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Reinjection Strategy Analysis in the Well KMJ-21 Against the Mass Flow Rate of Production wells in Kamojang Geothermal Field, Indonesia

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ABSTRACT

Continuous production activities in geothermal systems with large power generation can cause a pressure drop in the reservoir. One of the major efforts in maintaining the reservoir pressure in vapor dominated geothermal field is an appropriate reinjection management.

To ensure the interconnection between reinjection and production wells tracer tests are conducted and then validated with the trend of the injection rate and production wells flow rate.

This paper will describe the effects of reinjection in well KMJ-21 to the flow rate and decline rate of several production wells.

1. INTRODUCTION

The Kamojang geothermal field was the first geothermal power plant in Indonesia. This field is located in Bandung District, West Java. Kamojang geothermal plant has been operating commercially since 1983. It started with Unit 1, 30 MW, and then the developed capacity increase until 140 MW in the next five years. In 2008, addition of Unit 4, 60 MW, result in a total capacity of 200 MW.

Continuous production of geothermal steam for the generation of electricity will affect mass decline in the reservoir rapidly. Mass decline in the reservoir, indicated by superheat values at production wells, indicates that the reservoir is undergoing the process of dry out. One way to restrain the rate of decline in reservoir pressure is with a reinjection strategy by injecting the condensate geothermal steam back into the reservoir through injection wells.

The Kamojang geothermal field is a steam-dominated reservoir, therefore condensate steam produced from the cooling tower is only ~ 30% of the total mass steam that is produced from the reservoir.

Another steam-dominated geothermal field is The Geysers. For reinjection management, in 1997 The Geysers started to inject waste water and water from a lake through a pipeline along the ~ 47 km from the City of Clearlake. This strategy was able to increase production by 40-60% with an average decline stabilized at 3% per year. (Dellinger, M., and Allen, E., 1997. The Geysers Pipeline Project. GHC Bulletin, January 1997). Learning from these experiences, The Kamojang geothermal field has established reinjection into the reservoir by several injection wells, including well KMJ-21 to maintain the sustainability of geothermal steam production.

To determine the connectivity between the injection and production wells, a tracer test survey was done in 2013 in Kamojang geothermal field. Tracer test was conducted in injection well KMJ-21 and monitored in eight production wells surrounding KMJ-21. Based on the results of this tracer test flow, there is a connectivity between reinjection well KMJ-21 with 8 production wells surrounding it. This paper will describe the effect of reinjection in well KMJ-21 against flow rate in some nearby production wells.

2. TRACER TEST IN WELL KMJ-21

In February 2013, tracer tests were conducted by Operation-Production & Reservoir-Engineering Team of Kamojang geothermal field. Tracer test aims to determine the connectivity between the reinjection and production wells and the impact against production rate and reservoir performance.

As a geothermal field with a steam dominated reservoir, it is necessary to select the appropriate tracer to be used. There are two hydrofluorocarbons (HFC), R-134a and R-23, which have been developed for use as a vapor phase tracer in geothermal systems. These compounds with low molecular weight are volatile, non-toxic, relatively inexpensive, and have a detection limit as low as 10-5 ppm. Both of these compounds have good thermal stability.

Tracer tests were conducted in Kamojang geothermal field using HFC R134a as the vapor phase tracer. This vapor phase tracer has been used in water dominated field (Upstill - Goddard and Wilkins, 1995), two phase geothermal fields (Bixley et al, 1995; Moore et al, 2000), and steam dominated fields (Adams et al, 1991; Beall et al, 1994; Beall et al, 1998).

Based on tracer tests data, the reinjection well KMJ-21 located in the center of the Kamojang field qualitatively shows the interconnection with the surrounding production wells, KMJ-18, KMJ-34, KMJ-45, KMJ-49, KMJ-71, KMJ-69, and KMJ-76 (Figure 1).

The results showed tracer recovery values ranging in a sequence from the largest recovery to the smallest in the following order KMJ- 69, KMJ-76, KMJ-71, KMJ-18, KMJ-45, KMJ-49, KMJ-34, KMJ-33.

