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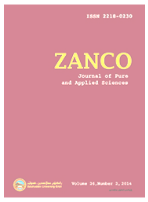

Analyze the Tranmissivity for Pumping Well testing with Single and Observation Well

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ABSTRACT

In general, for determining aquifer parameters pumping test conducted on the production well due to lack of observation wells in Erbil catchment area. In the present study steady state pumping test method using single well was used to estimate the tranmissivity of the aquifer. For this purpose pumping test conducted on a single production pumping well at the specific area which is located at the QATAWI area near Erbil city. The results of transmissivity obtained from single well pumping test data was compared with that obtained from observation well. The value of Transmissivity calculated from the field data via pumping test on single pumping well equal to 13.05 m2/day however its value obtained from observation well equal to 197.7 m2/day. It was observed that the results of transmisivity of the aquifer using single pumping well is less than that using observation well; this is mostly due to the losses that are available within the pumping well. To get a real value of transmissivity of the aquifer the pumping test should be conducted on an observation well or adjustment of the data is required when the test is conducted on the single pumping well.

1. INTRODUCTION

In order to understand the condition of aquifer basin in Erbil area; the property of aquifer layer and its thickness are required. The only reliable aquifer property obtained from single well test is transimissivity. For determination aquifer parameters, in many cases even in ministry of water resources it is common to conduct pumping well on single well as followed in Kurdistan region). The water stored in a saturated fractured rock or sand, which can

transmit water at a rate fast enough to supply significant amounts to wells (Fetter, 1998). The most important parameters of the aquifer are transmissivity and storativity. A constant rate pumping test consists of withdrawing ground water at a constant rate from a well and monitoring water level from another observation well nearby pumping well. While, pumping test in the case with single well the variation of water level monitored from the pumping well. There are many published researches to estimate aquifer parameters using different method. (Jacob and Cooper, 1946) determined the aquifer parameters (Transmissivity and Storativity) using straight line method for a single well discharging at steady state. (Chenini, I, et al, 2008) proposed a simple graphical method to estimate transmissivity and storativity of the aquifer which is based on Theis's formula. (T. P. Clement et at, 1996) presented a two well test to determine the aquifer parameters. Furthermore, (Amah E. A. and Anam G. S. 2016) conducted a pumping test using five boreholes to estimate aquifer parameters including transmissivity, the study recommended that the test duration should be long enough (2-3 hrs.) to give accurate estimation of parameters. Using single well test with the Cooper-Jacob method shows overestimate of transmissivity for unconfined aquifer while, for confined aquifer near to the known value (Keith J. Halford, et al, 2006). Moreover, (Anomohanran & serhien-Emekeme , 2014) performed a pumping test data to estimate aquifer parameters using Cooper-Jacob straight line method. They concluded that the aquifer is confined and it can effectively produce the required quantity of water for the area. (Cimen, 2015) proposed a method to estimate aquifer parameters, which is depends on the straight line through the field data of residual drawdown.

In the present study the transmissivity of a confined aquifer were analyzed using single and observation well. Jacob Cooper (1946) method was used; the tarnsmissivity of the aquifer was estimated using best fit straight line between time on ordinary scale with drawdown on logarithmic scale. Pumping test only conducted on a single production well in the field from Qatawi area at 23 August 2017. In order for comparison transmissivity for single and observation well, the existing data of pumping test on observation well 25 m away from pumping well received from (BATU, 1998).

STUDY AREA

The production well for the study area (QATAWI area), is located at south of Erbil City, Kurdistan Region of Iraq. The distance between Erbil city center to the study area is about 9.4 Km, the pumping well located at the coordinate of (0409055 – 3998851 WGS_1984_UTM_Zone 38 N) as shown in Figure 1.

Figure 1 Location of Qatawi well.

2. MATERIALS

Pumping well test required to compute aquifer parameters among them transmissivity. The following tools were used during pumping test for measuring the discharge and level of water in the pumping well:

1. Water pump
2. Container for measuring discharge (Figure 2),
3. Stop watch for recording time
4. Sounder for measuring water level in the well (Figure 3).

Figure 2 measuring discharge during pumping test

Figure 3 equipment used during pumping test

3. METHODS

To estimate aquifer parameters the generalized graphical method presented by Cooper-Jacob (1947) are used. The drawdown at a piezometer distance (r) from the pumping well is monitored over the time; this is based upon the Theis (1936) analysis:

$$s = \frac{Q}{4\pi T} W(u) = \frac{Q}{4\pi T}\left(-0.5772 - \ln u + u - \frac{u^2}{2.2!} + \frac{u^3}{3.3!} \ldots.\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

The value of u decrease as the time of pumping increase and as the distance between monitoring and pumping well decrease. Thus for pumping well the drawdown can be approximated after cancelling small orders:

$$s = \frac{Q}{4\pi T}\left(-0.5772 - \ln \frac{r^2 s}{4Tt}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.2$$

The above equation with logarithms (base 10) and rearranged can be written as:

$$s = \frac{2.3Q}{4\pi T} \log \frac{2.25\,T}{r^2 s} t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.3$$

