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Chapter

Evaluation of Analytical Methods to Study Aquifer Properties with Pumping Test in Deccan Basalt Region of the Morna River Basin in Akola District of Maharashtra in India

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Abstract

Fifteen pumping tests were performed in the Deccan basalt region of the Morna river basin in Akola district of Maharashtra in India. It is an artesian well as it is in the discharge zone of this coastal aquifer. Transmissivity (T) and storage coefficient (S) must be considered as aquifer parameters and used in groundwater recharge analysis. During the analysis of time-drawdown, the graphs were developed using pumping test methods and most of the pumps' water initially comes from the well storage. Analysis of the well in tapping aquifer in Deccan basalt shows the existing relationship between porosity and specific yield. All of the aquifer testing methods have suggested ground recharge structures such as open well, bore well, and reservoir in hard rock terrains. The data and information are very helpful for hydraulic conditions, aquifer zones, and open wells development and management. The aquifer's parameters are identified as important factors for groundwater resources evaluation, numerical simulation, development and protection as well as scientific management. The results are optimized, hence these aquifer parameters are important for scientific planning and engineering practices.

Keywords: pumping test, aquifer, Hantush method, Theis with Jacob method

1. Introduction

The basaltic hard rock has limited fresh water resources. Groundwater planning and management is a difficult issue for the current scenario [1, 2]. The observation wells have been storage and pumps and drawdown stages in the aquifer parameters. The aquifer characteristics were estimated using scientific methods.

The study area data like geological, hydrological, and geochemical data and laboratory results were combined to study water sustainability in the basaltic hard rocks [3]. The aquifer parameters were estimated through various pumping tests, while

groundwater has withdrawn and discharged from the open wells and bore wells, whose result is inserted into the well-flow equation and the hydraulic features [4]. The different curves matching and numerical methods are widely used to estimate aquifer parameters and plot graphs through pumping test data. In this study, two types of methods namely analytical and numerical were used for interpretation of pumping data in the aquifer software and mathematical equation [5]. Hence the present investigation has used numerical methods to achieve accurate results for aquifer characteristics conditions in the regions of Maharashtra [6].

2. Study area

The study area is located in the Akola district. The Morna river basin area covers 941 km² and is located between 76°47'54" and 76°6'44" E longitude and 20°53'26" and 20°22'22" N latitude (**Figure 1**). The major crops are pigeon pea, cotton, and soybean.