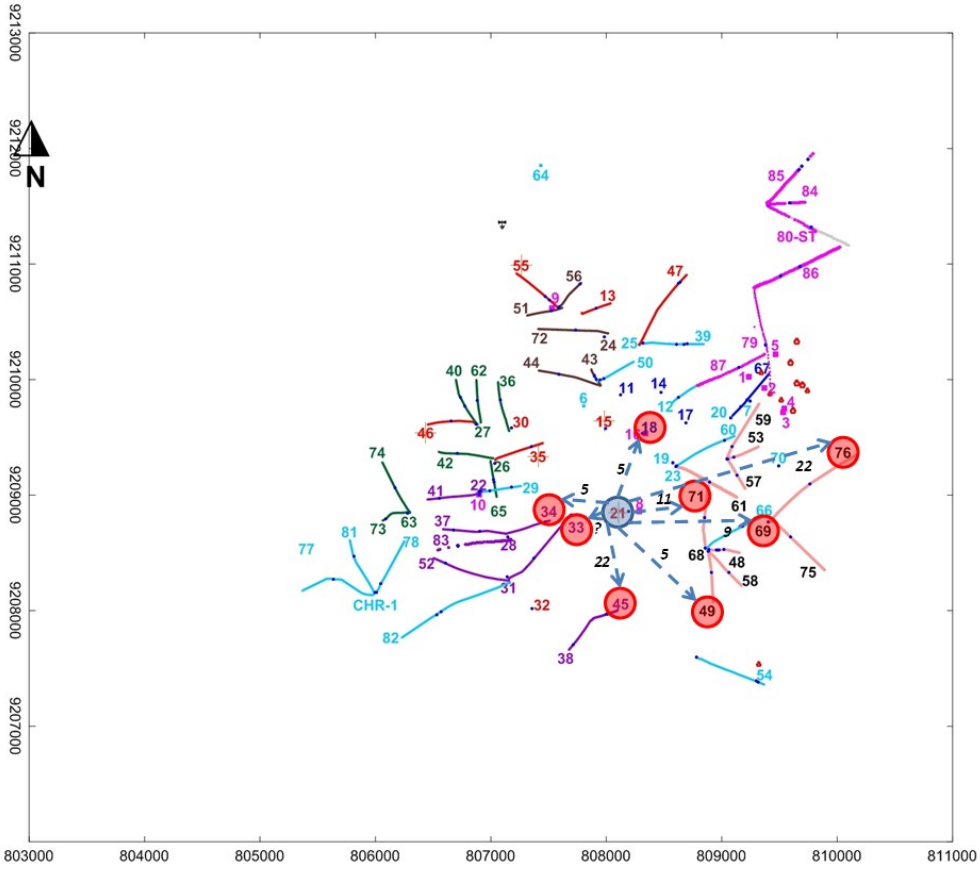


Figure 1: Map with the location of injection well and producer wells. Also it is showed the flow of condensate from reinjection well KMJ-21.

3. FLOWRATE MONITORING IN PRODUCTION WELLS

Based on the results of the tracer test, monitoring conducted against flow rate of reinjection and production wells ranging from years 2011 to 2013. The graphics of the injection effect against flow rate in several production wells are shown in Figures 2 to 5.

