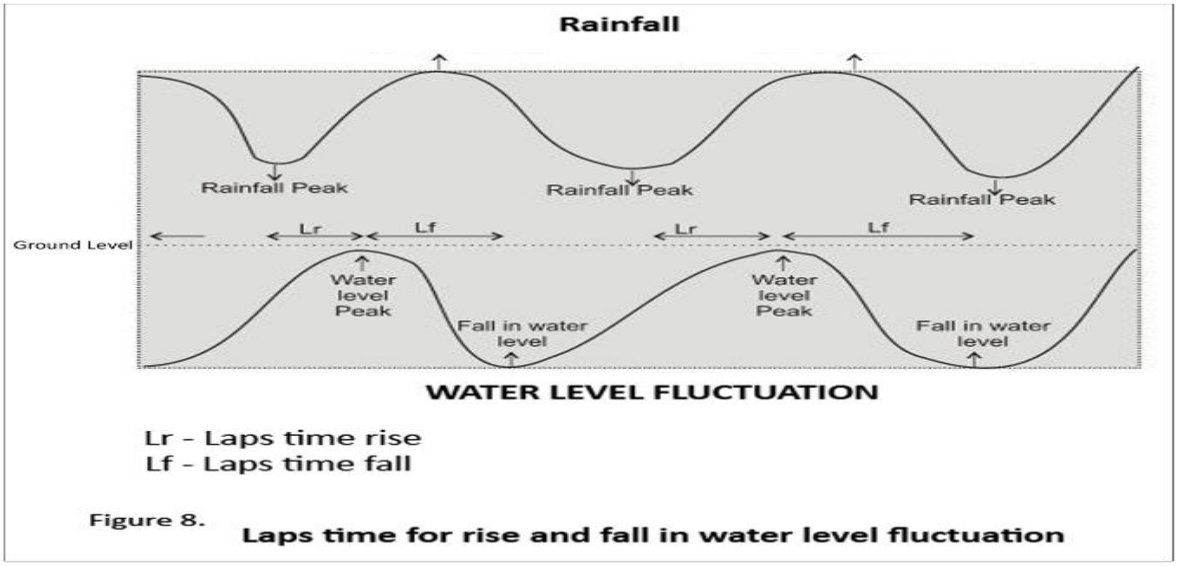


Figure 8. **Laps time for rise and fall in water level fluctuation**

The laps time for rise and fall as recorded for two rain fall zones in the basin are described in the following:

a) Akkalkot Rainfall Zone:

1) Lapse time for maximum water level rise after rainfall peak for all the three geological formations are between three and four months.
2) Average Lapse time for maximum water level fall is six months.

The fluctuations in water levels for different formations are as follows.

Jointed/fractured basalts 3.6m
Vesicular/zeolitic basalts 2.8m
Weathered formations 3.4m

b) South Solapur Rainfall zone:

1) Lapse time for maximum water level rise after rainfall peak is between two and four months for jointed/ fractured basalts where as for vesicular/ zeolitic formations and for weathered rock, it is between three and four months.

2) Lapse time for maximum water level fall is six to seven months for fractured basalt and for Vesicular/ Zeolitic basalt and weathered formations it is between five and six months.

The average fluctuation in the water level for different formation is as follows:

Jointed/fractured basalts 4.2m
Vesicular/zeolitic basalts 3.4m
Weathered formations 4m

5. Aquifer performance test:

Pump test on 32 observation wells consisting of weathered, jointed, fractured, and vesicular/ zeolitic rock types where carried out initially by using modified Cooper Jacob (1948) method of solution. The values of transmissivity and storativity obtained from this technique where used as initial values to archive refinement by the computer aided method suggested by Singh and Gupta (1988). The results of the aquifer tests are given in the table 1. It has been observed from the results that transmissivity(T) varies between $9m^2$/day and $368m^2$/day, and storativity from 3.33×10^{-5} to 7.70×10^{-2},the values are higher where weathered, highly jointed, fractured and zeolitic basalts from the earth and along the streams.