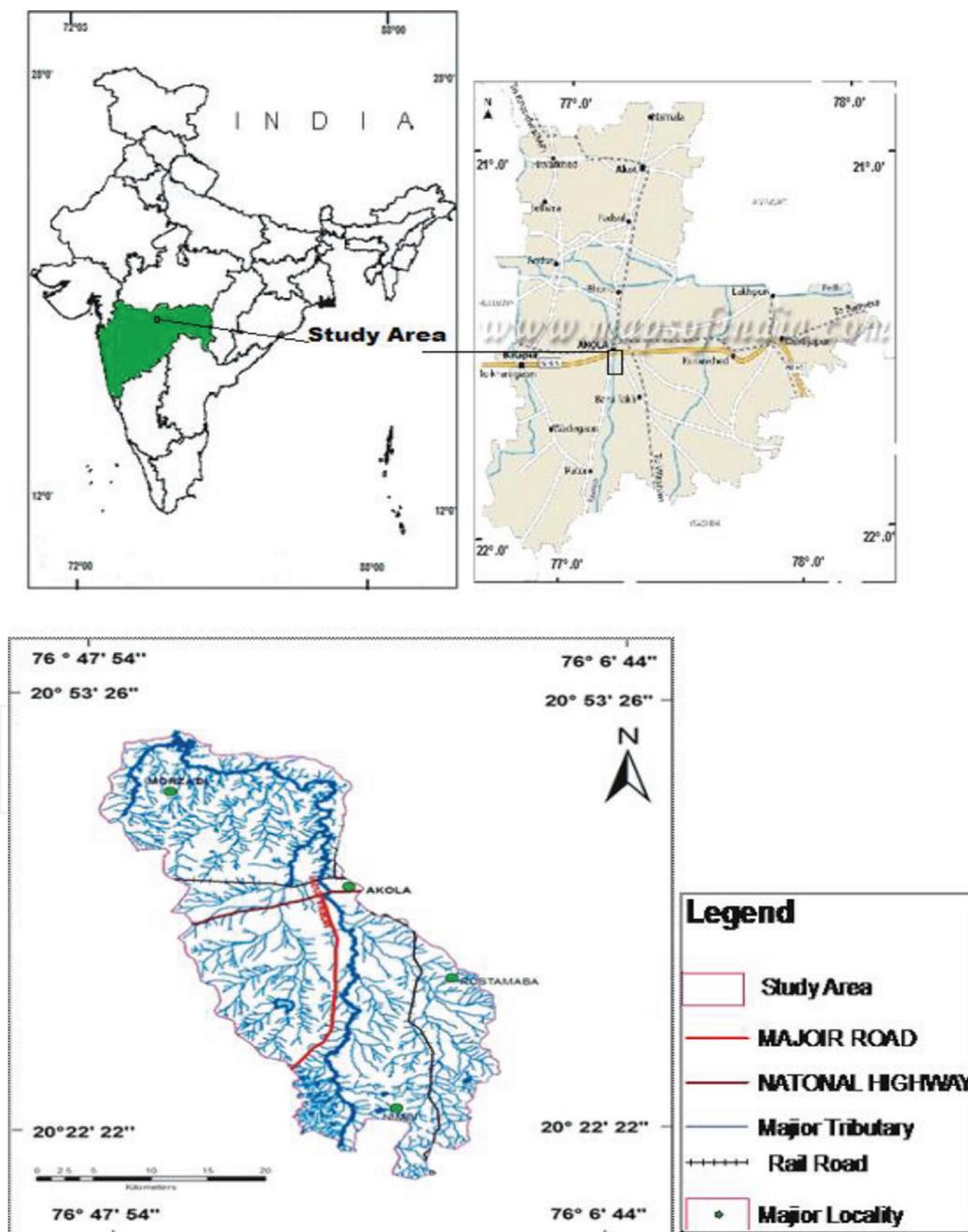
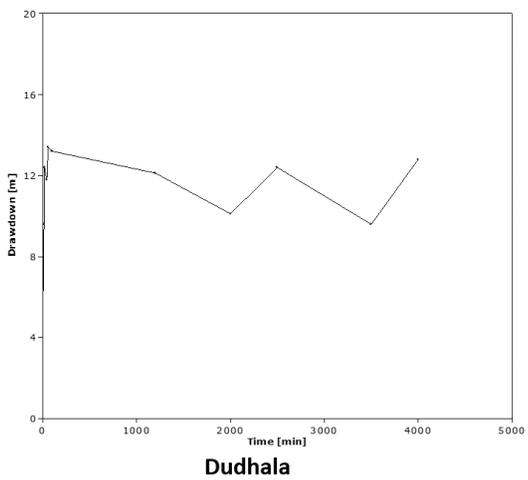
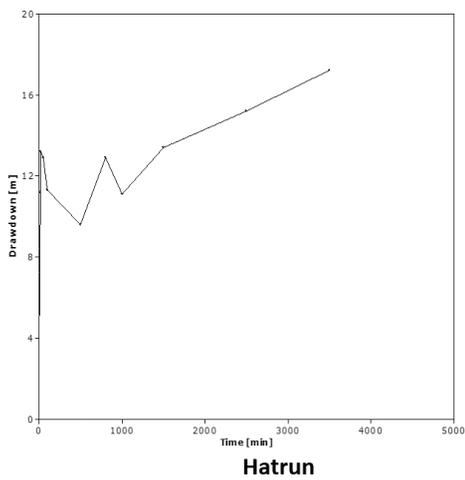
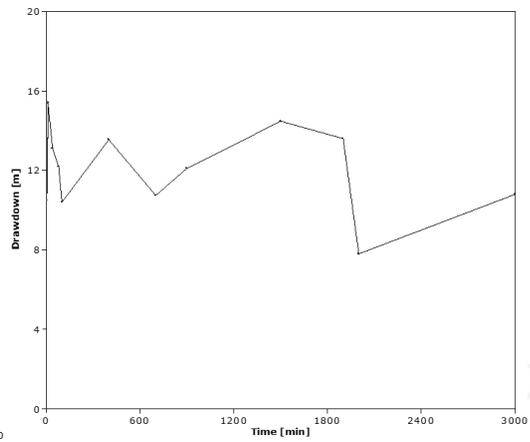
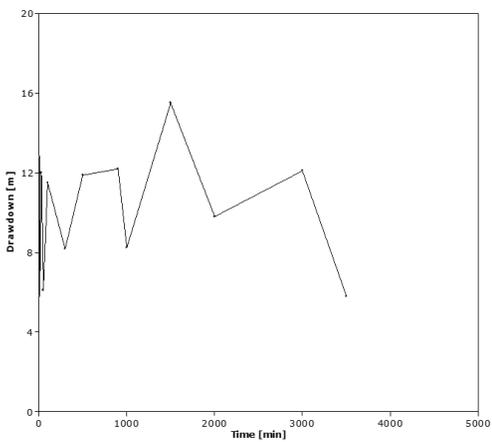
