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Determination of Aquifer Parameters by Using Aqtesolv-software

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ABSTRACT

Several aquifer properties regulate groundwater inflow/outflow to any area, and determination of properties like hydraulic conductivity (K), transmissibility and storativity (S) is essential to ascertain the sustainable well yield. In situ estimation of these properties/parameters is accomplished by conducting pumping tests. Aquifer parameter tests deliver vital information to resolve regional and local groundwater flow concerns. In both the confined and unconfined aquifers, there are numerous methods for the determination of aquifer parameters. In the present research, ten pumping tests were conducted at different geologic locations in the hardrock region-dominated watershed to estimate aquifer properties. Method "Papadopulos-Cooper (P)" was considered a reference, and "AQTESOLV (Aquifer Test SOLver)" software methods which include (Theis method, Cooper and Jacob (C) method, Neuman (N) method and Tartakovsky-Neuman (T) method) were utilized for the estimation of aquifer properties. Results revealed that T values calculated using the P-C method varied from 105.1 square meters per day to 322 square meters per day. However, T values estimated employing AQTESOLV ranged from 122 to 300 square meters per day. All approaches using the software gave T values that were found to be strongly correlated with the P-C method (Curve matching technique).

Key words : *Papadopulos-Cooper method, AQTESOLV software, Pumping test, Transmissivity, Storativity*

Introduction

The mobility and yield of groundwater (GW) in geological formations are controlled by the transmissivity and S of aquifers Birpinar (2003). Pumping tests (PT) are mostly exercised to assess the hydraulic characteristics of aquifers, which are essential inputs for GW modeling and management Cimen (2009); Srivastava and Guzman-Guzman (1994). Aquifer properties such as transmissivity and storage coefficient (S) must be considered while analyzing groundwater recharge Moharir *et al.,* (2020). Using the observed drawdown in an observation well situated at a particular distance from a completely penetrated tube well that is pumped at a uniform rate, Theis (1935) introduced an equation to calculate the transmissivity and S in a homogeneous, isotropic, infinite areal extent confined aquifer Naderi (2019).

Traditionally, effective hydrogeological parameters have been determined using analytical solutions for a 2-dimensional, nonsteady-state GW system within a restricted aquifer under the hypothesis of uniform radically convergent flow conditions. This is accomplished by matching observed drawdown data to analytic outcomes, e.g., the Theis Method Theis (1935) and Wu *et al.,* (2005) or Jacob's semi-logarithmic approximation (Cooper and Jacob, 1946), and (Wu *et al.,* 2005). The Type-curve method (TCM) and straight-line methods (SLM) Neuman (1980); Neuman *et al.,* (2007) are commonly used to estimate isotropic or anisotropic effective transmissivities during the drawdown data matching process. However, in the non-availability of a systematic technique for determining the optimal solution of the parameters in the aquifer, either method can readily introduce modeling uncertainties. It will be challenging to find an optimal answer utilizing these strategies if the pump test is not long enough Wu *et al.,* (2008). Therefore, using AQTESOLV software, the aquifer parameter can be estimated without much difficulty Dahiphale *et al.,* (2014).

Materials and Methods

Study area and data acquisition

Nand Samand Dam is located in Rajsamand district of Rajasthan state, India, between 24°0′0.5" and 26°0′0.5" N latitudes and 72°59′59.50" and 73° 59′59.50" E longitudes. The research area map is presented in Fig. 1. The research area falls under arid to semi-arid climate with an annual average rainfall (2001-2011) of 640.45 mm CGWB (2013). The winter season starts in Rajasamand by the middle of November, and with a mean daily minimum temperature of 7.8 °C and 38.6 °C, January is the coldest month, and May is the warmest month of the year. The southwest monsoon receives nearly 93% of the total annual rainfall in the state. The district's central and eastern areas are mainly flat, forming the foothill of the Aravalli ranges. The general slope of the terrain is towards the east. The major river of the