Table 1 Transmissivity and Storativity from Aquifer test analysis for the different locations in the

Dhubdhubi Basin

Sr. No	Q No	Well No.	Lat	Long	Village	T	S	Lithology
1	2	1	17.40	76.04	Shripanhalli	224.64	0.003358	Weathered Basalt J/F
2	3	2	17.41	76.05	Dhotri	60.72	0.0340	F/J Basalt
3	5	3	17.39	76.04	Kardehalli	82.17	0.00442	Weathered Basalt J/F
4	6	4	17.39	76.05	Wadgaon	76.58	0.04533	F/J
5	9	5	17.35	76.02	Hanamgaon	335.00	0.7700	Zeolitic Basalt
6	10	6	17.37	76.05	Dindur	368.018	0.03617	Zeolatic Basalt

7	11	7	17.36	76.07	Tirth	56.56	0.02198	F/J Basalt
8	13	8	17.33	76.02	Hiple	64.38	0.00046	Zeoletic
9	14	9	17.34	76.02	Shigadgaon	136.00	0.059	Weathered Basalt
10		910	17.33	74.04	Achegaon	28.83	0.00030	Zeolitic Basalt
11	15	11	17.39	76.05	Walsang	12.00	0.008	Massive Basalt
12	16	12	17.34	76.07	Karjal	53.31	0.000333	Massive Basalt & weathered Basalt
13	17	13	17.35	76.09	Dahitanewadi	210.00	0.056	Massive Basalt & J/F
14	19	14	17.32	76.02	Auj	79.51	0.00047076	Zeolatic Basalt
15	20	15	17.32	76.01	Tillehal	26.81	0.0024949	Zeolatic Basalt
16	21	16	17.31	76.06	Hanjgi	42.60	0.020063	Zeolatic Basalt
17	22	17	17.33	76.08	Konhalli	124.34	0.0342	Weathered Basalt
18	23	18	17.32	76.09	Bagehalli	283.00	0.0652	Massive Basalt
19	25	19	17.30	76.01	Alegaon	9.00	0.033	Weathered Basalt
20	26	20	17.30	76.02	Kanbas	84.65	0.001032	Weathered Basalt
21	28	21	17.29	76.06	Jeur	21.00	0.085	Zeolitic & Massive Basalt
22	29	22	17.30	76.11	Dodyal	15.00	0.018	Massive Basalt
23	31	23	17.28	76.04	Shirval	163.00	0.048	J/F Basalt
24	32	24	17.26	76.05	Handral	108.00	0.020	Zeolitic Basalt
25	33	25	17.26	76.07	Gaudgaon	115.00	0.039	Zeolitic & Massive Basalt
26	34	26	17.27	76.09	Kadabgaon	119.38	0.04276	Weathered Basalt
27	36	27	17.26	76.03	Karajgi	63.74	0.075048	Massive Basalt
28	37	28	17.25	76.05	Kalhippargi	175.00	0.052	Zeolitic Basalt
29	40	29	17.22	76.04	Andhewadi	98.00	0.034	Weathered

								Basalt
30	41	30	17.23	76.05	Shaval	51.68	0.027	Massive Basalt & Zeolatic
31	42		17.22	76.04	Kudal	275.040	0.075	Zeolitic Basalt
32	43	9	17.35	76.02	Limbi – Chincholi	51.75	0.03055	Weathered Basalt J&F

*** J & F – Indicates – Jointed or Fractured Basalt**

6. Vadose zone studies:

Vadose zone is that part of the aquifer which is unsaturated and lies between ground surface and water table. This zone is potential for recharge. More the Vadose zone more is the scope for recharge. The Vadose zone fluctuates depending upon the availability of water. The thickness of the Vadose zone decides the scope for groundwater harvesting in hard rock terrains, because the pore spaces in this zone undergo restorations during infiltration and recharge and undergo destoration during evaporation and drainage. The volume of saturation involved in the process of change in saturation in Vadose zone (Zone of weathering) is far larger than the changes in volume of water involved in the elastic storage of water below the water table. Therefore the dynamic resource in groundwater reservoir is governed by the "Vadose Zone" through which water level fluctuates. Therefore information regarding water saturation, thickness and permeability of vadose zone / weathering zone are to be known before going for recharging schemes (CGWB 1994 and 2002). Thus for the Dhubdhubi basin the thickness of the Vadose zone for pre and post-monsoon period have been observed and presented in figure 9 and 10, respectively.