Equation (3) is similar to the equation of straight line, which is the relation between drawdown (s) and time (t), it can be written as

$$s = \frac{2.3Q}{4\pi T} \log \frac{2.25\,T}{r^2 s} + \frac{2.3Q}{4\pi T} \log t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

$$Y = C + BX \quad \text{.........} 5$$

Where: C is the intercept and B is the slope of the line

The relation between drawdown (s) and time (t) on log scale are shown in figure (2), which is a straight line. To calculate transmissivity and storativity the line was extended to the time axis when the drawdown is zero and t = $t_{o,}$ it gives:

$$\frac{2.25\,Tt_o}{r^2 S} = 1 \quad \text{.........} 6$$

The slope of the straight line (per log cycle) is equal to:

$$\Delta s = \frac{2.3Q}{4\pi T}$$

Where:

s: is the draw down at any time (m)

T: is the Transmissivity of the aquifer (m^2/min)

Q: is the pumping flow rate (m^3/min)

S: is the storativity of the aquifer

r: is the radial distance (m)

t: is the pumping time (min.)

W (u): is the well function

t_o: is the initial time when the pump start to working at zero drawdown (min.)

5. RESULTS AND DISCUSSION

The Transimisivity of the aquifer were calculated for the data obtained from pumping test for single well at Qatawi area (table1) and the existing data of the observation well which is drawdown and time using Cooper-Jacob's (1946) straight line method.

Table 1 Time and Drawdown for pumping well

Time (min.)	Drawdown (m)	Discharge (m^3/min)
0	0	0
0.5	6	0.7425
1	11	0.7425
1.5	15	0.7425
2	16.5	0.7425
3	19.5	0.7425
4	21.1	0.7425
5	22	0.7425
6	22.4	0.7425
7	22.4	0.7425
8	22.6	0.7425
9	22.7	0.7425
10	22.9	0.7425
15	23.1	0.7425
20	23.3	0.7425
25	23.5	0.7425
30	23.6	0.7425
40	23.6	0.7425
50	23.6	0.7425
60	23.6	0.7425

The drawdown and time is plotted on a semi-logarithmic paper, and then the difference in drawdown for one cycle of time (ΔS) was determined. The plot of drawdown versus time for pumping well testing data and observation well are shown in figures 4 and 5 respectively.

$$T = \frac{2.3Q}{4\pi\Delta s} = \frac{2.3 * 0.7425}{4\pi * 16} = 0.00906\frac{m^2}{min} = 13.05\frac{m^2}{day} \text{ for single well}$$

The Tranmissivity of the aquifer using observation well which is 25 m away from the pumping well is:

$$T = \frac{2.3Q}{4\pi\Delta s} = \frac{2.3 * 0.375}{4\pi * 0.5} = 0.137\frac{m^2}{min} = 197.7\frac{m^2}{day} \text{ for observation well}$$

Also AQTESOLV software was used for calculation the transmissivity of the aquifer for single at Qatawi area and observation well the results are shown in figures (6 & 7). The results of AQTESOLV software and spread excel sheet are very close to each other. According to the values of Transmissivity for single well and observation well it is clear that there is a difference between the value of Transmissivity obtained from single at Qatawi area and existing data of observation well. This is mostly due to the fact that in the pumping well there are extra losses due to well screen. According to the results it is clear that the transmission rate of the ground water in the aquifer is low.