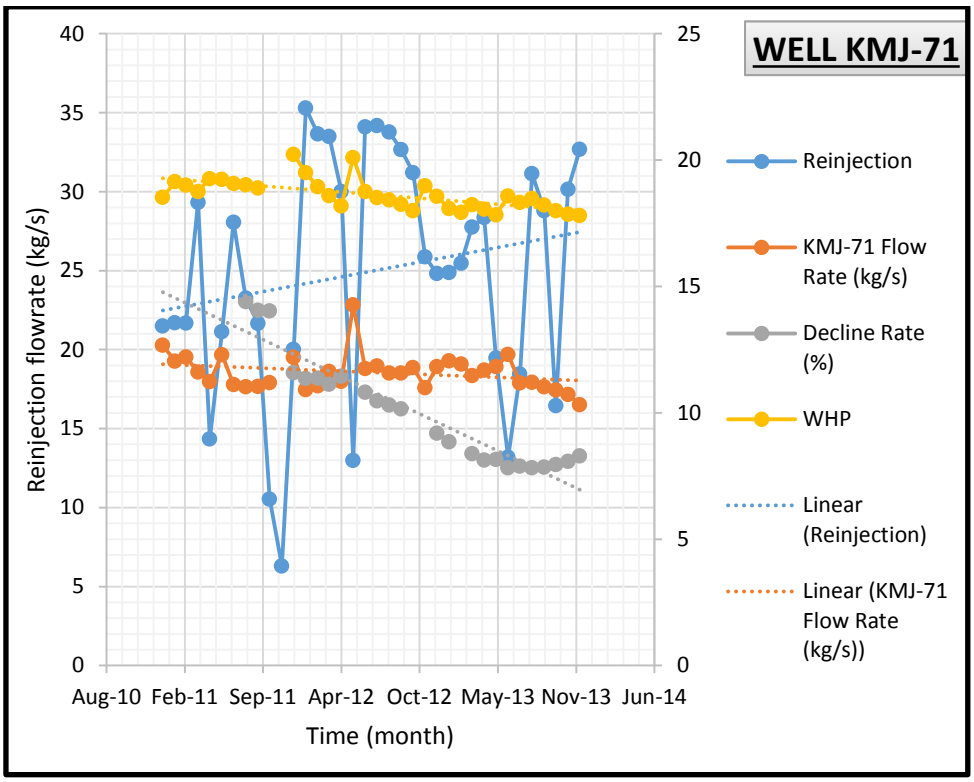
Based on this monitoring, we can see that according to the results of previously conducted tracer tests, there is connectivity between the reinjection well KMJ-21 with several production wells. The effects of reinjection in general gave a positive value between wells. Positive values are shown in wells KMJ-49, KMJ-34 and KMJ-33.

From the graphs for wells KMJ-33, KMJ-34 and KMJ-49, showing the influence relation between performance reinjection and tracer recovery rate, it can be seen that high flow rate at reinjection well KMJ-21 does not reduce significantly the flow rate in production wells. So is the pressure drop at the wellhead. The amount of pressure at the wellhead remained stable despite the decline, but the decline is still within reasonable limits.

A positive influence on the flow rate of production wells due to reinjection can be seen quite clearly in well KMJ-49. The trend of reinjection rate against the production flow rate showed a comparable relationship, if the flow rate to the reinjection well KMJ-21 increases, then the flow rate production also increased.

For some other wells, KMJ-76, KMJ-45, KMJ-18 and KMJ-69, reinjection in well KMJ-21 showed that the correlation is not so good. Reinjection made the trend of wellhead pressure decreasing fairly large. For example, in well KMJ-45, a decrease in wellhead pressure of about 1.6 bar in the period of 2011 to 2013 can be observed.

Other negative effects are likely also experienced by well KMJ-76, although not as extreme as in well KMJ-45. Well KMJ-76 shows that the effect of reinjection is not stable, which at a certain moment the increase of reinjection flow rate can increase the production flow rate, but in other moments the increase in the rate of reinjection flow can reduce flow rate production.