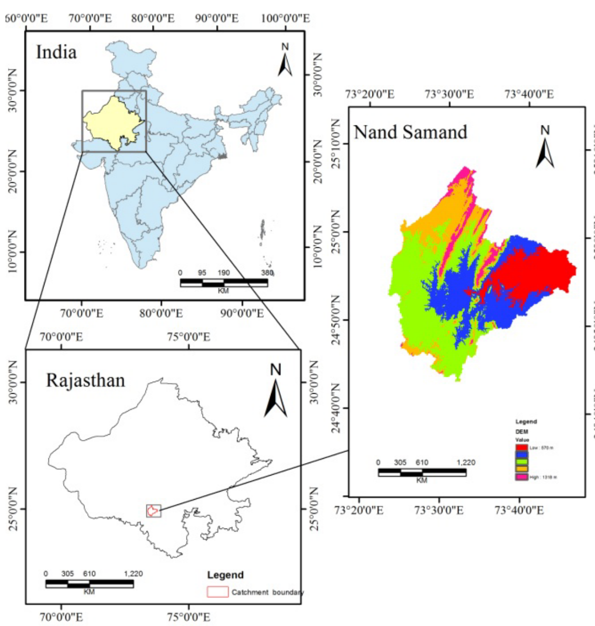

Fig. 1. The study area map

district is Banas, with its tributaries, i.e., Khari and Chandrabhaga creating a perfect drainage system in the area GWDR (2013). The total study area is 865.18 l with the highest elevation (1318 m) and the lowest (570 m) above mean sea level. A total of 10 PT were conducted in selected wells in the Nand Samand catchment for this study. The wells chosen for the pumping test were large diameter open dugwells that extract groundwater from an unconfined aquifer while being pumped.

Papadopulos-Cooper (P) method

This method can simulate the unsteady-state flow in a large diameter well that completely penetrates a confined aquifer. A partially penetrating large diameter well in an unconfined aquifer was studied using the following equations.

$$S_w = \frac{Q}{4\pi T} F(u_w \quad .. (1)$$

$$u_w = \quad .. (2)$$

Where,
= drawdown in well
Q = discharge rate of the well
T = transmissivity
$F(u_w$ = well function
S = storage coefficient
t = time since pumping start
= effective radius of a well screen or open hole
Procedure

1) On the log-log paper family of type curves versus, for different values of á was plotted Fig. 3.
2) On another sheet of log-log paper of the same scale, data curve versus t was plotted.
3) Then the matching of the data curve with one of the type curves was done.
4) Then choosing the arbitrary point on the superimposed sheets and noted for that point the values of , ,, and t..
5) Then substituted the values of and s, together with the known value of Q, into equation 1 and T was calculated.

The curve matching methodology of the Papadopulos-Cooper method was used to estimate transmissivity and S in an unconfined aquifer, with Jacob's suggested drawdown corrections (1967).

$$S_c = S_{su} \quad .. (3)$$

Another way to account for partial well penetration in an unconfined aquifer is to convert confined aquifer drawdowns into equivalent drawdowns in completely penetrating wells, as given by Hantush (1964).

$s_{fc} = S_c$ – (4)

Where,

= equivalent drawdown in a confined aquifer.

= drawdown observed in an unconfined aquifer.

= equivalent drawdown in a completely penetrating

well in a confined aquifer.

m = initially saturated thickness of the aquifer

L = penetration depth of the pumped well.

AQTESOLV software

AQTESOLV is the world's most used software for analyzing aquifer testing. This software gives direct values of S, transmissivity & hydraulic conductivity of the aquifer. AQTESOLV is software designed to determine hydraulic conductivity, storativity, and