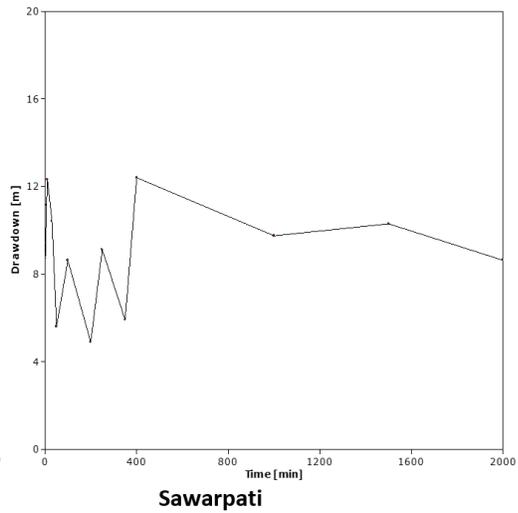
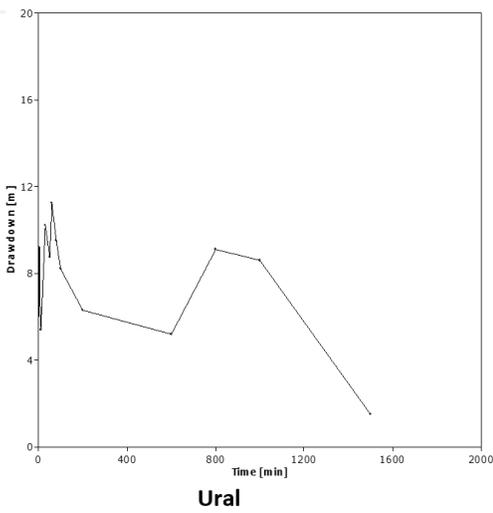
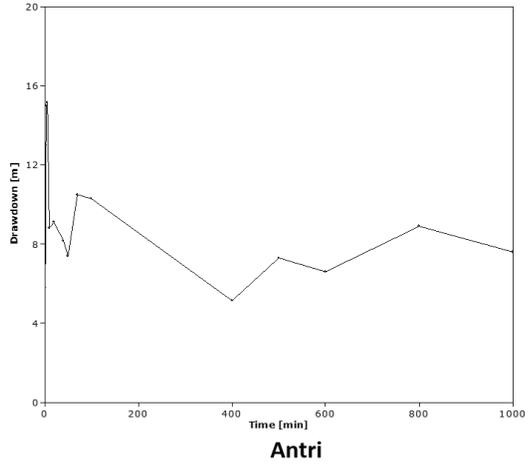
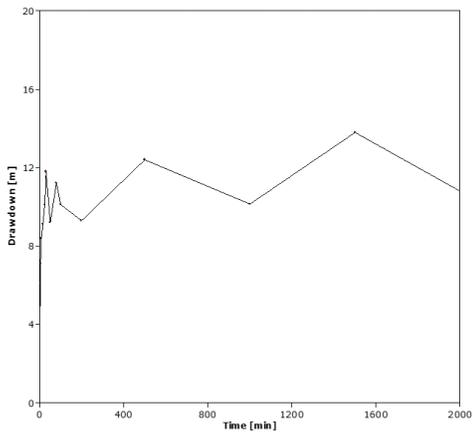