Figure 9, Shows pre- monsoon vadose zone in which the following features are observed:

a) There are four zones (H1, H2, H3, and H4) with high vadose thickness, one on the north, one at the center and two are on the south. These are potential regions for artificial recharge.
b) There are two regions with low Vadose zone thickness, one on the north and the other in the south. These are less suitable for artificial recharge.

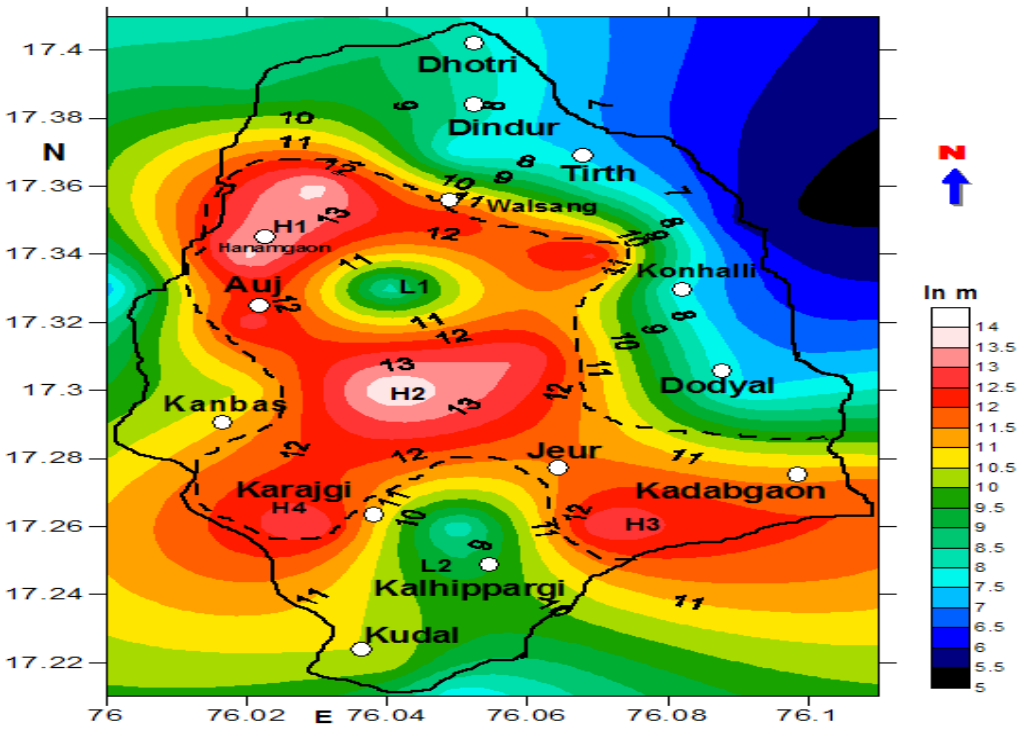


Figure 9.