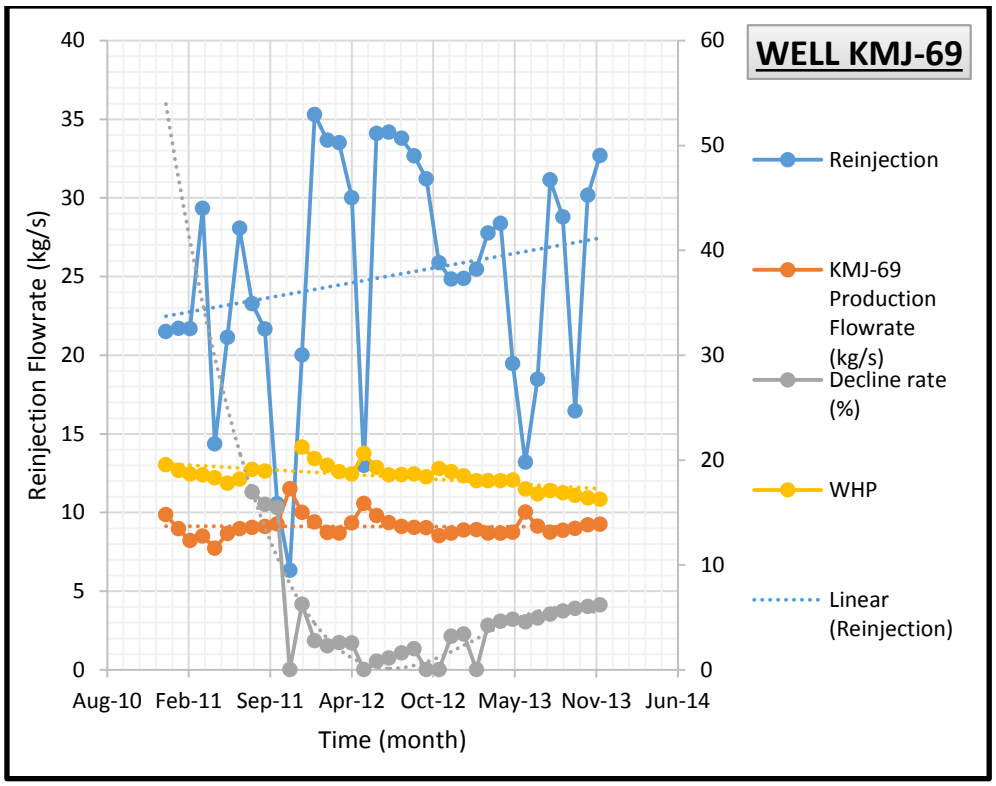
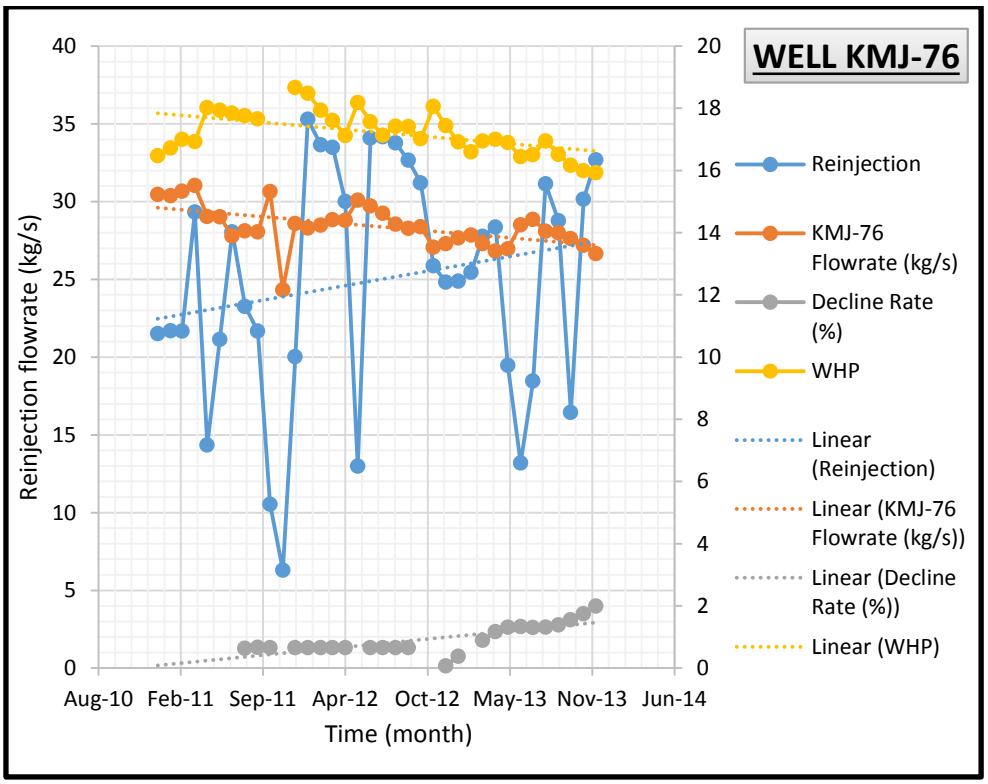


Figure 2: Effect of reinjection in well KMJ-21 against flow rate and decline in wells KMJ-71 and 69.



