Efficient monitoring of wells used for direct use

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ABSTRACT

Thermal water used with granted water concession have to perform a continuous monitoring of abstracted quantities, of impacts of water exploitation and use, and systematical monitoring of hydraulic properties of geothermal objects. This has mostly been established at all Slovenian sites in early 2019 and makes a firm ground be able to provide, the first time ever, a reliable national overview of the quantity and quality status of geothermal aquifers.

1. INTRODUCTION

Geothermal resource estimation can be made with various uncertainties. In the regions with traditional use of thermal waters as in the Pannonian basin (Rman et al. 2015), it is expected that at least some measurements on hydraulic and thermal conditions exist. The quantitative and qualitative assessment of aquifers, independent of national borders, is also important in the framework of groundwater body assessment within the River Basin Management Plans required by the Water Framework Directive (2000/60/EC). Production and surveillance monitoring systems are the appropriate tools for this and may differ in detail based on the type of observed geothermal system.

Currently, monitoring of geothermal aquifers is rarely the case in the wider Pannonian basin region (Rman et al. 2011, Rman et al. (these proceedings), Szőcs et al. 2018). Some indications on over-exploitation of the transboundary low temperature Upper Pannonian sandy geothermal aquifer have been investigated on a local (Rman 2014,) and regional scale (Rman et al. 2016, Szőcs et al. 2013, Tóth et al 2016), however, it was also very difficult to gain comparable monitoring data from the neighbouring countries.

This presentation will enlighten the situation on production and surveillance monitoring systems of geothermal aquifers in Slovenia. Slovenia is a country which lies on the western rim of the huge Pannonian sedimentary basin and has more than 50 sites with thermal water (20-75 °C) occurrences.

Two types of concessions can be granted for the use of thermal water. If total reinjection (a geothermal doublet) is established, the mining concession based on the Mining Act is being granted by the Ministry of Infrastructure. If this is not the case, a water concession under the Water Act is being granted by the Ministry of the Environmental and Spatial Planning.

It is worth emphasising that only one mining concession is granted for geothermal use even in 2019, for a doublet in the district heating system of the town Lendava. As these monitoring requirements significantly differ from the ones listed in water concessions (the first being less rigorous), we will focus only on the situation with the water concession in this paper.

2. METHODOLOGY

Due to various legislative complications most thermal water users gained their water concessions only in 2015. Their Decrees on Water Concession have had prescribed several types of monitoring:

i) monitoring of abstracted quantities,

ii) monitoring of impacts of water exploitation and use,

iii) monitoring of hydraulic properties of geothermal objects.

Consequently, groundwater levels, temperatures and abstraction rates in production and observation wells with concessions have to be measured continuously with at least an hourly interval of data collection, sometimes also with daily transmission of data to the Environmental Agency of Slovenia. The requirement is also that only 5% of data can be missing otherwise (also financial) measures can be taken.

Moreover, chemical analyses (field parameters, main and trace elements, organic substances and pesticides) and isotopic analyses (activity of tritium, stable isotopes of oxygen and deuterium in water) of thermal water must be performed annually, while composition of noble gases in water is analysed only once, preferably in the first year when the concession is granted. Accredited labs are required to perform the analyses. After the first three years of full inspection of composition and when the natural variation of composition is expected to be reliably evaluated, modification of the parameters list can be made in the monitoring programme which has to be submitted to the Environmental Agency of Slovenia every three years. This approach is expected to be a cost-effective

and data-reliable way, acceptable to both parties, the concessionaire and the surveillance agency

The temperature and quantity of waste thermal water have to be monitored continuously, with at least daily recording. Large efforts are now being put into the harmonisation of requirements and harmonisation with the emission monitoring.

Monitoring of hydraulic properties of geothermal wells should be performed by running pumping (step) tests periodically. The first one should be made in the first year when the water concession is granted, the second in the third year, and the next ones every six years.

