Application of Specific Capacity In Monitoring Groundwater Well : A Case Study of Kota Agung Groundwater Well

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Abstract. Maintaining the quality and quantity of the groundwater from the well is important aspect for the well sustainability. Well monitoring is mandatory for sustainable water management especially for the well with high iron and manganese that easily precipitate at well screen and rock surround well screen due to oxidation. Based on daily well flow rate and water level data, which recorded with electromagnetic flow rate and hydrostatic water level sensor, historically specific capacity data could be obtained. The study case in this paper take place at Kota Agung groundwater well on southern slope of Mount Tanggamus. The well has confined aquifer with lithology sandstone, fractured andesite lava and volcanic breccia as its aquifer and high iron and manganese concentration that enough to precipitate and clog the well screen and rock surround the well screen that impacted well efficiency. Based on historical specific data of the well, well efficiency that impacted by iron and manganese clogging can be predicted without knowing the visual condition of well screen. Decreasing of specific capacity has direct correlation with the well screen clogging and validated by the video logging. By using specific capacity data we don’t need to perform video logging borehole camera to know well condition. In addition to that, by monitoring specific capacity data, well efficiency can be predicted and well maintenance schedule can be defined to restore well to its initial condition.

1. Introduction
Maintaining the quality and quantity of the groundwater from well is important aspect for the well sustainability. Every well have its own problem such as sand or gravel intake, clogging from iron sediment that affecting quantity of water that we can pump from well. Well monitoring is mandatory as sustainable management to know well condition by monitoring specific capacity. After we know well condition, we can make action plan and predict when we need to perform well rehabilitation to restore well to its initial condition.

2. Data and method
Specific capacity is discharge capacity divided by drawdown. This value is measure of the productivity of a well [1]. Larger specific capacity value, better for the well efficiency. Specific capacity can be calculated as described on equation 1. Well efficiency describes the effectiveness of a well in yielding water. It is easier to use specific capacity as monitoring parameter due to its simplicity of data. Specific capacity only need two parameter, flow rate and drawdown that we can collect directly even real time data if we have the equipment inside well. In addition to that, specific capacity
also may be a viable alternative to assess productivity aquifer in well when there is lack transmissivity data [2].

The equation how to determine the value of specific capacity is:

\[ \text{Sc} = \frac{Q}{\text{Sw}} \]  

Note:
\( \text{Sc} \) = Specific capacity \( (\text{l/s/m}) \)
\( Q \) = Discharge \( (\text{l/s}) \)
\( \text{Sw} \) = Drawdown \( (\text{m}) \)

Drawdown can be determine by:

\[ \text{Sw} = \text{Pumping water level} - \text{static water level} \]  

Discharge can be measured either with V notch weir, analog or digital flow rate sensor and measure water level with water level indicator or water level sensor (either float, pressure transducer, ultrasonic or radar). Schematic water level monitoring can be seen in figure 1. Thus, for a given pumping rate \( Q \), any factor affecting drawdown \( \text{Sw} \) also will affect the value of specific capacity.

![Figure 1. Water level monitoring with transducer or float system (Risser, 2010)](image)

Groundwater well terminology profile can be seen in figure 2. Drawdown is highly affected by aquifer loss and well loss. The increasing of well loss in operating well due to a lot of factors such as poor gravel pack shape, iron; manganese; fine particle from aquifer that become clogging that could affect specific capacity.

Kota Agung groundwater well is a well that located in southern slope (distal zone) of Mount Tanggamus in Lampung Province. Water in this well come from sandstone, fractured andesite lava and volcanic breccia that act as confined aquifer. Confined aquifer is a geologic unit that can store and transmit water at rates fast enough to supply reasonable amounts to wells which are overlain by confining layer [3] [4]. This lithology is member of Young Quartenary Volcanics [5]. Geological map of research area can be seen in figure 3. Kota Agung groundwater well contain iron and manganese with concentration that sufficient to precipitate and clog well screen.
Figure 2. Groundwater well terminology profile [6]; L: screen length; R: radius of influence; rb: well radius; rc: distance between center of well to center of observation pipe; rg: distance from center of well to annulus; ra: distance from center of well to damage well zone (EDZ); Stot: total head loss; ds: aquifer head loss; ds': EDZ head loss; ds'': gravel pack head loss; ds'”: screen head loss. Combination of ds’, ds’”, ds’” are called well loss.