Figure 1.
Location map of the Morna river basin.



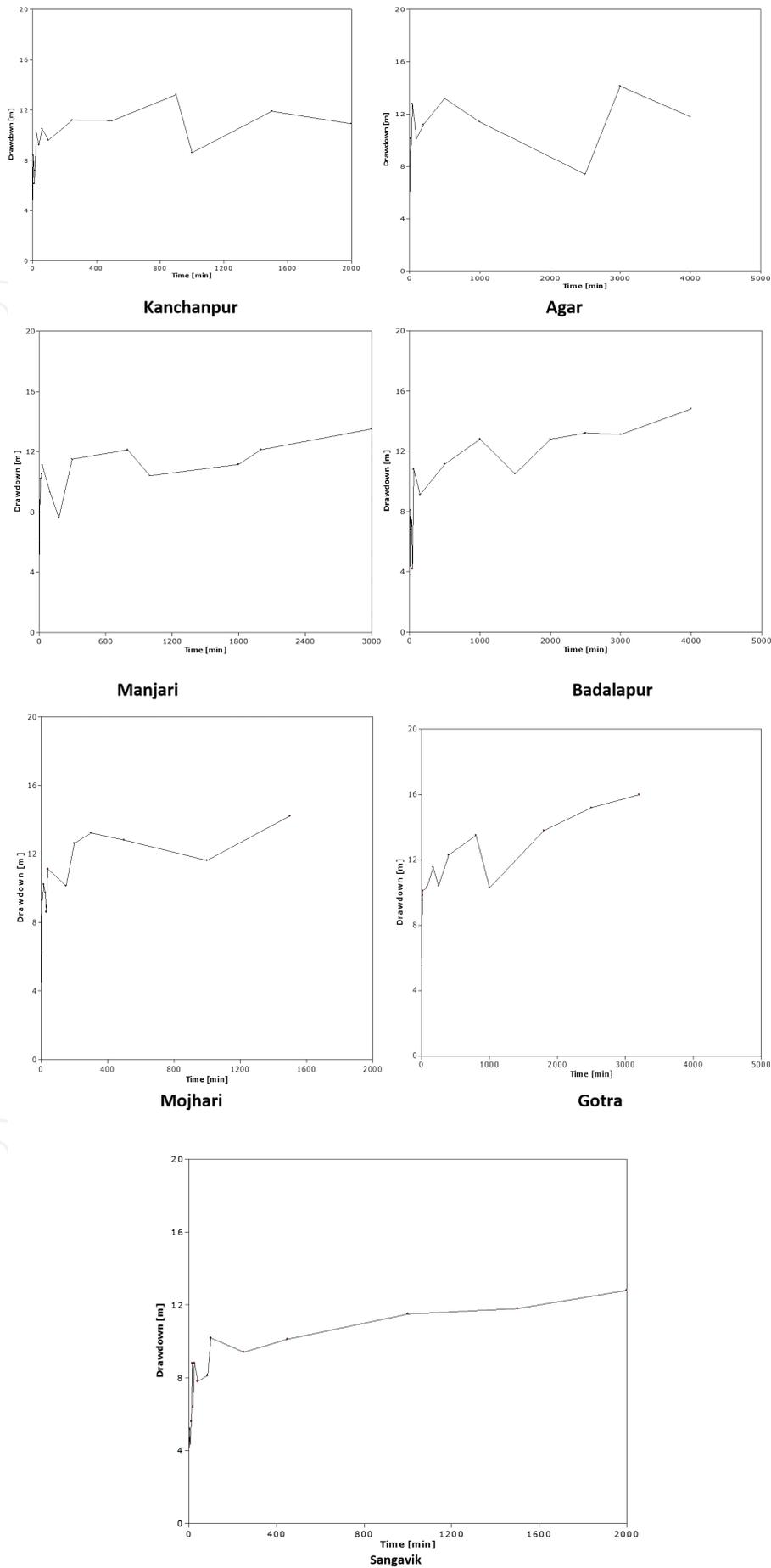


Figure 2. Time and drawdown graph of (i) Andura, (ii) Antri, (iii) Ural, (iv) Phal, (v) Sawarpati, (vi) Morgaon, (vii) Sangavi, (vii) Dhudhala, (viii) Hatrun, (ix) Kanchanpur, (x) Agar, (xi) Manjari, (xii) Badalapur, (xiii) Morjhadi, (xiv) Gotra, and (xv) Sangavi pumping test.

The large area is under basaltic rock and alluvium patches with reference to geological map. The average annual rainfall of the Akola district is 750–950 mm. The river originates from the southwest part of the Patur tahsil, Washim district. The Morna river basin is 90 km long; however, there are no main tributaries of this basin, with few small tributaries pouring into the river [7, 9].

3. Methodology

Fifteen observation wells were established for the analysis of pumping test data using GPS and field verification of the Morna river basin. The 15 observation wells' data were collected from study area after the time drawn graphs of these wells were prepared with the help of Aquifer software. They are particularly calculated for the graphical presentation and for obtaining detailed information about pumping test data. Therefore, two methods such as a pumping test and slug test are included in the aquifer software. These results were calculated and plotted in graphs using different aquifer parameters with five techniques, namely Papadopulos and Cooper method, Theis method, Theis with Jacob correlation, Hantush, and z time drawn method (**Figure 2**).

4. Result and discussion

Pumping tests were performed on large-diameter observation wells in basaltic rock in the Washim and Akola districts of Maharashtra, India. All observation wells were in the basaltic rock and alluvium zones. The alluvium groundwater has high salt content in the wells. The normal value of transmissivity in the Deccan trap is 30–100 sq.mt/day [10]. The analysis of the effect of the 15 pumping test wells was carried out using five aquifer methods to categorize the wells as excellent, moderate, and low productivity wells. The results show that observation wells in the basaltic hard rock regions display excellent prospective for sustainable groundwater exploration with increase of protected yields. Some observation wells in the alluvium zone displays moderate due to groundwater's high range of pH with medium safe yield to very low protected yield and poor recovery. The outcome of pumping test data is the understanding of the transmissivity and permeability values. These values can be calculated based on the pumping test data and aquifer graphs [11]. All of this analysis of aquifer properties may also be used for further groundwater development and planning of the basin area. The result of study area shows an inadequate groundwater during pumping test data and graphs (**Table 1**).