Exceptions in all these requirements are possible either when survey was already properly performed prior the concession has been granted and duplication is, of course, not needed or of there are some technical issues which would cause unreasonable costs to establish a fully-monitored system.

All required monitoring data has to be interpreted annually in a standardised Excel-form report and submitted to the Environmental Agency of Slovenia which approves (or not) it.

3. RESULTS

In three years (2015-2018) of establishing such production monitoring systems, several challenges have had to be solved, technically and legislatively.

In practice, artesian wells with high free CO_2 gas content and/or methane emissions still pose a technological challenge for the long-term operation of monitoring equipment. Such wells have pressure and temperature probes installed at the wellheads, which causes several issues which have to be accounted for within interpretation: i) temperature is often dependant also on the ambient air temperature, showing higher temperatures in the summer season; ii) when the well is not in operation, it cools down and the temperature cannot be used to calculate the thermal efficiency of the system, iii) pressure can vary dependent on the scaling effects or gas outbursts etc. Such gas wells also have huge problems with the water meters. Based on several manual discharge rate measurements, these meters can show 1.8 to 2.6-times larger yields as there is the actual water outflow rate.

There are also some modifications on monitoring the quantities of natural thermal springs. Here, the total outflow usually cannot be measured due to costly need for re-working of the capture to install a water meter. It even happened that even though the natural spring was discharging directly into a swimming pool (it was built above the spring), the user has built a concrete pool above it instead and fills it with water from a well, just to easily measure the actually used thermal water quantity. Spring also show the highest tritium activity of thermal waters in Slovenia due to the mixing of thermal and shallow groundwater, however, it is still often well below 3 TU.

One of the greatest challenges was posed by doing the short-term (step-drawdown) pumping tests. In most cases, they were not successful the first time (prior to 2017) and this occasion was the first example when the hydrogeologist and the utilization-system-operator at the site have discussed in very details how the wells are operated, what-kind are the submersible pumps and how they are controlled (many but not all have frequency regulators). Since 2016, step test were performed in more than 40 wells in Slovenia by two different methodologies. The first one is of a traditional type – 3 steps with increasing 3 quantities being pumped for approximately the same time each (30 to 120 minutes, depending what was the time slot the user provided from the test – how large were its thermal water needs). Within the second method we tried to have 4 steps, sometimes with a pause in between the each step. This forms an unique database of data where from not only engineering solutions on specific capacity and its changes in time for each well were evaluated, but we plan also to make a scientific assessment of joint interpretation of gained results based on differenced for such test performance in regards to the aquifer's porosity type.

Previous investigation on chemical and isotopic composition of thermal water (Rman 2016) showed a generally stable situation over at least one-year period. Still, at some locations long-term trends in decreasing mineralization, emerging natural gas emissions and similar were indicated, implying local deterioration of the aquifer. This has been confirmed by production monitoring analyses also. The greatest issue here was how to provide comparable methods and sampling procedures over time, to be able to compare the data in a long-term and be really sure that chemical trends are not a consequence of a measurement uncertainty and similar. We have learned that careful investigation of the analytical results is needed each time, and some errors can be identified only after several analyses have been performed, therefore we found this annual sampling approach extremely valuable to really be able to define what is the natural variation of thermal waters' composition and what are random or systematical measurement errors.

The requirements have resulted in much better care for thermal water wells in general, as many well-logs and camera inspections were made to establish a reliable status of the casing (and its leakage) to plan well rehabilitation. Many users installed also additional heat pumps to reduce the waste thermal water temperature, now approaching 20-25 °C and not 30 °C anymore. This is favourable for keeping good aquifer's status and also enhanced use of direct geothermal energy, respectively.

3. CONCLUSIONS

The Slovenian requirements for production monitoring are rather extensive and strict. However, in 2019 almost all thermal water concessionaires have had it properly

established and we already see from the available interpretations at individual sites, but also regional and national evaluation has been done recently, that we will be able to provide a really reliable national overview of the quantity and quality status of geothermal aquifers for our country.

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