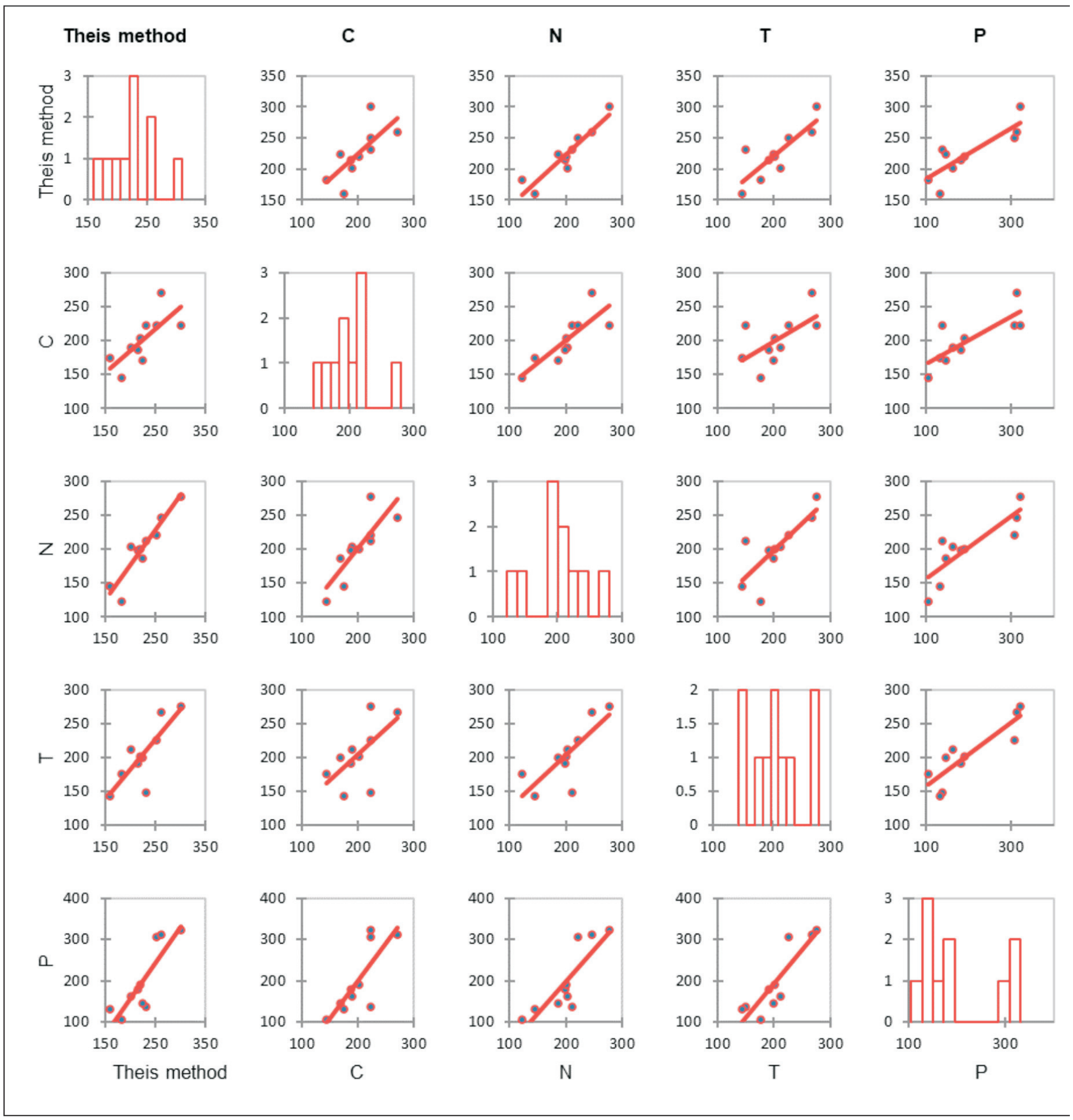

Fig. 2 Scatter plots of software methods and Papadopulos-Cooper method

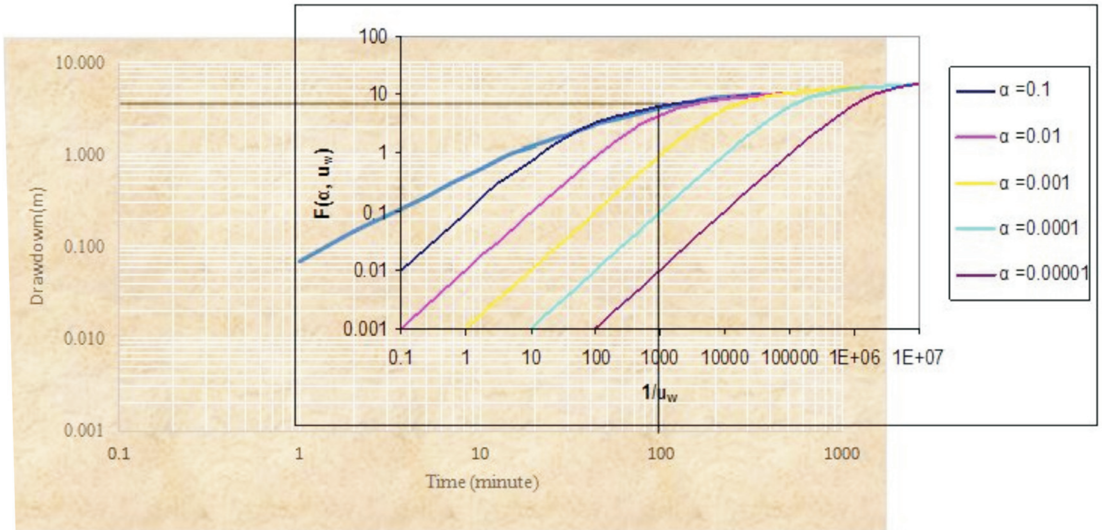

Fig. 3 Observed time-drawdown curve matching with standard Papadopulos-Cooper type curve for well no. 1.

other aquifer characteristics from data collected during slug and aquifer PT.

Results and Discussion

The research was undertaken to calculate the aquifer properties in the Nand Samand catchment by using Papadopulos-Cooper (P) method and AQTESOLV software. For this study pumping test was conducted out in ten operational wells in the research area. The results obtained in both methods are discussed below.

The well number 1 was conducted at a uniform discharge rate of 432 m^3/t. The drawdown analogicallyto time was noted down with the help of the TLC meter (Temperature Level Conductivity meter) shown in Fig. 4. Time versus corrected drawdown field data curves wasplotted on double logarithmic paper for all test wells. All the values of transmissivity and S are reported in Table 1. The radius of the well was found to be 2.33 m. The total match point coordinates for well no. 1 (Fig. 3) were obtained as, t = 100 min, s = 3.9 m, F(, α) = 8, 1/ = 1000. Using Equation (1), Transmissivity (T) for the total match point was determined as given below. T = 137.58 $m^3/_t$, and storage coefficient was calculated by using Equation (2) S = 0.01.

From Table 1, it is evident that the average value

Table 1. Transmissivity (T) and storage coefficient (S) by Software and Papadopulos - Cooper method

Well no.	Theis method		Cooper & Jacob method		Neuman method		Tartakovsky and Neuman method		Papadopulos-Cooper method	