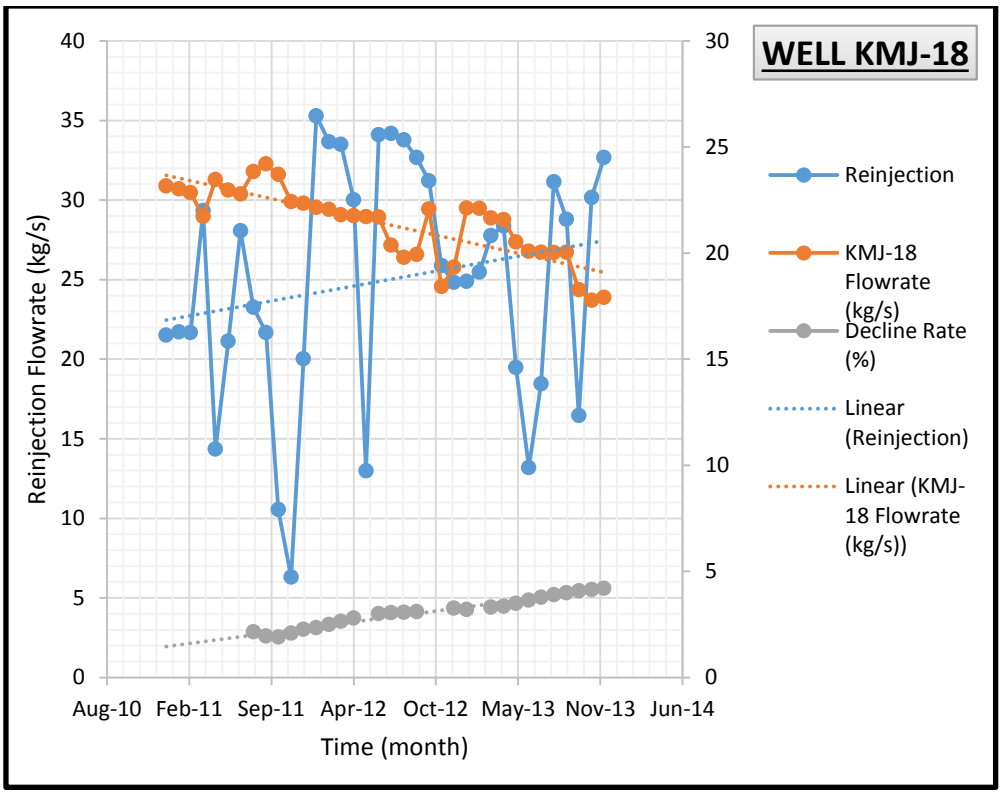
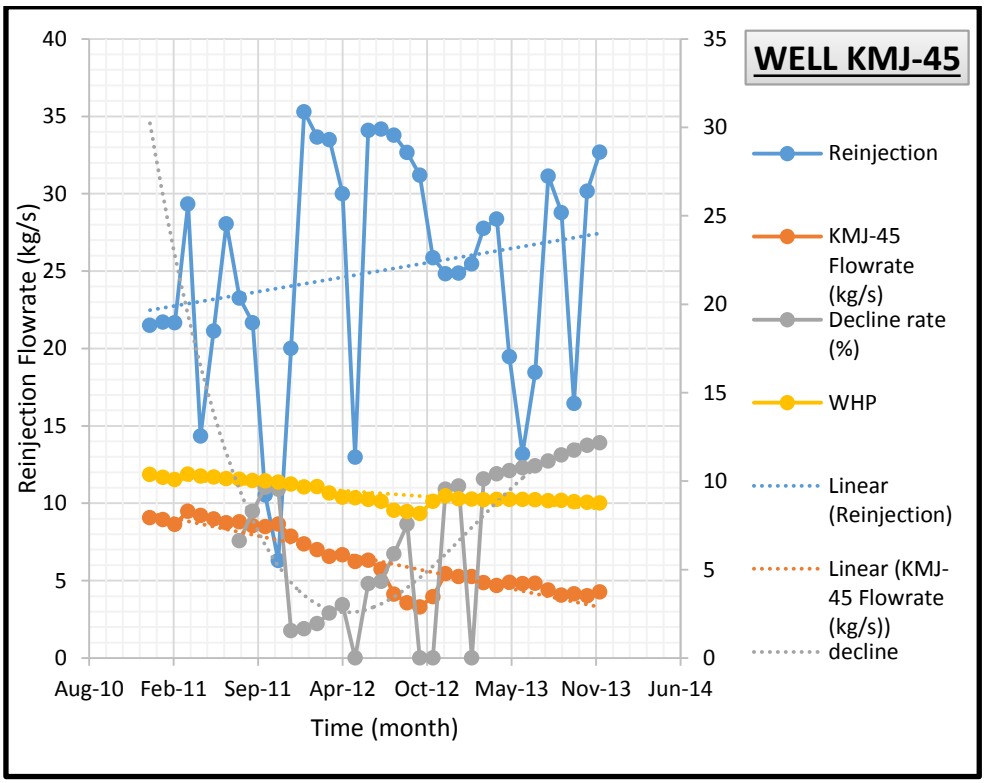