5. Geology

The study of classification of basalt rocks deciphers as main group of rock formation and lava flows. The basaltic rock is deposited around the southern part of Deccan rocks belonging to the Cretaceous age. These basalt rocks are divided into primary and secondary openings with regard to fractures and joints [12].

6. Pumping test

The groundwater was monitored and water level variations of wells were recorded with help of aquifer graphs and convention methods of pumping test analysis [13]. In past years, many different methods were proposed on the aquifer mapping by few

Manjari village		Badalapur village		Morjhadi village		Gotra village		Sangavik village		Andura village		Antri village		Ural village		Saarpati village		Morgaon village		Sangavi village		Dhudhala village		Hatrun village		Kanchanpur village		Agar village			
Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level	Time	Water level
1	4.1	1	3.8	1	4.5	1	5.5	1	4.2	1	4.5	1	5.8	1	6	1	8.7	1	11.38	1	5.3	1	4.8	1	5.2	1	4.8	1	5.6		
5	6.1	4	5.11	2	8.4	4	6.8	3	5.2	3	6.1	3	13	2	8.7	2	8.9	3	7.2	2	7.8	3	8.4	2	8.9	5	8.4	2	6.12		
6	8.8	9	8.11	3	6.2	6	8.10	5	4.38	5	7.10	4	15	3	9.2	3	9.4	5	12.8	4	10.5	4	7.2	3	7.8	8	7.6	3	8.4		
8	8.5	18	6.8	5	9.3	12	9.5	10	5.6	8	8.4	6	15.15	5	7.1	7	11.14	10	5.8	8	13.6	6	5.11	5	6.3	10	6.12	4	7.2		
15	10.2	28	7.4	8	9.3	15	9.8	15	8.4	15	9.12	10	8.8	10	5.4	11	12.3	30	12	10	15.4	8	6.8	10	8.12	15	7.2	8	9.2		
25	10.5	40	4.2	15	10.2	20	10.12	18	6.4	25	10.1	20	9.10	30	10.2	30	10.4	50	6.1	40	13.1	15	11.2	15	9.6	25	10.11	15	10.5		
30	11.1	60	10.8	25	9.7	80	10.32	25	8.8	30	11.8	40	8.18	50	8.74	50	5.6	100	11.5	80	12.2	20	13.2	20	12.4	40	8.14	25	9.6		
100	9.3	150	9.12	30	8.6	170	11.55	40	7.8	50	9.20	50	7.4	60	11.24	100	8.63	300	8.18	100	10.4	50	12.9	45	11.8	60	10.11	40	12.8		
180	7.6	500	11.14	40	11.12	250	10.4	85	8.12	80	11.2	70	10.5	80	9.5	200	4.9	500	11.88	400	13.55	100	11.3	60	13.4	100	9.2	100	10.11		
300	11.5	1000	12.8	150	10.11	400	12.3	100	10.18	100	10.12	100	10.3	100	8.2	250	9.12	900	12.2	700	10.75	500	9.6	100	13.2	250	10.5	200	11.2		
800	12.12	1500	10.5	200	12.6	800	13.5	250	9.4	200	9.30	400	5.14	200	6.3	350	5.9	1000	8.15	900	12.1	800	12.9	1200	12.12	300	9.4	500	13.2		
1000	10.4	2000	12.8	300	13.2	1000	10.30	500	10.11	500	12.4	500	7.3	600	5.2	400	12.4	1500	15.5	1500	14.48	1000	11.10	2000	10.11	900	11.2	1000	11.4		
1800	11.15	2500	13.2	500	12.8	1800	13.8	1000	11.5	1000	10.15	600	6.6	800	9.1	1000	9.75	2000	9.8	1900	13.6	1500	13.4	2500	12.4	1000	11.14	2500	7.2		
2000	12.12	3000	13.11	1000	11.6	2500	15.20	1500	12.5	1500	13.8	800	8.9	1000	8.6	1500	10.3	3000	12.10	2000	7.8	2500	15.20	3500	9.6	1500	13.2	3000	9.8		
3000	13.5	4000	14.8	1500	14.2	3200	16.0	2000	12.8	2000	10.8	1000	7.6	1500	15	2000	8.63	3500	5.8	3000	10.80	3500	17.21	4000	12.8	2000	8.6	4000	14.14		

Note: Time (min) and water level (ft).

Table 1.
Details pumping test data of Morna river basin.

researchers to study the pumping test data and aquifer parameters. The output of the study area may be utilized for the analysis of groundwater flow in unconfined and confined aquifer of the Deccan trap rock especially in Maharashtra, India [14].