	T(m^2)	S	T (m^2)	S	T (m^2)	S	T (m^2)	S	T (m^2)	S
1	231.36	0.20	222.00	0.27	211.56	0.40	149.00	0.40	137.58	0.01
2	250.66	0.59	223.00	0.54	221.44	0.53	225.67	0.49	306.53	0.01
3	201.00	0.47	189.00	0.76	203.78	0.35	212.45	0.96	162.55	0.00
4	213.72	0.20	187.00	0.27	199.00	0.24	191.00	0.22	180.66	0.01
5	223.00	0.00	170.00	0.21	187.00	0.32	200.00	0.36	146.75	0.00
6	220.00	0.37	203.00	0.29	199.76	0.23	202.22	0.26	191.08	0.01
7	159.93	0.50	175.00	0.49	145.29	0.52	143.81	0.48	132.17	0.00
8	183.00	0.00	145.00	0.32	122.00	0.43	176.23	0.35	105.10	0.00
9	300.00	0.44	223.00	0.76	278.00	0.76	276.00	0.77	321.90	0.02
10	259.80	1.18	271.23	0.82	246.20	0.66	267.00	0.61	311.25	0.02
Average	224.25	0.39	200.82	0.47	201.40	0.44	204.34	0.49	199.56	0.01

Fig. 4. TLC meter

of transmissivity obtained by the Theis method was 224.25 $m^3/_t$ and matching of time-drawdown data with type curve as shown in Table 1. The average value of the storage coefficient was 0.39. The average value of transmissivity and S by Cooper- Jacob method was 200.82 $m^3/_t$ and 0.47, respectively. For the Neuman method, the average transmissivity value was 201.4 m^3/t and the average storage coefficient value was 0.44. The average values of transmissivity and storage coefficient of the Tartakovsky-Neuman method were 204.34 m^3/t and 0.49, respectively. The average values obtained by software methods were nearly the same. The storage coefficient values obtained by this software were very high. The transmissivity values of all the software methods were strongly correlated with thescatter map of all the methods shown in Fig. 2. Software methods show very strong positive correlation with each other for storage coefficient values.