Figure 3: Effect of reinjection in well KMJ-21 against flow rate and decline in wells KMJ-76 and 18.



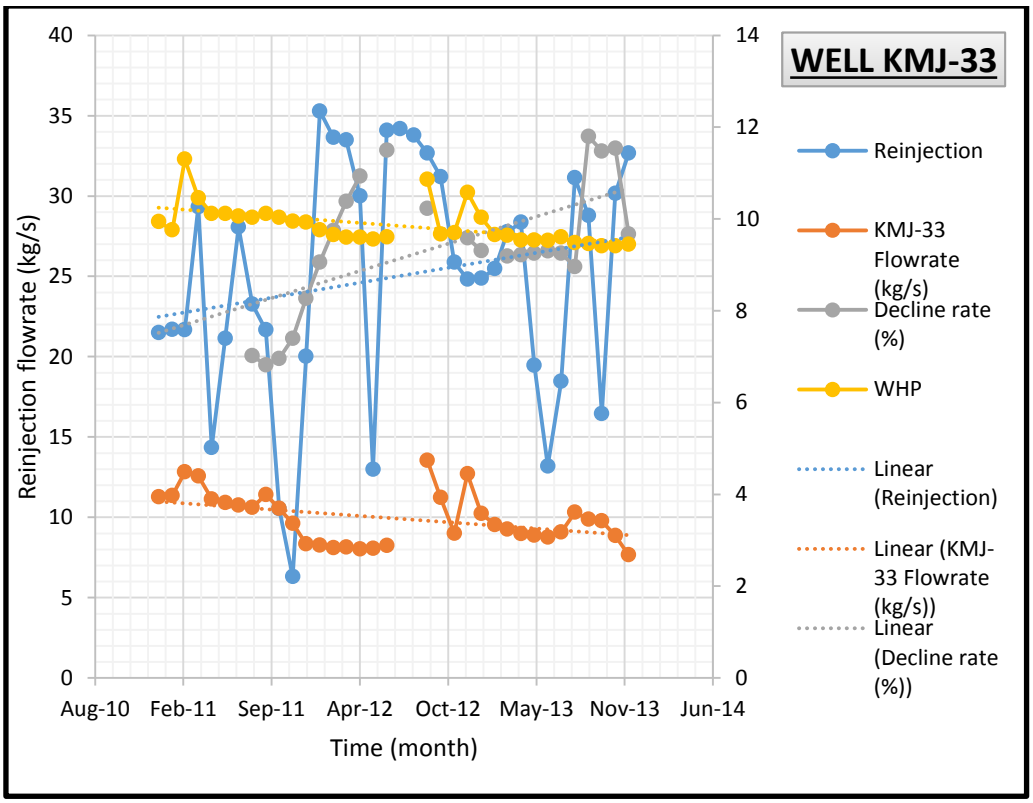