Figure 3. Regional geological map of study area [5].
Data that are used in this study are well monitoring data from Apr’16 to Jan’18. Well flow rate and water level data are recorded using electromagnetic flow rate sensor and hydrostatic water level sensor. Drawdown data are calculated using equation (2). Those data can be seen in figure 4. Flow rate are fluctuate due to pump adjustment thus also affecting fluctuation of drawdown data. There is no fluctuation in water level due to seasonal effect. Initial data in Apr’16 show that with flow rate 11.71 l/s, drawdown in Kota Agung well is 4.69 m. After that in the following months there were pump adjustment in each month and caused drawdown fluctuate around 3 m. In October 2016 there was increasing flow rate from previous month from 10.43 l/s to 10.92 l/s and it caused increasing drawdown (6.11 m) comparing to drawdown data in Jun’16 (3.5 m) with similar flow rate data. This condition was worsening until early Jan’18. In Jan’18, pumping was running with 8.34 l/s and caused 8.14 m drawdown in well [6].

The hypothesis of this research is degradation of well efficiency that caused by clogging is also shown by decreasing value of specific capacity. The method that is used in this study is by monitoring historical specific capacity value in Kota Agung groundwater well we predict well condition. Video logging borehole camera had been conducted to verify it. The correlation between variables above validated by regression analysis statistic because this method serve as a basis for drawing inferences about relationships among interrelated variables [7].

3. Result and discussion
With flow rate and water level data, specific capacity are calculated using equation 1. Historical specific capacity in Kota Agung groundwater well can be seen in figure 5. Initial data in Apr’16 show that initial specific capacity for Kota Agung well is 2.5 l/s / m. The following months data show that the specific capacity was fluctuate from 3.85 to 2.86 l/s / m. After increasing flow rate in Oct’16 as explained above, specific capacity was drop to 1.91 l/s/m. After that, the trend line until Jan’18 was specific capacity decreasing over time with specific capacity in Jan’18 is 1.02 l/s / m. From figure 4 and 5, specific capacity drop align with drawdown drop.

Regression analysis was conducted to quantified how strong the relationship among variables between specific capacity (as dependent variable), flow rate and drawdown (as independent variables). Regression was analyzed using Microsoft Excel 2010. Result of that analysis can be seen in table 1.

| Parameter          | Value |
|--------------------|-------|
| Multiple R         | 0.94  |
| R square           | 0.89  |
| Adjusted R square  | 0.88  |
| Standard error     | 0.34  |
| Observations       | 22    |
| Fo                 | 74.81 |
| F table            | 0.11  |
| t drawdown (to)    | -11.9 |
| t flowrate (to)    | 4.09  |
| t table            | -1.32 |

Hypothesis statistical test is conducted to test whether there is relationship between variables or not. The result are statistically proven that drawdown and flow rate have strong correlation to specific capacity value because Fo > F table and to > t table.
Figure 4. Historical flow rate and drawdown data of Kota Agung groundwater well.

Figure 5. Historical specific capacity of Kota Agung groundwater well from April 2016 to January 2018. If you compare figure 4 and 5 (same raw data and same interval data), monitoring well condition by monitoring historical specific capacity graph is easier to interpret. This work especially for well with a lot of pump adjustment as show in the pictures above.

The correlation between well discharge and drawdown are affected by its well construction and well development [8]. This is applied when well was in its initial condition. When well have been already in production stage, any significant decline in specific capacity of a well can be caused by either to a reduction in the transmissivity due to a lowering of groundwater level or to an increase well loss associated with clogging or deterioration of the well screen [1].

In September 2017, video logging borehole camera was conducted in order to know well condition and validate the root cause of specific capacity drop. Video logging results can also be used to determine problems related to well construction and possible contamination [9]. The result of video logging borehole camera can be seen in figure 6 and 7. It show indication of iron and manganese precipitation at the blank pipe and become clogging in screen. This clogging block water from aquifer to inside well in screen thus affecting the decreasing of specific capacity value.
Video logging borehole camera also validated that degradation of specific capacity align with rates of clogging inside well especially in screen area. Furthermore, well efficiency can be predicted by analyzing specific capacity data.

4. Conclusion
Decreasing well efficiency is linear with specific capacity decreasing. By monitoring specific capacity data, well efficiency can be predicted and well rehabilitation schedule can be defined to restore well to its initial condition.

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