7. Theis with Jacob correlation method

Aquifer parameters are determined by easy methods; for example Cooper and Jacob [15] modified the Theis method and suggested it for better understanding of groundwater flow in the basalt rocks [15, 16]. The method does not require curve matching. The semi-log papers can be used for plotting time-drawdown data (time on log axis and drawdown on linear axis). The wells values should be less than 0.01 because the test should be conducted. From 15 observation wells, data have been correlated in Theis with Jacob equations of aquifer method using Aquifer software. The maximum wells' recharge time is very low due to the availability of groundwater flow in the region and remaining wells is good but the recharge is so much large show in the Theis with Jacob correlated graph (Figure 3). This type curve is one of the presented type curves, which has the plotted values of $W(u)$ and $1/u$ on a log-log sheet. On a similar log-log sheet, field values of drawdown and time are plotted. In the matched position, a match point is selected. The values of $W(u)$ and $1/u$ for this match point is read from the type curve (Eq. (1) and (2)).

The Theis (log-log) graph shows the maximum observation wells of water level ranges in between 4 and 12 m and the recharge time is very less as compared to other wells of the study area (Figure 4).

The aquifer parameters are calculated by the following formulas:

$$T = 2.3 \frac{Q}{(4\pi\Delta s)}, \quad (1)$$

$$S = 2.25 \frac{Tt_0}{r.r} \quad (2)$$

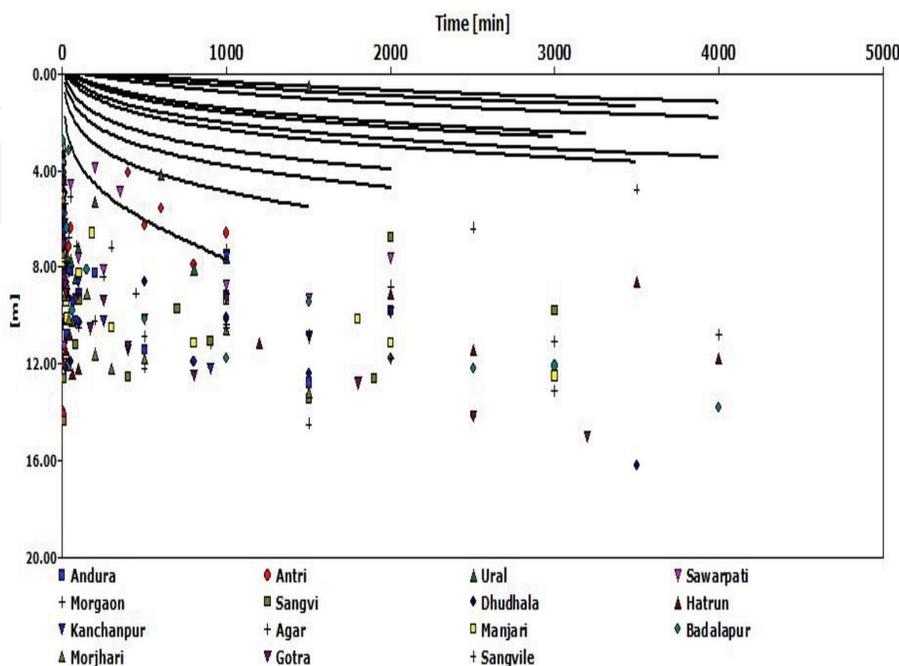


Figure 3.
 Drawdown versus time plot using Theis with Jacob correlation.