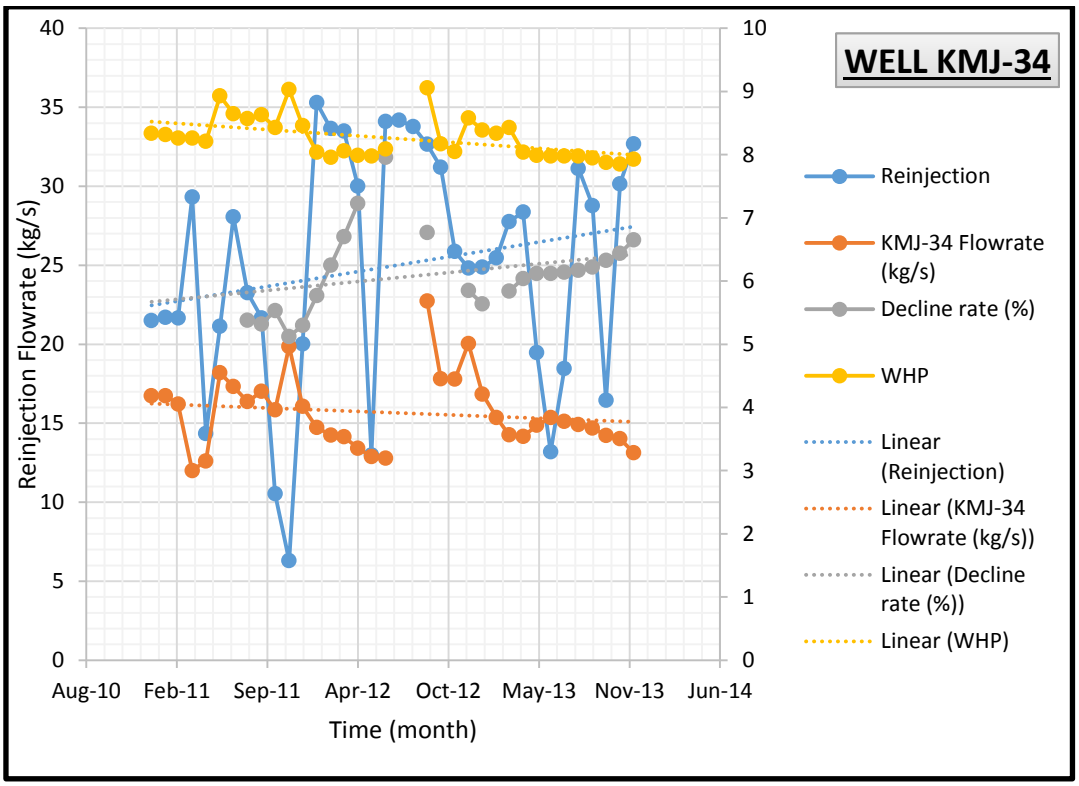


Figure 4: Effect of reinjection in well KMJ-21 against flow rate and decline in wells KMJ-45 and 33.