THICKNESS OF PRE MONSOON VADOSE ZONE IN DHUBDHUBI BASIN, SOLAPUR DIST. MAHARASHTRA, CONTOUR INTERVAL: 0.5 m

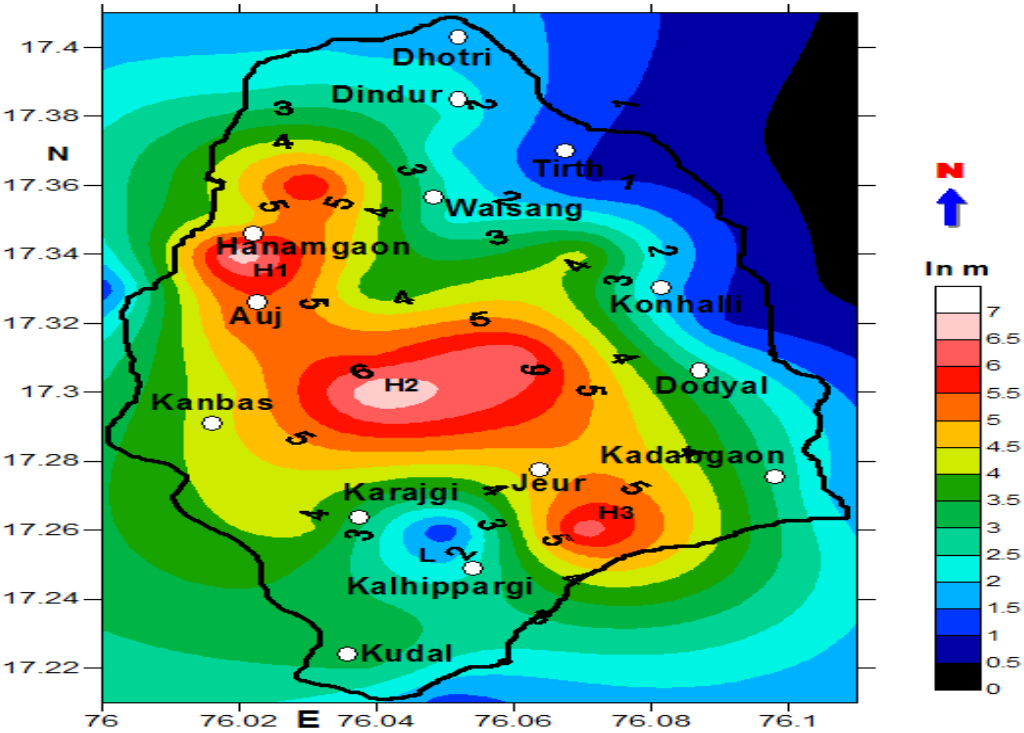


Figure 10.

THICKNESS OF POST MONSOON VADOSE ZONE OF DHUBDHUBI BASIN, SOLAPUR DIST. MAHARASHTRA, CONTOUR INTERVAL: 0.5 m

The following observations from figure 10 are made for the post-monsoon period:

a) There are three regions with Vadose zone thickness (>5 m) shown as H1, H2 and H3 with a NW-SE trend. The central region (H2) is thicker.
b) The southern part (L) has vadose zone thickness less than 1m.

7. Discussions and Conclusions:

The Dhubdhubi basin represents three sets of confined aquifers, formed by basal clinker, vesicular/ zeolitic and jointed/ fractured basalts which are sandwiched between compact basalts. However, phreatic aquifers are formed by the top weathered, fractured and vesicular/ zeolitic basalt units.

The aquifers formed by soft vesicular/ zeolitic unit and weathered basalt, shows less seasonal variations in water levels and the water table rise after the rainfall peak, takes two to three weeks. This shows relatively high permeability for these formations. Aquifers formed by jointed and fractured basalts shows water level fluctuations of several meters. The deepest water level, 14m, below surface, is observed during pre- monsoon and the minimum depth of water table is 1m, below ground level for post- monsoon periods.

It has been observed from the results of the aquifer test that the transmissivity (T) varies between $9m^2$/day and $368m^2$/day. Storativity (S) ranges between 3.33×10^{-5} to 7.70×10^{-2}. The values are higher where weathered highly jointed, fractured and vesicular/ zeolitic basalts, forms the earth sections and along streams, which shows preferred flow paths. This confirms that hard rock formations normally show heterogeneous character.

Pre- monsoon water levels in the basin are always 7.6m, below ground level and that for post –monsoon the range is between 1 and 8m, below ground level. There are four zones with high Vadose zone thickness in the north, central and south zones.

It is observed that if the depth to water table is more than 4m, below ground level during post- monsoon and the areas having more than 4m, difference between pre and post – monsoon are suitable for artificial recharge, on this basis 61% of the total area is favorable for artificial recharge/ groundwater harvesting in Dhubdhubi basin. It is also observed that there are three regions during post- monsoon having more than 5m; thickness of Vadose zones which are favorable for artificial recharge, on this basis 60 to 62% area in the basin is favorable for artificial recharge.

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