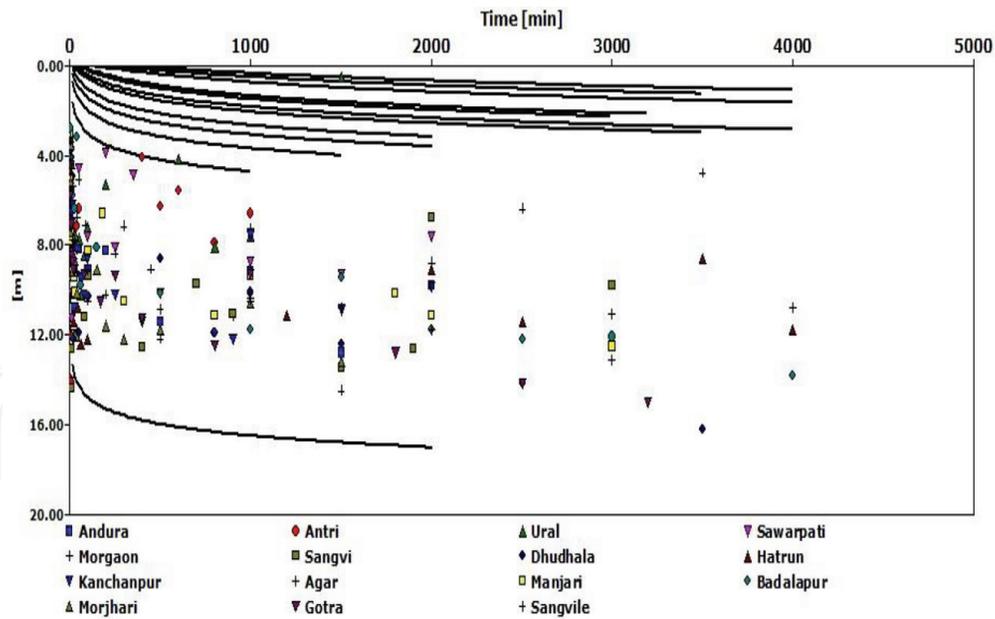


Figure 4.
Drawdown versus time plot using the Theis log-log method.

8. Hantush's method

The groundwater flow of observation wells under the leaky aquifer which is a horizontal plane may be analyzed with the aquifer technique. The Hantush method is used for confined aquifers on the straight flat surface. From the pumping test, data have been analyzed using the Hantush log-log method by the aquifer software (Eq. (3)) (**Figure 5**). There is a single additional unidentified parameter mixed up, the leakage feature L , which is specified [17-19]

$$Ln = \sqrt{(KD)_n}^c \quad (3)$$

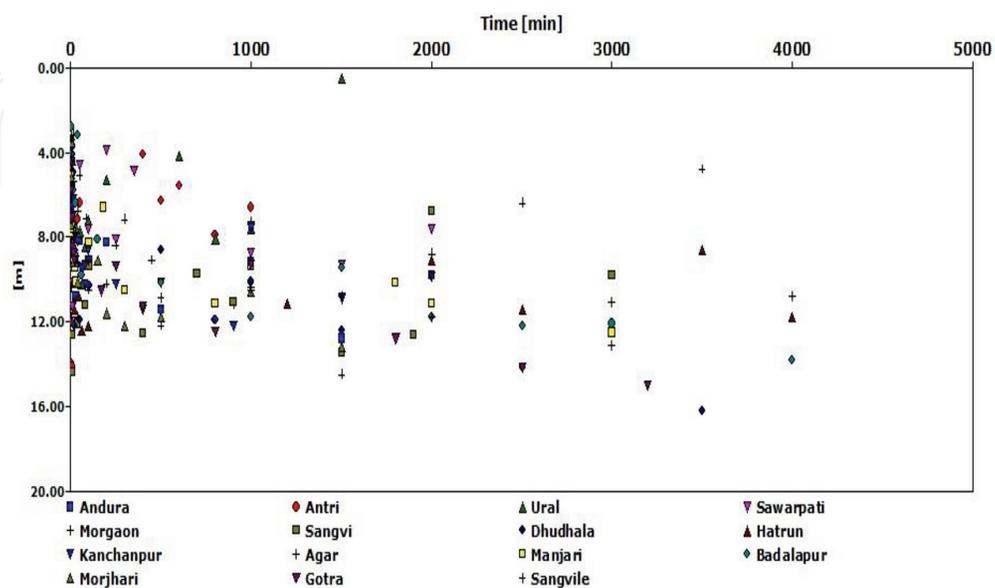


Figure 5.
Drawdown versus time plot using the Hantush method (log-log).

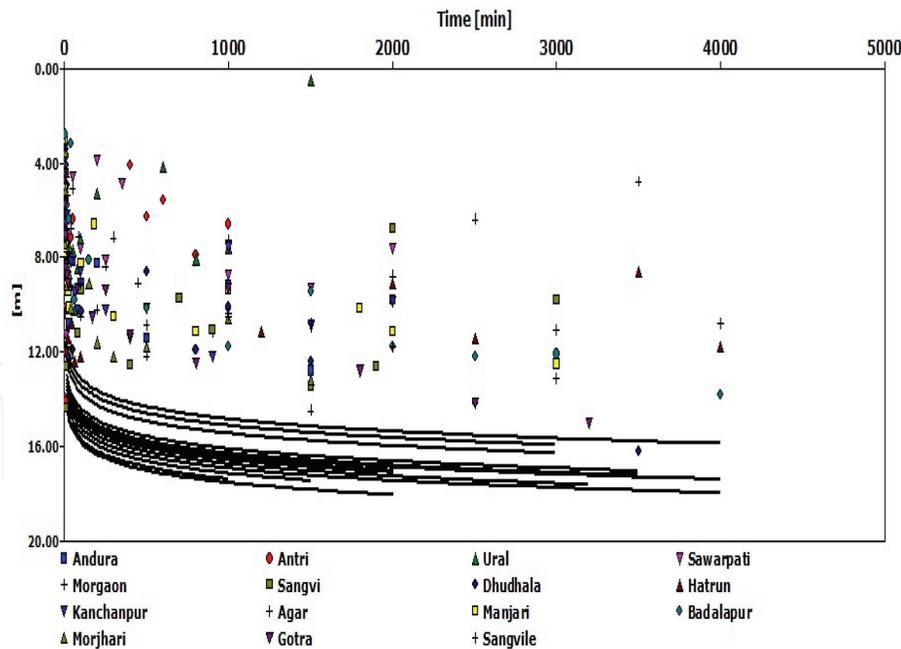


Figure 6.
 Drawdown versus time plot using Papadopulos and Cooper log-log method.