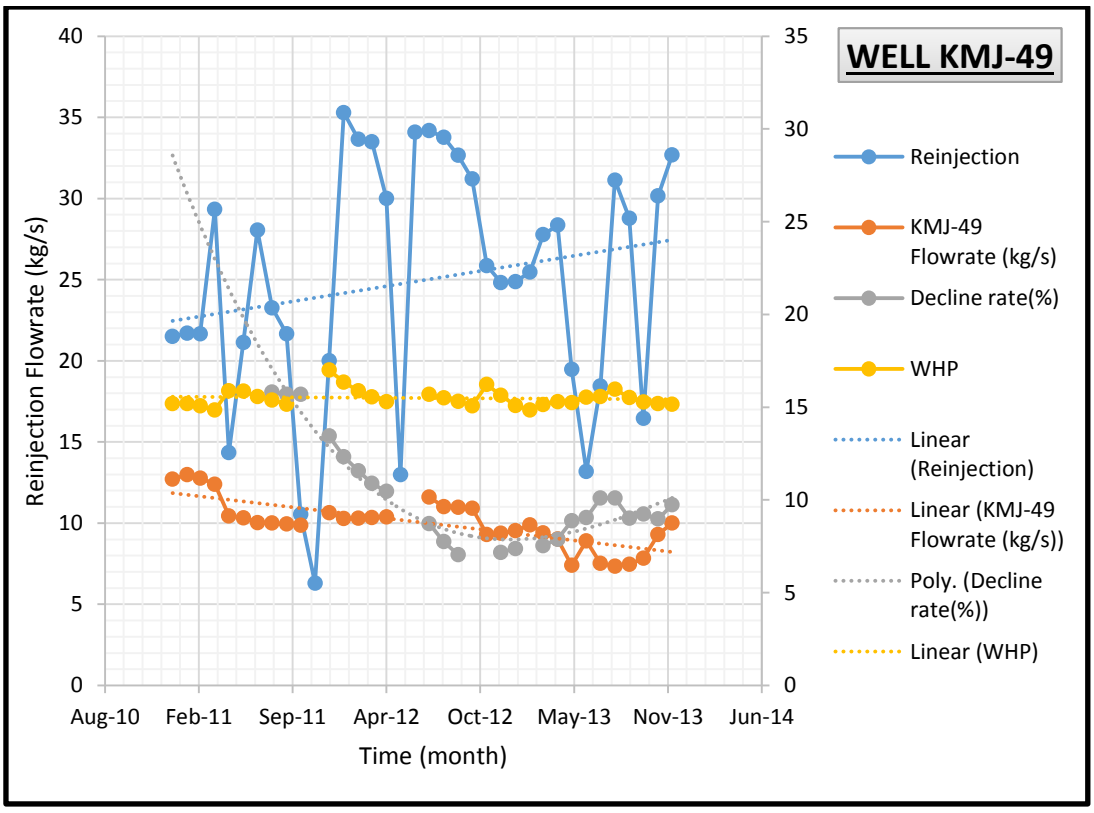


Figure 5: Effect of reinjection in well KMJ-21 against flow rate and decline in wells KMJ-34 and 49.

A similar effect happens in the well KMJ-69, when the reinjection flow rate at well KMJ-21 is decreased the flow rate in the production well will increase. Whereas if the reinjection flow rate increased the production flow rate will decrease. Figure 2 shows an increase in the decline in well KMJ-69 within a period of 1 year.

Things looks different in well KMJ-71. An increase of the injection flow rate in well KMJ-21, means a gradual reduction in the flow rate of the production in this well. While a decline in the rate of re-injection can increase the production flow rate. On the other hand the reinjection that was conducted over a period of 2 years has produced an effect on decline in wellhead pressure of about 0.7 bar. Meanwhile, the decline that occurred is a bit different, because usually a decrease in the flow rate will lead to an increase in decline. Based on this conditions, well KMJ-71 needs to be examined further to determine the decline that occurred in connection with the production and reinjection strategy.

4. CONCLUSIONS

By monitoring the effect of the flow rate of reinjection in well KMJ-21 on some of the production wells in the Kamojang geothermal area, it appears that reinjection in well KMJ-21 gave a positive correlation in some of the wells, KMJ-49, KMJ-34 and KMJ-33. On the other hand, there is a negative correlation in some other wells such as in KMJ-45, KMJ-69 and KMJ-76. Well KMJ-71 needs to be examined further to determine if the decline that occurred was in correlation with the production and reinjection.

To anticipate the worse impacts on the performance of the reservoir, more studies need to be conducted to determine the number of effective flow rates in well KMJ-21. Reduction of the flow rate is temporarily a rational choice and continue with another studies.

From this analysis, there are still many things that need to be studied, especially for the management of reinjection, because the data used in this study is only from 8 monitoring wells during the tracer test at well KMJ-21. For the overall analysis of the tracer test, it should be done in other reinjection wells, so as to obtain complete data in Kamojang geothermal field. This data can later provide a clear correlation between connectivity throughout the reinjection to production wells in the Kamojang geothermal field and subsequent reinjection into the basic management.

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