Conclusion

Estimation of aquifer parameters is of utmost importance to assess the potential of groundwater availability, planning water extraction techniques, and planning and designing artificial groundwater recharge structures. This research investigation shows AQTESOLV software's capability in estimating aquifer parameters in hard rock geological formation in the semi-arid region of Rajasthan state, India. In the hard rock area of the Nand Samand catchment, the average transmissivity obtained by Papadopulos and Cooper method was 199.56 m^2/t Whereas the mean value ofthe storage coefficient was estimated as 0.007. The transmissivity values obtained by the AQTESOLV software variedfrom a minimum of 122 to a maximum of 300. The aquifer parameters obtained using the software were compared with observed data collected at ten pumping test locations.This software's storage coefficient values were very high, so these values are unreliable for hard rock areas. All of the software approaches' transmissivity values were highly correlated with one another. For storage coefficient values, software techniques have a very significant positive correlation.

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References

Birpinar, M.E. 2003. Aquifer parameter identification and interpretation with different analytical methods. *Water sA* 29 : 251-256.

Çimen, M. 2009. Effective procedure for determination of aquifer parameters from late time-drawdown data. *J. Hydrol. Eng.* 14 : 446-452.

Cooper, H.H. and Jacob, C.E. 1946. A generalized graphical method for evaluating formation constants and summarizing well field history. *Transactions of theAmerican Geophysical Union.* 27 : 526–534.

CGWB 2013. Central Ground Water Board. Ground Water Information Rajsamand district Rajasthan, Government of India Ministry of Water Resources, Western Region Jaipur.

Dahiphale, P., Purohit, R.C., Singh, P.K., Yadav, K.K. and Nikam, S. 2014. Curve matching and software technique for determination of Aquifer parameters. *Eco. Env. & Cons.* 20 (3) : 1159-1162.

GWDR 2013 Ground Water Department Rajasthan. Hydrogeological atlas of Rajasthan Rasamand district.

Hantush, M.S. 1964. Hydraulics of wells, in *Advances in Hydroscience* (V.T.Chow, ed.). Academic press. NewYork. 1 : 281-432.

Moharir, K.N., Pande, C.B., Singh, S.K. and Rio, R.A.D. 2020. A book 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. doi: http://dx.doi.org/10.5772/intechopen.84632

Naderi, M. 2019. Estimating confined aquifer parameters using a simple derivative-based method. *Heliyon,* 5, e02657.

Neuman, S.P. 1980. A statistical approach to the inverse problem of aquifer hydrology. Improved solution method and added perspective. *Water Resources*

Research. 16 (2) : 331–346.

Neuman, S.P., Blattstein, A., Riva, M., Tartakovsky, D.M., Guadagnini, A, Ptak, T. 2007. Type curve interpretation of late-time pumping test data in randomly heterogeneous aquifers. *Water Resources Research.* 43 (10) : W1042.

Papadopulos, I.S. and Cooper, H.H. 1967. Drawdown in a well of large diameter. *Journal of Water Resources Research.* 3(1) : 241-244.

Srivastava, R. and Guzman-Guzman, A. 1994. Analysis of slope-matching methods for aquifer parameter determination. *Gr. Water.* 32 : 570–575.

Theis, C.V. 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage. *Eos Trans. Am. Geophys. Union.* 16 : 519–524.

Wu, C.M., Yeh, T.C., Zhu, J., Lee, T.H., Hsu, N.S., Chen C.H. and Sancho, C.H. 2005. Traditional analysis of aquifer tests: comparing apples to oranges. *WaterResources Research.* 41 : W09402.

Wu, S.C., Tan, Y.C., Chen, C.H., Lin, S.T. and Ke, K.Y. 2008. A two-dimensional inverse model to identify transmissivity in an anisotropic aquifer. *Hydrological Processes.* 22 : 5086-5096.