9. The Papadopulos and Cooper method

Papadopulos and Cooper [20] have given a theoretical solution for analyzing the pumping test data from large diameter wells taking into account the storage capacity of the wells. Papadopulos and Cooper equation is totally dependent on the assumption that the aquifer is confined, isotropic, and extensive; the entire thickness of the aquifer is penetrated by the well, unstudied state of flow at constant discharge rate and negligible well losses [21]. The general flow equation is given by Papadopulos and Cooper for a well of large diameter as follows (Eq. (4) and (5)):

$$T = Q \cdot F(U_w) / 4 \quad (4)$$

$$SS = (4Tt) / (1/U_w r_w^2) \quad (5)$$

The field data are plotted on a transparent bio logarithmic paper (of modules equivalent to that of type curve) with “s,” the drawdown on Y-axis, and “t,” the time since pumping started on X-axis. In this method, the groundwater flow is shown using log-log methods using Aquifer software (Cooper and Jacob) (Figure 6).

10. Discussion and conclusion

Many aquifer mapping project implementers have observed problems and knowledge gaps that require to be focused or would be cooperative to know at different stages in a setup to handle aquifer or groundwater recharge projects. The issue of study area, every graph and pumping data, as discussed above, makes an input to the area of information that helps block these breaks, as shown in results. These tables of pumping data can be used as guidelines to help discover information on problems most essential to developers and supervisors of future and current projects.

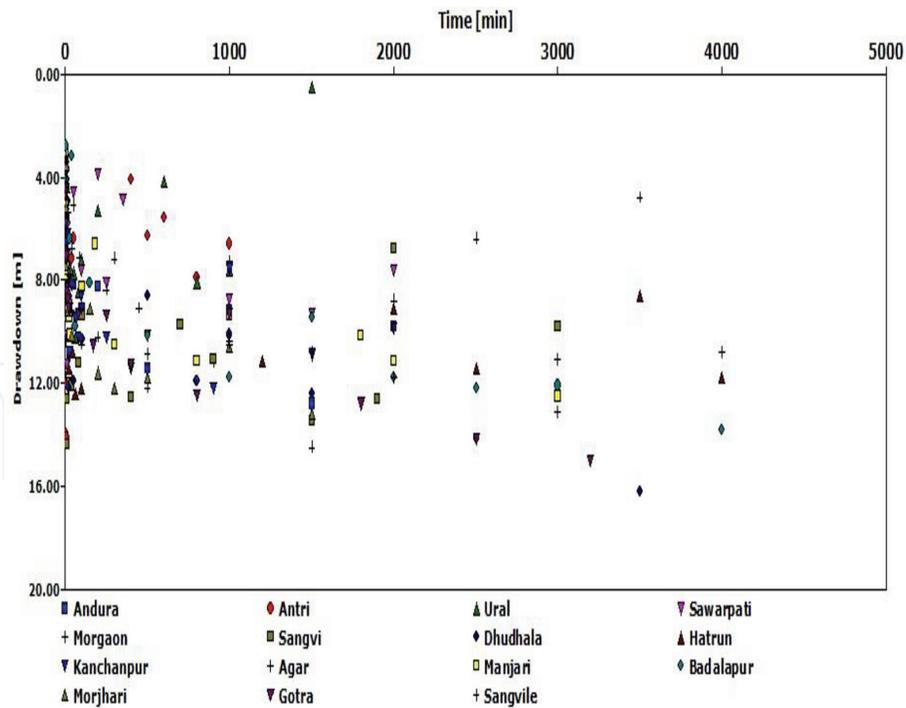


Figure 7.
Time drawn method using aquifer software 2014; Jacob's semi-log (slope) method.

The area is very high runoff found on the surface and this since all area is need water conservation structures in the ground of confined and unconfined layers. The analysis of Theis with Jacob correlation, Jacob's semi-log, Hantush, and Papadopulos and Cooper methods systematically shows groundwater recharge and their level in the basaltic rock area. The results can be used by local village society and government agency to approach the sustainable use of groundwater (**Figure 7**).

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