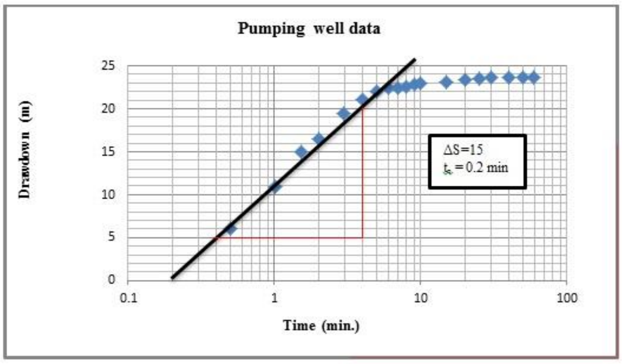

Figure 4 Jacob method for single well method

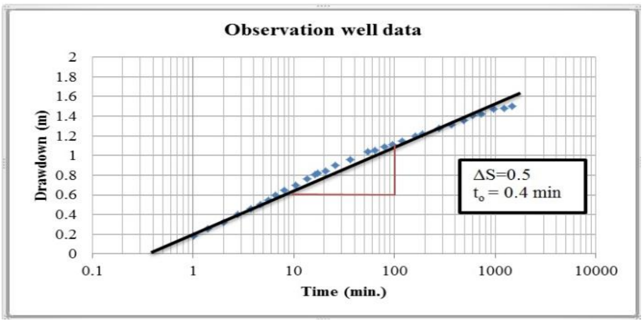

Figure 5 Jacob method for observation well method

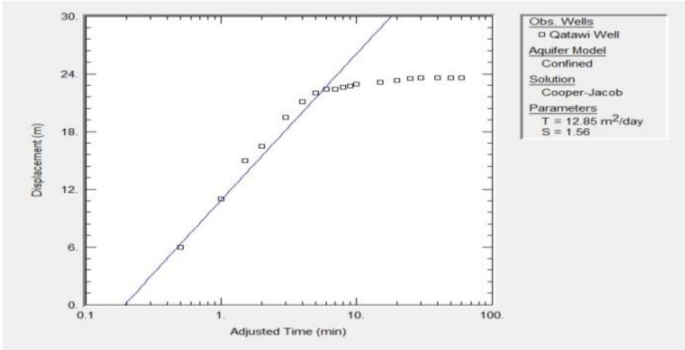

Figure 6 Jacob method for single well method using AQTESOLV software

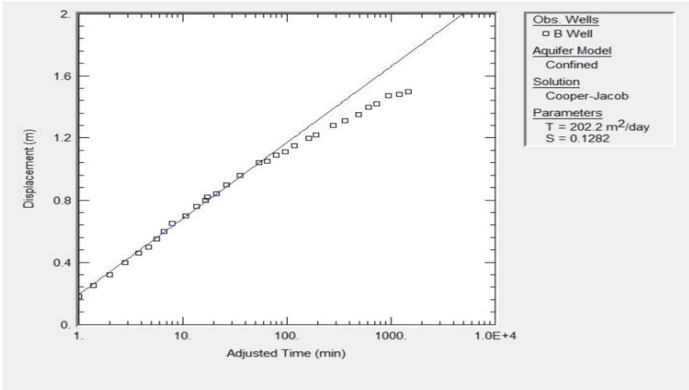

Figure 7 Jacob method for single well method using AQTESOLV software

6. CONCLUSION

The present study deals with the estimation of the transmissivity of the aquifer using approximate straight line proposed by Cooper – Jacob (1946). In addition with the excel spreadsheet the AQTESOLV software was provided for calculation transmissivity of aquifer. The results for the single at Qatawi area and observation well are compared to each other, the following conclusion were obtained:

1. The transmissivity of the aquifer calculated from single well at Qatawi area is equal to (13.05 m^2/day), while from observation well equal to (197.7 m^2/day).
2. The results of transmissivity of the aquifer that obtained from single well pumping test in many cases is not a real value, since it affected by many factors such well losses and aquifer losses. Well losses consists linear component which include losses in gravel pack and losses due to screen entry velocity, non-linear component include head loss due to turbulent flow in well casing.
3. In order to obtain a reasonable value of transmissivity a pumping test should be conducted on the observation well rather than pumping well or adjustment of the data after each single well testing. In that case since it has no any screen the results of the transmissivity of the aquifer are more accurate. The adjustment includes quantifying the aquifer and well losses, since the total draw down consists both aquifer (BQ) and well losses (CQ^2) as it is clear from (Figure 8).

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B and C are aquifer and well losses coefficient respectively.

The aquifer and well loss coefficient can be estimated using step drawdown test as shown in figure 9

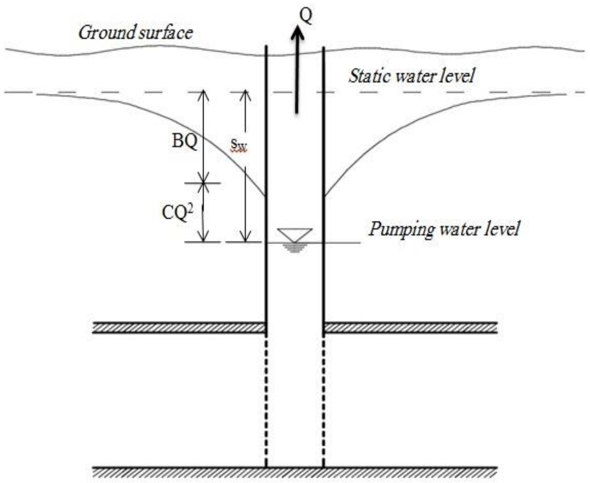

Figure 8 Well and aquifer losses

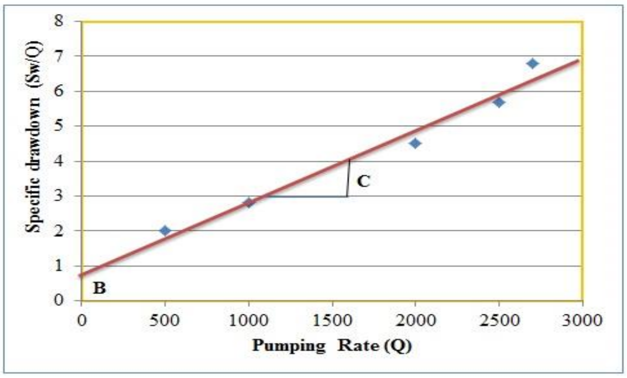

Figure 9 Estimation of aquifer and well losses coefficient

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